Alliance for Global Sustainability Bookseries

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Mapping Sustainability

Knowledge e-Networking and the Value Chain

Springer

Mapping Sustainability

ALLIANCE FOR GLOBAL SUSTAINABILITY BOOKSERIES
SCIENCE AND TECHNOLOGY: TOOLS FOR SUSTAINABLE DEVELOPMENT

VOLUME 11

Aims and Scope of the Series

The aim of this series is to provide timely accounts by authoritative scholars of the results of cutting edge research into emerging barriers to sustainable development, and methodologies and tools to help governments, industry, and civil society overcome them. The work presented in the series will draw mainly on results of the research being carried out in the Alliance for Global Sustainability (AGS).
The level of presentation is for graduate students in natural, social and engineering sciences as well as policy and decision-makers around the world in government, industry and civil society.

Mapping Sustainability

Knowledge e-Networking and the Value Chain

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THE AGS

The Alliance for Global Sustainability

DEDICATION

In memory of

Elizabeth McLaughlin.

CONTENTS

PREFACE

Challenges and Focus

This book focuses on three interdependent research initiatives designed to facilitate the management of transitions toward sustainable development. These initiatives consist of: (a) mapping sustainability as a domain of knowledge; (b) contributing to the development of global knowledge e-networking and extending the knowledge value chain; and (c) exploring new methods to expand our knowledge and to improve e-networking practices. While the activities differ in nature, scale and scope, they are highly interconnected. It is our hope that, jointly, they will contribute to our common quest for a sustainable future.

Our underlying objectives are to contribute to the provision, management, and sharing of knowledge, and to enhance the value of knowledge and its uses by different constituencies in diverse contexts and at different stages of development. The central theme of this book, connecting its different parts, is about ways of transcending critical barriers to the effective uses of knowledge and e-networking. Of special relevance is the development of new approaches to the provision and transmission – from local sources to global networks and from global sources to local networks. In many ways, this is a book of theory and methods, as well as policy and performance.

Concepts Defined

According to *Webster's New Collegiate Dictionary*, *to map* is "to make a survey," and "a network" is "an interconnected or interrelated chain, group, or system." *Mapping Sustainability* means surveying the broad area of sustainable development and presenting a detailed accounting of its characteristic features, and, on this basis, generating a structured ontology of the knowledge domain. In this context, *global knowledge e-networking* means engaging in cyber-based interaction and communication, around a knowledge domain of shared interest, framed by common organizing principles that enable further consolidation as well as greater expansion of knowledge. *Extending the value* *chain* means identifying and engaging in effective ways of enhancing the gains associated knowledge and e-networking. *Exploring new knowledge and e-networking* means designing and using novel methods for generating knowledge and enhancing the utility of e-networking. It also means illustrating the potentials of the innovation and demonstrating its relevance to the issues at hand.

In this context, *Mapping Sustainability* is both a concept-based and a content-based, approach to the domain of "sustainable development," with the full realization that the nature of such understanding changes over time, and that representations of concept and of content must evolve accordingly. *Mapping* generates the ontology for the sustainable development domain, which serves as a baseline for future inquiry.

The ontology represents our prevailing understandings of dominant problems due to human activities as well as the range of solutions as currently conceived – in scientific and technical terms, as well as in social and regulatory terms. For mapping purposes, the focus is on the content-architecture: the levels, linkages, and complexities of sustainability. By extension, *global knowledge e-networking* is about innovations in strategic uses of cyberspace for providing sharing, developing, creating, and organizing knowledge for sustainability.

The various initiatives that bear upon about the *knowledge value chain* are about ways of thinking about and creating new knowledge pertaining to transitions toward sustainable development – taking into account global complexities associated with states and firms, local and global considerations, and diversity in methods and technologies of inquiry.

Finally, *new explorations and innovations* involve relatively untested approaches for enhancing our stock of knowledge, to specific value for the sustainability domain, and to enhancing modes of facilitating knowledge-based transition foundations of the global agenda.

Plan of the Book

As a collaborative initiative – involving the efforts, ideas, contributions, and insights of a large number of individuals and institutions worldwide – this book is in three Parts.

Part I focuses on developing a map for sustainability and its computational implementation in an e-Laboratory, known as the *Global System for Sustainable Development* (GSSD), as well as on several applications that represent the e-Laboratory to date. Part I is theoretical and analytical, as well as methodological and computational – focused on the process of *mapping sustainability*, designing ways of transcending the barriers to knowledge, and implementing a knowledge networking system of global reach.

Among the dominant barriers to sustainable development, several of the most compelling are addressed in this book. Among these are fundamental ambiguities surrounding the concept of sustainability, compounded by multiplicity of perspectives, conflicts and contentions, as well as powerful cleavages due to differences in language, culture, and socio-economic condition. Then there are barriers on the ground, involving infrastructure conditions and constraints, differentials in price and cost, and differences in access to new user-based technologies for exploiting the power of cyberspace. In addition, there are key impediments embedded in existing venues for knowledge networking, related to content development and its provision in e-venues. Individually, each of these barriers is daunting in its own right, but collectively they become especially powerful.

The chapters of Part I are about ways in which we have addressed these critical barriers. A key feature of Part I is the ontology of sustainability, which puts forth a detailed profiling of the domain content. In terms of methods, the key features include new applications of e-technology and computational tools, the design and management of distributed workflow, and the related instrumentalities of e-collaboration on a global scale.

Part II focuses largely on the issue of value – the value of knowledge and the value chain. It concentrates on contextual, institutional, and operational challenges associated with knowledge e-networking in private and public domains and explores particular types of innovations and technological applications. Accordingly, Part II addresses methodological, institutional, and cross-cultural challenges related to global knowledge e-networking as well as applications in fundamentally different cultural, linguistic, socio-economic, political and decision contexts.

The chapters of Part II are written from the perspective of concerns and issues evident at the end nodes of distributed global knowledge networking. Several chapters involve e-based interactions across languages and cultures and address different ways of understanding challenges of sustainable development. They also illustrate the operational implications of some new trajectories for knowledge and derived from experience to date. More specifically, we focus on the perspectives of Arabic-speaking and Chinese-speaking participants in global e-networks. This means that we need to better understand how knowledge can be utilized in order to realize targeted changes.

In addition, Part II also considers specific aspects of e-knowledge value for global business, and reviews various ways in which the value of knowledge can be captured. The chapters that address such challenges highlight the importance of driving functions, organizational reach, and decision scope for different types of global enterprises.

Part III is about new exploration and innovations in a wide range of issue areas, to illustrate both the novel perspective as well as its potential applications. While these chapters may seem disjointed in focus when considered individually, collectively however, they illustrate explorations and innovations in a wide range of contexts bearing on transitions toward sustainable development. More specifically, individual chapters focus on: (a) new visualization technologies for extracting inferences and information about the global system, on the whole and in its individual parts, (b) attention to new activities and functionalities for government and governance of states, given the technological opportunities provided by cyber venues, electronic communication, and access to the Internet, (c) *Global Agenda!*, a simulation and gaming e-system, and potential teaching tool, for grappling with decision and choice in a world of increasingly severe hotspots, (d) ways of illustrating the synergy between law and sustainability, (e) empirical manifestations of the role of property rights in environment and growth, and (f) early data on the ways in which the banking system is responding to the challenges of climate change and attendant implications for risk associated with finance of critical projects.

These chapters are followed by an effort to take stock of the conceptual foundations in the study of international relations. This chapter highlights key differences between basic (mainstream) theoretical perspectives and the more advanced (emergent) logic. The former represents the traditional views that remain dominant to date. The latter departs from tradition and takes into account key interconnections between social systems and natural systems over the past decades – between human and nature – and provides important correctives for the distorting effects of the pervasive homo-centrality imposed by tradition.

In its entirety, this book is an international initiative. It is a product of sustained collaboration among a large number of individuals in the scientific and academic communities, in business, industry, and in public policy. Many aspects of this effort are rooted in activities of the *Alliance for Global Sustainability*. But, it is clearly the persistent interest and commitment of the editors, the authors and all of the contributors that has brought this initiative to its successful conclusion.

Nazli Choucri

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PART ONE

Chapter 1

MAPPING SUSTAINABILITY

Logic and Framework

Nazli Choucri

Introduction

While almost everyone agrees that the quest for sustainable development is one of the most significant challenges for all societies in all parts of the world, there are considerable disagreements about the specific meaning of *sustainable development* and a range of contentions surrounding the term *sustainability*. This situation is particularly problematic in light of the explosion of information about sustainability now available in electronic form, the increasing use of the Internet as a mode of communication and exchange, and the difficulties often encountered in locating and selecting relevant knowledge on any specific set of issues. These conditions create a critical imperative, namely, one of devising a strategy for organizing and managing information flows about sustainability on the Internet, where quantity dominates and quality is often sacrificed. This imperative revolves around matters of *content* and of *conduit.*

The purpose of this chapter is to present a conceptual framework to guide our understanding of the overall issues at hand and examine their constituent elements in order to organize existing knowledge on sustainable development. The conceptual framework also serves as the basic architecture for thinking about, searching for, and retrieving knowledge bearing on the specific aspects of sustainability of interest in any situation. Since the process of engaging in transitions to sustainability is itself a moving target, we would expect that efforts to develop a knowledge-base on sustainability will yield results that change over time. In this context, the challenge is to capture the elements that appear to be most relevant, and to discard others as appropriate.

A fundamental prerequisite, however, is to recognize the all-encompassing context within which such issues take on their most fundamental

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meaning, namely the nature of the global system and globalization process. It is no longer possible to consider sustainability of individual entities, states, or groups without taking into account the broader configuration of natural and social systems within which all entities are embedded. Accordingly, in this chapter we highlight some of the most important facets of the global system as currently understood, particularly focusing on critical features of the globalization process. These facets frame the terms of reference, within which we will engage in Mapping Sustainability.

1.1 Globalization and the Global System

Over the course of many centuries, a major alteration of the international system has occurred as populations expanded their activities and political entities broadened their reach. The concept of the global system – recent addition to the semantics of international relations and world politics – formalized our recognition of the powerful interconnections among natural systems and social systems. This concept highlights the embeddedness of social activities within prevailing environmental contexts and all attendant considerations. An inevitable extension of this understanding is reflected in the notion of globalization. The ongoing globalization – a legacy of the 20th century – may well constitute the greatest challenge to world populations since the end of Western European Feudalism, which led to the Congress of Westphalia and the establishment of the nation-state system.[1]

In principle, the global system refers not just to the social, political, and economic systems, but also to the earth, its geological and geographical features, its flora and fauna, and its surroundings (including the sun) which provide a unique and indispensable environment for life as we experience it. In a sense, the natural environment holds us all hostage and the implications of such bindings have become increasingly more complicated as population growth and advances in technology have enabled human beings to extend their activities and interests into remote enclaves of the planet (and space). As a result, we increasingly intervene in natural processes, often blindly and without knowledge of the consequences.

Such interventions lead to toxins. Once we have released our toxins into the soil, water, and air, for example, nature's processes take control. Once released, the trajectory, intensity, and damages of effluents are seldom, if ever, subject to legal or strategic control. The global system remains disrespectful of, even oblivious to, our political regimes and state boundaries.

[1] The Westphalia principles defined the state and its sanctity as the basic unit of international relations, and thus reinforce those very factors that undermine the emergence of a global, rather than an international, system.

And the forging of cyberspace, an essentially technological achievement, invariably alters the traditional distributions of voices in international relations, shaping new domains of interactions relevant to human behavior, the role of the state, and the structure of the international system.

In this connection, Peter Haas argues that the growing importance of epistemic communities is shaping our understanding of the global system and its fundamental processes, and that this role is a clear acknowledgement of the interconnections between natural and social processes (1989).[2] Haas argues that these environmental conditions constitute a formal recognition of a *fourth image reversed* scenario, where international politics are shaped by global conditions.[3] It can be compared only indirectly to Peter Gourevitch's *second image reversed* since the latter focuses entirely on social interactions (political, economic, strategic, etc.) with no recognition of the natural system (Gourevitch, 1978). With these considerations in mind, later in this chapter we shall point to key features of the changing contexts for states and firms, and then focus specifically on our strategy for charting this new 21st century reality.

More immediately, we can consider the forging of cyberspace and the new domain for the conduct of political discourse to be a critical feature of the global system. Clearly created by human beings and their technological ingenuity, this fourth level encompasses the third image, namely the international system that is composed of state actors and others enfranchised by the state, as well as those that are commonly thought of as transnational. New policy arenas for discourse are responses to new modalities of actions and interactions are in the offing. As a result, there are new demands for global accord and coordinated action.

Whatever we may do that drastically interferes with the natural system – at any level – can have global repercussions. And any such repercussions at the global level could have local implications. Only a global view will demonstrate the extent to which war, peace, environmental, and other problems

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[2] This characterization refers to the concept of 'image' in the study of international relations which signals levels of analysis. The traditional levels – defined by the individual, the state, and the international system – were first defined by Waltz (1959) extending the notion of 'image' introduced earlier by Boulding (1956). North (1990) and Choucri and North (1993) first articulated the concept of the global system, as the fourth image. Choucri (1993) made the first extension of the fourth image, as the global system by taking into account cyberspace, as a human-created, technological driven generation of new space of interactions that transcend the conventional three images of the international system.

[3] Among the related efforts in international relations theory contributing to the articulation of the fourth image are Modelski (1996), Alker and Haas (1993), Ostrom (1990), Starr (1997), Vitousek et al. (1997), Holling (1995), and, of course, Hardin (1968) in the context of framing sustainability. Implications of the fourth image for the properties of the second image can be derived from Litfin (1998) while at the same time taking into account select imperatives of the third image. See also Pollins and Schweller (1999) "linking the levels" focusing on shifts in U.S. foreign policy over long spans of time.

impinge on one another. In this context, we need to consider how individual humans and their needs, wants, desires, demands, capabilities, and actions create, constitute, train, shape, and constrain the state and the international system, and how all three – individuals, the state, and the international system – are embedded in an overall global system.

A rather simple way of looking at global trends and select constitutive elements is presented in Figure 1.1, which shows the distribution of states in terms of carbon emission and GDP.

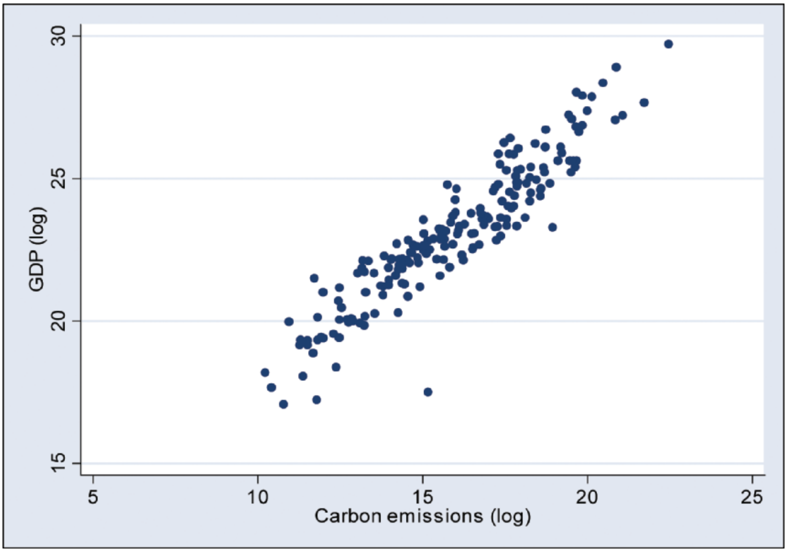

Figure 1.1 **Carbon emissions (thousands of metric tons) and GDP (constant USD), 2000. Based on observations from the *United Nations Common Database.*** [4]

An obvious inference is that poor countries produce less and pollute less; while the richer countries produce more and pollute more. What happens, however, when the poor become richer? What are the stresses that result from growth? Can sustainability substitute for growth?

In this figure, as well as all of the ones that follow, the observations displayed contain two sets of information: one pertains to the distribution of countries at one point in time, and the other pertains to the imputed evolutionary pattern of development over time. In the context of Figure 1.1, therefore, over time countries located on the lower bottom left side of the graph will gradually 'travel' along a trajectory of change that leads from lesser to greater levels of development toward the top right side.

When observed empirically, such trajectories go a long way toward helping us understand the patterns of growth, development, and evolution of

[4] All figures in this chapter are constructed using Stata 9.

states and empires from their pristine beginnings through their rises, declines, and eventual disintegrations. A different set of issues is raised in Figure 1.2, which shows the distribution of states in terms of energy consumption and population size. Since both variables represent aggregate characteristics of states, it is not surprising to observe that countries with larger population consume a greater amount of energy.

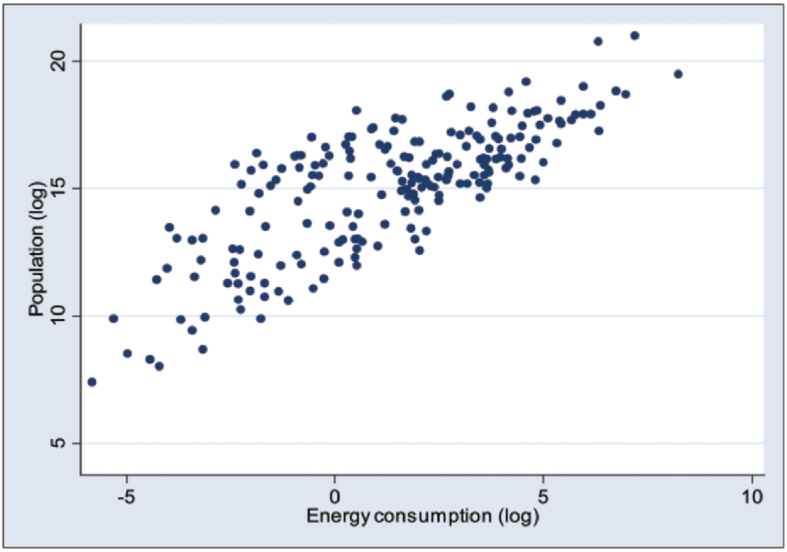

Figure 1.2 **Population and energy consumption (electricity, in millions of kWh), 2000. Based on observations from the *United Nations Common Database*.**

In still a different vein, we show in Figure 1.3 another perspective on the distribution of countries in the global system, namely the distribution of life expectancy at birth, on the one hand, and GDP per capita on the other. The obvious is worth noting since it reflects the stark reality of inequality in the international system: with few exceptions, the countries with higher GDP per capita are also those with higher life expectancy.

Finally, we show in Figure 1.4 the distribution of countries in terms of military expenditures and economic output, GDP.

Once more, we see the generic inter-state pattern signaling a now-familiar view of distribution of states worldwide. This distribution is especially informative as it allows for a simple inference. With the exception of one or two cases, it is clear that with greater material output (an indicator of wealth) come greater expenditures on the military (an indicator of security or insecurity as the case may be). Both of these factors are usually correlates of the globalization process.

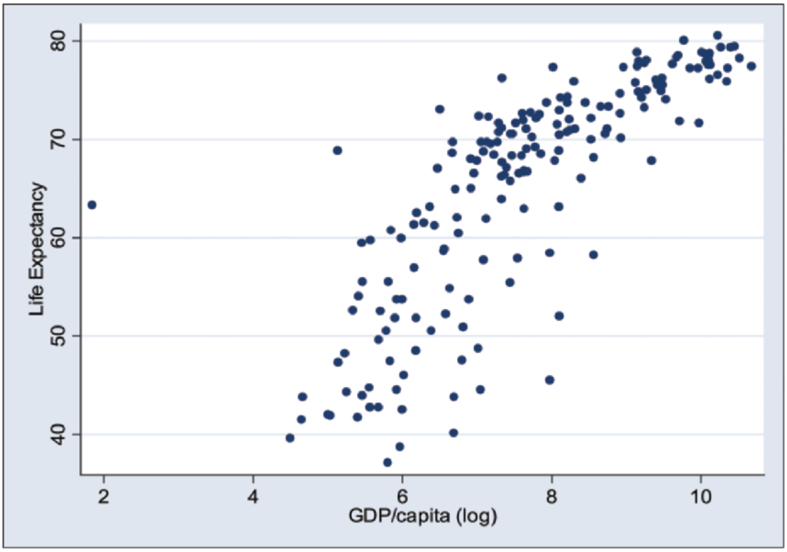

Figure 1.3 **Life expectancy (years) and GDP/capita (constant USD/person), 2000. Based on observations from the *United Nations Common Database.***

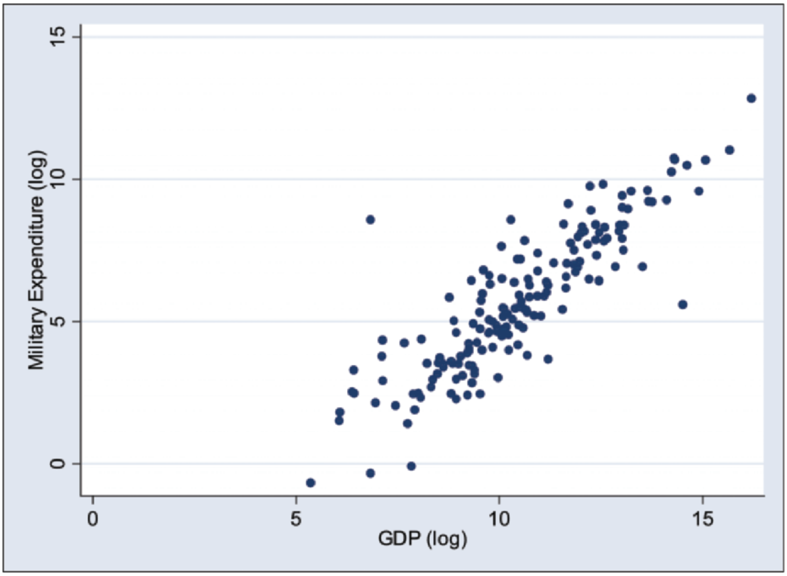

Figure 1.4 **Military expenditure (constant USD) and GDP (constant USD), 2000. Based on observations from the *United Nations Common Database.***

1.1.1 The Meanings of Globalization

Despite the dominance of *globalization* in both development and international relations debates and discourses, fundamental differences persist about the meaning of this term. It is not always easy to determine which is growing faster: the globalization debates or the globalization process itself.[5] At the very minimum, globalization refers to growing patterns of cross-border activities involving aggregations of human activities at various levels of analysis. These aggregations shape social interactions, as well as environmental considerations.

From a theoretical perspective, however, the spectrum of globalization is bracketed by two views. At one end is the conventional view, which is focused largely on economics and economic transactions; at the other end is an emergent view which stresses the dynamics and complexities of globalization.

More specifically, the conventional view defines globalization as the increased integration of national economies in terms of input, factor, and final product markets. This view focuses on *intra-state* impacts and on issues surrounding convergence and divergence of cross-border of policy responses. While the economy-centric view is important, it is very restrictive as it obscures many of the more pervasive system-transforming features of today's realities. It may also impede an appreciation of ways in which globalization creates new demands for governance induced by social, political, and economic transformations. When placed in the context of current realities, the conventional view of globalization represents the processes of growth from the perspective of those on the 'top' of the global system and pays considerably less attention to than by those situated at the 'bottom.'

1.1.2 Emergent Logics

At the other end of the continuum is the emergent logic of globalization – the view assumed in this book – which stresses the complexities and attendant interdependences created by the movements of goods, services, people, ideas, and influences across national borders. This perspective is particularly dynamic in that it is focused on *transformations* within and across states due to various patterns of mobility, notably those which strain prevailing modes of governance and forge new policy spaces as well as demands for new forms of coordinated policy responses.

In this context, we define *globalization* as the complex process engendered by (a) the movement of populations, goods and services, influences,

[5] See Castells (1996) for a sociological perspective on globalization and its challenges.

effluents, and ideas across state boundaries, such that (b) these alter the structure of national economies and societies, and create new forms of interdependencies across economies; (c) these changes, in turn, alter the subsequent movements of goods, services, people, and ideas across boundaries; as a result, (d) changes in international structures and process forge new policy spaces and (e) create demands new forms for coordinated policy responses.

In short, this emergent view centers on impacts of flows and movements along a causal chain and draws attention to the feedback logic. The causal logic flows from differential national and international conditions to shaping the movements across boundaries; from movements across boundaries to impacts on national economic, political and social structures to conditions that create new movements and new processes; from new process effects to alterations in the structure of the international system; and from such alterations to shaping of new policy spaces that, by necessity, create demands for new policy responses.

The essence of globalization lies in the transformations of structures and processes that lead to the formation of common policy spaces and require new institutional responses. This emerging logic suggests that almost everyone is involved in the process and everyone is affected – albeit in different ways. The specific manifestations of structure and process may differ, but the inherent logics and the feedback dynamics are generic in nature.[6]

Increasingly, the socio-political and economic dimensions of today's globalization appear to be knowledge-driven, making knowledge intensity one of the most significant features of the world economy at this time. While enhanced economic dependence on knowledge has fueled competitiveness worldwide, its impacts are considerably less evident in development contexts. Against such imperatives, we now turn to the deployment of knowledge for facilitating transitions toward sustainable development.[7]

1.2 Knowledge for Sustainable Development

According to *Webster's New Collegiate Dictionary*, *to know* is to "hold something in one's mind as true or as being what it purport to be"…[this] "implies a sound logical or factual basis" [and it also means] "to be convinced of…."

[6] As an example, if we consider extended enterprises, private and public, whose performance is contingent on efficiencies of the internationally distributed supply chain, the exposure to globalization pressures is not only unprecedented in scale and scope, but also rapidly changing.

[7] Such imperatives further compel us to question the wisdom of the conventional economic model that views more growth as a necessary imperative, and the requisites of efficiency as a dominant value.

By extension, knowledge refers to the "fact or condition of knowing something with familiarity gained through experience or association; acquaintance with our understanding of a science, art, technique, condition, context, etc." [including] ... the range of one's information and understanding to the best of abilities in place [as well as]… "The fact or condition of being aware of something…" accordingly, what is 'known' is that which is 'generally recognized….' However lacking in elegance these observations might seem, they aptly characterize common views of knowledge (1976).

1.2.1 Knowledge System Defined

We extend the standard view to take into account a cluster of understandings that we refer to as a knowledge system. Thus, we define a *knowledge system* as:

> An organized structure and dynamic process of interaction generating and representing content, components, classes, or types of knowledge, that are (a) characterized by domain-relevant features as defined by the user community, (b) reinforced by a set of logical relationships that connect the content of knowledge to its value, (c) enhanced by a set of iterative processes that enable the evolution, revision, adaptation, and advances, and (d) subject to criteria of relevance, reliability, and quality.

Among the most fundamental attributes of knowledge is that its acquisition and utilization follows the law of *increasing returns.* This means that the more knowledge which is obtained and used, the greater the likelihood that it will be valuable to the user. This critical feature is a distinctive input into social and economic activities. Our purpose here is only to highlight a feature upon which much of the trends toward knowledge intensity are based. The presumption is that a knowledge system has value, in one form or another, and that capturing this value is essential for enhancing knowledge intensity in economic activities. Further along, we specify the constituent elements of a knowledge market in modular terms.

Conventionally, *value* is defined as "fair return or equivalent in goods, services, or money for something exchanged" (Webster, 1976). *Value* also connotes worth of some kind, as well as being of some importance. But the terms of *value* are not implied in the core concepts, nor are its units of measurement. The value of knowledge has different meanings in private and in public settings. In public settings it is viewed in terms of facilitating the provision of services for meeting social needs and for implementing policies to improve social and public well being. In private contexts, it is often connected to economic gain, notably to market prices and conditions.

At the same time, however, harnessing knowledge is only part of the challenge. Equally, if not more, important is the ability to communicate, share, manage, expand, revise, and generate new knowledge.

As noted in the Preface, *Webster's Collegiate Dictionary* states that *to map* is "to represent … to delineate … to assign to every element of a … set an element of the same or another set," and "to be located near the corresponding structural [element]" (1976). In such terms, *Mapping Sustainability* presents a way of representing knowledge content in the domain of sustainable development, with the full expectation that such knowledge changes over time, and that its representations must adjust accordingly. For mapping purposes, the focus here is on the content-architecture – the levels, linkages and complexities – that characterizes the domain of sustainability.

1.2.2 Sustainable Development

Our view of sustainable development focuses on human activities, and places the individual, in social settings, at its core, while taking into account and respecting the imperatives of nature and natural systems. We define sustainable development as *the process of meeting the needs of current and future generations without undermining the resilience of the life-supporting properties of nature and the integrity and security of social systems.*

Extending this definition further, we differentiate among critical fundamental processes that represent the sustainability arena. These processes refer to the nature of *ecological* systems, the type of *economic* activities, modes of *governance*, and *institutional* performance. To become sustainable, a social system must exhibit a certain degree of viability within and across each of these processes. Accordingly, it is useful to consider the various features of these processes and the ways in which these processes may lead toward sustainability.

Specifically, a system will tend toward sustainability if the (a) ecological systems exhibit balance and resilience; (b) economic production and consumption account for efficiency and equity; (c) governance involves participation and responsiveness; and (d) institutions demonstrate adaptation and feedback. In short, if – and only if – prevailing trends point toward these conditions will a social system tend toward sustainability.

In this connection, access to, and effective use of, knowledge is critical in shaping and managing social goals. This knowledge imperative is especially relevant for trajectories toward sustainable development – in all contexts and in both industrial and industrializing countries. Despite advances in information and communication technologies, major political, strategic, economic and institutional barriers continue to impede the use of knowledge for policy purposes. In the sustainability domain, as in many others, the making of decisions and the formation of policy seldom draw on the full range of relevant knowledge, or utilize critical knowledge materials that may be available. Moreover, the complexity of sustainability, coupled with ambiguities in its meanings and understandings, further reinforce the difficulties of bringing existing knowledge into policy debates.

The challenge at hand does not arise from a lack of knowledge, data, information, published materials, raw observations, and so on, but rather from the absence of intellectual coherence and some internally consistent logic, which if put in place, would lead to best uses of existing materials. The dearth of integrative approaches (or frameworks) may well be among the most significant barriers preventing effective access to large bodies of knowledge that bear upon the domain of sustainable development. Different stakeholders in different parts of the world have different views and priorities about what is real, what is important, and what can be done as a result. This is especially true in the domain of sustainable development where a wide range of knowledge and knowledge systems are emerging.

1.2.3 Rationale for Mapping Sustainability

Given that the quest for sustainable development has become a global challenge, we need to converge on a shared understanding of the knowledge domain. This convergence requires a multidisciplinary perspective, spanning local to global levels as well as a range of very diverse forms and types of knowledge. More specifically, there are four imperatives shaping this mapping initiative:

Conceptually, while everyone recognizes that sustainable development is a holistic and integrative concept, there are considerable ambiguities pertaining to interconnections among various facets of human activities, to the constituent elements of sustainability, and to the proverbial matter of interlinkages. More importantly, there is as yet no overall view of the ways in which major forms of human activities generate problems that threaten social systems and natural environments or a coherent understanding of various solutions, socio-economic and political, as well as scientific and technical.

Disagreements also persist regarding the solutions to sustainability problems, and the conditions under which one alternative might be better than another. *Mapping Sustainability* is a step in the direction of intellectual order and coherence. It involves unbundling the knowledge content, and rendering a detailed account of issues central to sustainable development.

Strategically, mapping the knowledge domain of sustainable development is intended to help organize evolving knowledge about sustainability, and to make it more accessible for agents of change in public policy, business strategy, and creative ventures. It is also intended to facilitate access to cutting-edge analysis, innovative technologies, and multidisciplinary perspectives. We also seek to expand opportunities for knowledge provision and sharing through experimenting with different forms of collaboration and take into account diverse views and perspectives.

Operationally, mapping provides a set of rules for organizing existing knowledge about sustainability in ways that are functional as well as replicable. As such, it serves as a means of enhancing our understanding and reducing barriers to sustainable development. At the same time, mapping alerts us to situations in which the solution to one problem becomes, itself, the sources of another problem.

Functionally, to the extent that the mapping initiative is effective, it provides the foundations for the design of web-based capabilities for knowledge management, networking and sharing. It also enhances our appreciation of the details surrounding this domain of human activity helps to define policy responses and practices.

1.3 Frame System for Mapping Sustainability

Clearly articulated, the framing challenge is straight-forward: how best can we apply intellectual order to a domain of knowledge which remains *ad hoc* in its nature? In this book, we frame the domain of sustainable development, formulate a basic ontology, and derive rules for indexing knowledge materials in internally consistent and structured terms.

1.3.1 Frame and Ontology

Drawing on the work of Marvin Minsky – the founding Director of MIT's Artificial Intelligence Laboratory – it is useful to think of a frame as "a sort of skeleton, something like an application form with many blanks or slots to be filled" (1986: 245). Our framing challenge is to provide the skeleton within which to fill knowledge materials pertaining to the general subject of sustainable development. In so doing, we are developing the framework for articulating the parameters of sustainable development as a knowledge domain. Moreover, as Minsky reminds us, "[f]rames are drawn from past experience and rarely fit new situations perfectly. We therefore have to learn how do adapt our frames to each particular experience" (1986: 245).

The knowledge pertaining to the sustainability domain consists of the materials that are used to fill the slots. When the frame is fully articulated, and the slots are defined in sufficient detail, we can accommodate multiple aspects of sustainable development.

This way of thinking about knowledge representation is particularly useful in new domains, where the referent is of increasing importance to an every growing community of people and of countries, but where there remain considerable uncertainties and ambiguities about the nature of the slots, and about the items that should be used to fill in the blanks. The challenge now becomes one of deriving a knowledge-representation architecture.

Earlier in this chapter we put forth our operational definition of sustainnable development, and identified its fundamental conditions. Useful as that definition may be, it is still too general a statement to serve as anything other than delineating the nature of the framing challenge. The skeleton remains to be structured and the slots remain to be defined, so that the blanks can be filled. What is now needed is a set of rules for articulating a complete frame system, one that can yield an internally consistent ontology for sustainability.

Given the origins of ontology in philosophy and epistemology, it is often easy to overlook the operational implications for knowledge representation. In the context of devising a frame system for sustainability, the term ontology refers to the detailed description of concepts and sub-concepts, as well as relationships that represent interactions among entities associated with the domain. An *ontology* is a description – like a formal specification of a program – of the concepts and relationships that can exist for an agent or a community of agents. For our purposes, given the computational objectives, the term *ontology* takes on a specific operational meaning.

Consistent with the *mapping* objectives signaled above, the goals of ontology for sustainability are conceptual, strategic, operational and functional. More specifically, for architectural purposes, we need to articulate knowledge content with sufficient specificity as to enable computational representation which, when successful, then ensures effective knowledge sharing and management. The one critical ontology rule is that of respecting internal consistency in structuring the *skeleton* and then populating the *slots* – both italicized terms due to Minsky (1986).

The frame system yields an architecture structured as a set of nested and hierarchical relationships, or individual parts and coherent wholes. In terms of core principles, the representation of sustainability is anchored in three basic principles. The first principle consists of the definition of the individual *domains* of human activity (i.e. topics or conditions at hand). The second principle involves the specification of attendant *dimensions* spanning each of the domains (i.e. problem created and types of solutions proposed). The third principle of the frame system is an accounting of the *coordinated international actions* that are designed to steer, reduce, mitigate, or otherwise manage the challenges to sustainable development through the use of multilateral policy instruments.

We now turn to the content of the domain and dimensions, and their intersection (thus addressing the first and the second principles), and then we consider the types of coordinated actions among members of the international community in response to sustainability challenges (the third framing principle).

1.3.2 Domains

The point of departure for mapping sustainability is to select the core concepts (or topics) of interest. The goal is to be indicative and inclusive, not exhaustive or definitive. We show in Table 1.1 the differentiation of domains by generic type, yielding 14 distinct, but interconnected, aspects of human activities and conditions. Simplistic as this figure might seem, it is foundational in terms of conceptual architecture. It is an essential feature of the frame system, as it meets the requirements of the first design principle, namely identifying the specific domains of human activity to be addressed throughout the mapping initiative.

***Table 1.1* Domains of sustainable development.**

Demographic domain

- Population Dynamics
- Urbanization
- Migration and Dislocation
- Consumption patterns
- Unmet basic needs

Energy and natural resource domain

- Energy use and source
- Forests and land uses
- Water uses and sources
- Agricultural and rural activities

Technology-centered domain

- Trade and Finance
- Industry and Manufacturing
- Mobility and Transport

Domains of decisions and choices

- Conflict and War
- Governance and Institutions

Note that Table 1.1 shows only the first-order differentiation of human activity, the first step in developing ontology on ontology as a foundation for computation. As we proceed, we demonstrate how a set of disaggregation (or unbundling) rules allow for considerable refinement or granularity of representation or sustainable development domains without deviating from the core principles or the rules that connect them.

Figure 1.5 shows the same domains as in Table 1.1, however the display is different, and meaning is assigned to the difference. Figuratively, each topic constitutes a *slice* of the overall domain space. As we proceed, we will show how each of these slices (of core concepts) is further differentiated in terms of content-specificity and embedded in an integrated structure of knowledge representation. We will also identify the major problems generated by domain-specific types of human activities. In other words, we are seeking to identify the modal relationships between activities and conditions, on one hand, and sustainability problems that emerge as a consequence, on the other.

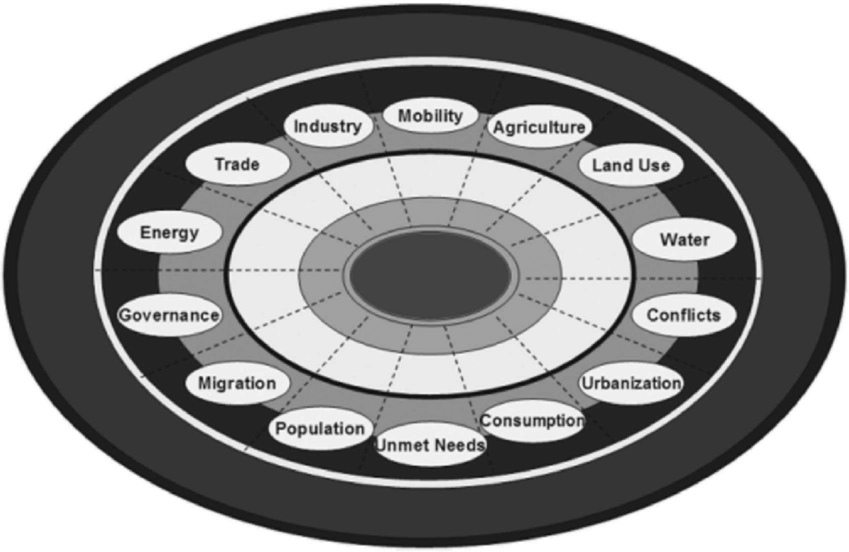

Figure 1.5 **Domains of the conceptual framework.**

Operationally, the forgoing means that we resort to the consistency factor in order to render the representation of the first principle (domains) consistent with that of the second principle (dimensions), both noted earlier. Retaining a consistency of structure across domains and dimensions allows us to build topic-specific ontology-segments that remain consistent across all topics addressed. At the same time, as we note further along, we must lift this restriction when incidents of coordinated international interactions transcend domains and dimensions. The restriction refers to the nature of the third principle, also defined earlier.

1.3.3 Dimensions

The next step is to specify the problems created by human activities that may threaten the viability of natural and/or of social systems and to delineate as specifically as possible the characteristic features of these problems. Conceptually, this means that the domains shown in Table 1.1 and in Figure 1.5 must be further disaggregated into a set of dimensions whose individual contents are customized to the realities of each domain of human activities. These dimensions are represented as a set of concentric circles, consistent with the embedded aspects of *Mapping Sustainability.*

The dimensionality issue refers to a specific design decision about select characteristics. For each of the individual domains, we seek to articulate the type of problems that are generated by human activities and conditions. Once the problems are identified, then we can take stock of the body of solutions available. In practice, the challenge of creating an ontology is to specify in some detail the contents for two broad classes of solutions. The first pertains to classes of Scientific and Technical solutions, and the second addresses Social, Economic, Political and Regulatory responses. In the context of Figure 1.5, the dimensions are depicted as *rings*, and the domains are depicted as *slices*. It is important to keep in mind that problems and solutions are dynamic, and will thus change over time. What might be regarded as a solution to one problem today may well be defined as a problem in its own right later on. Fundamental to the entire enterprise of knowledge development and representation is the expectation that the contents will change and that, under certain conditions, the underlying conceptual framework will also change. If the changes are substantial then the very fundamentals are called into question, and prospects of an entire paradigm change must then be raised.

A simplified view of the key dimensions is shown in Figure 1.6 for the 14 domains identified in Table 1.1 and signaled by the radial differentiations in Figure 1.5.

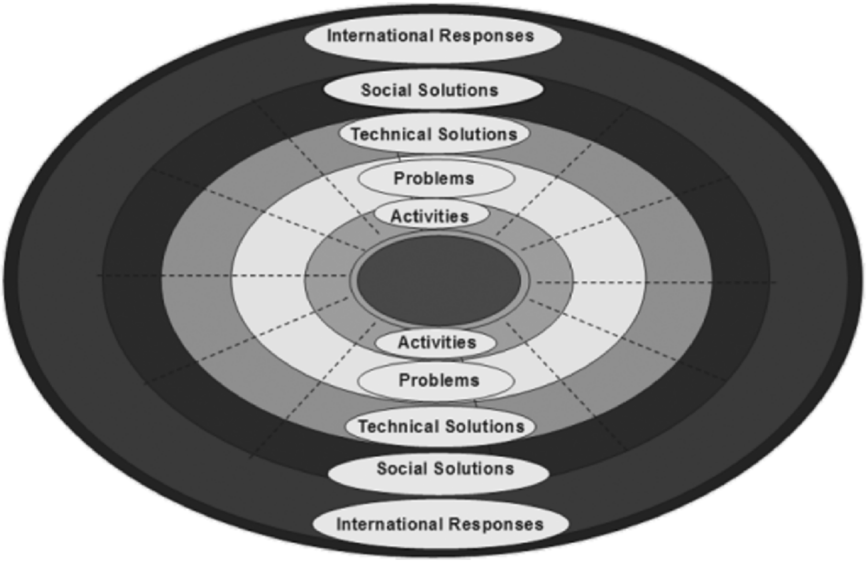

Figure 1.6 **Dimensions of the conceptual framework.**

So far, we have met the requirements of the first and the second principles for insuring a robust frame system, we now turn to issues at the intersections between domains and dimensions.

1.3.4 Intersections of Domains and Dimensions

Given the substantive coverage, the overall knowledge representation strategy can now be described in terms of domain representation and the hierarchical dimensions. Combining content around concepts in a hierarchical design yields the integrated framework, whereby each core concept (domain or topic) is extended in vertical and nested terms and thus connects domains and dimensions.[8]

With such considerations in mind, we proceed to disaggregate the knowledge contents for domains as well as dimensions of sustainability. This display is topic-specific, thus yielding 14 *ontology-contents* (or slices), which we show in Appendix A. Each topic array can be seen as representing the *table of contents* for the individual issue-areas. In other words, Appendix A shows the basic content structure in skeletal form for each of the 14 domains of human activities, thus addressing the dimensions-details as well.

Further along in this chapter we show the conceptual logic, as well as the operational logic, for representing the connectivity structure between domain and dimension – for each of the fourteen issue-areas. The connectivity properties are essential to the integrity of the knowledge-base as the essence of the nestedness lies in the intersection between domains and dimensions.

1.3.5 Coordinated International Actions

To complete the mapping initiative, we now turn to the third principle of the frame system by providing structure to the all-encompassing set of coordinated international actions designed to manage the damages and dislocations generated by human activities. In this segment of the knowledge-architecture, the contents of coordinated international as a new element in the design, namely the fifth ring.

This new feature encompasses and spans across the entire knowledge system of human activities, problems and solution types. With this move, the architecture departs from the domain-dimension structure of the nested system – whereby each domain of human activity is also characterized in terms of dimension-features. This ring is shown in Figure 1.7 and represents modal types of coordinated international actions. Parenthetically, the whitespace in the center indicates the location of Figures 1.5 and 1.6 (i.e. the slices and rings for the frame system) that meet the first and the second framing principles.

[8] The details of the nested elements are described further along.

Figure 1.7 **Global sustainability strategies.**

The deviation from the design imposed by the first and the second framing principles (slice and ring) rests on the assumption that individual forms and types of international agreements cover a range of topics or elements within and across the nested system. Recall that, jointly, these two principles help ensure consistency or congruence of knowledge representation for the core issue areas addressed in *Mapping Sustainability.* This factor is a form of fragmentation-by-necessity. At the same time, it is only such for initial organizational purposes. The radials differentiating among the various domains of human activities are presented in broken, not solid, lines – as a rather reminder of this very important precept.

In terms of content, the third principle provides internal consistency needed in order to take stock of a set of generic forms of coordinated international responses that, individually and jointly, these modalities are designed to facilitate consensus towards sustainability, e.g. *Agenda 21*, various conventions and other new development mechanisms.[9]

[9] New development mechanisms include joint implementation and clean development, among others.

1.4 The Connectivity Structure

Designed to ensure consistency in the representation of content, the knowledge strategy for *Mapping Sustainability* is structured in terms of a hierarchically nested system. At this point, we show in some detail the architecture of the nesting logic, and the ways in which the first and second principles of design for the frame system are pulled together. The same conceptual specifications hold across all 14 substantive domains pertaining to sustainability. They provide an internally consistent, subject-driven, knowledge-management strategy.[10] Linkages across subjects are facilitated by a cross-referencing system.[11]

1.4.1 Framework Elements

The elements of the overall conceptual framework in Figures 1.5 and 1.6 present a broad view of the frame system and its design scheme. At this point, we put forth the formal definition for each key term.

Slice: Domain of Core Concept. A slice is a hierarchy of elements that constitutes the content features customized for each of the individual domains.

Ring: Dimension of Problem and Solution. A ring refers to specific aspects of issues, consequences, and responses, namely, (i) types of human activities and conditions associated with each general issue area, (ii) types of problems or dysfunctions generated by such activities and conditions, (iii) technical and scientific solutions proposed to date, and (iv) the socio-economic, political, and regulatory solutions.[12]

Cell: Granular Manifestation. A cell represents distinctive micro-level knowledge items at specific intersections of slices and rings (i.e. domain and dimension).[13]

1.4.2 Linkage System

The entire frame system – the knowledge structure – is integrated through its connectivity logic which defines how different pieces of the framework are

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[10] Note again that the connectivity structure operates across first and the second frame principles, but not the third since the latter refers to actions that can target any item of slice or ring.

[11] The cross-referencing is done at the point of entry, in the Submit Site form, as discussed later in Part I.

[12] Figure 1.7 also includes an additional Ring in the system as a whole, namely that of coordinated international actions that transcend and cut across all of the domains of human activity.

[13] All of the above holds throughout the entire system structure, with the exception of the additional ring in Figure 1.7.

connected to each other and to system as a whole. This logic serves also as a mechanism to (a) guide the content-based indexing system and links the elements of the hierarchical system and (b) provides the computational protocol for knowledge management.

Accordingly, Figure 1.8 shows the nested linkages and the connectivity logic in generic form. This logic holds for each of the fourteen domains (i.e. topics, concepts, or activities). Thus, Figure 1.8 presents the generic linkage frame of the entire knowledge-base, for both conceptual as well as computational purposes.

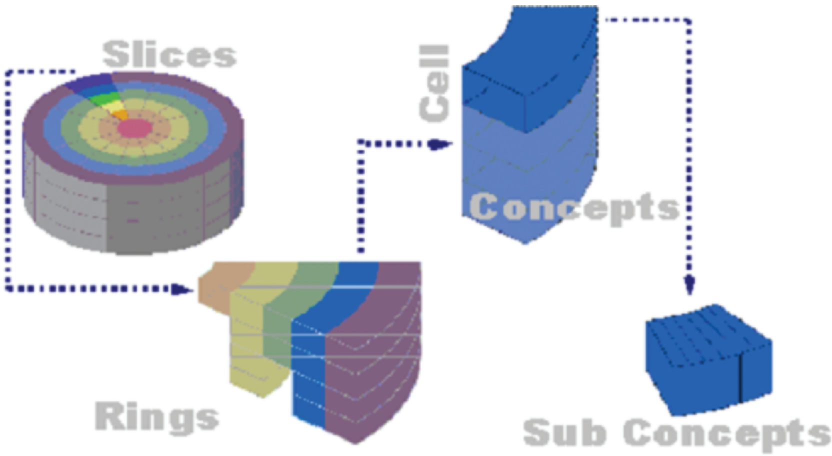


Figure 1.8 **Linkages across the conceptual framework.**

A view of the integrated frame system for domains and dimensions is thus derived by combining knowledge about the individual domains (i.e. concepts, types of human activity), with the attendant characteristics features. As to be expected, when the slots are filled – even in a first-order rendering – the display of content can be quite dense.

Figure 1.9 presents a simplified view of the knowledge-base, by that identifying the domains explicitly and noting the dimensions graphically. The multidimensionality of the conceptual frame is evident even in this aggregate representation. It is useful to note that this design is generic in the sense that it can be applied to any issue-area or problem of interest. For example, if we consider the domain of industry, we can then differentiate among different types of facets of industrial activity in considerable detail, while still adhering to the basic conceptual framework.

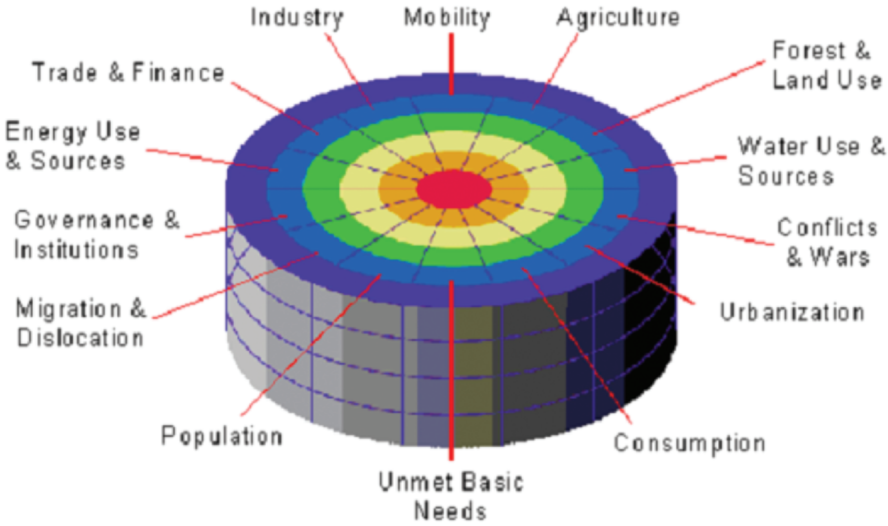


Figure 1.9 **View of domains and dimensions.**

As presented here, Figure 1.9 can accommodate any structured knowledge domain or knowledge content. This feature greatly facilitates the task of customization for meeting individual user demands for different content-representations versions.[14] The design as a whole can be modified by adding or deleting individual slices and rings.

1.5 Integrated Knowledge Content

At this point, we turn to the challenging task of content display and the representation of substance representation. The challenge lies less in the formulation of content, since it is essentially rule-derived, and instead in accommodating the constraints of the hard-copy printed page in the physical form, venue.

The display of content for the knowledge domain of sustainable development, shown in Figure 1.10 consists of the slots of the frame system, the slices and rings, filled with the appropriate content. Figure 1.10 is thus the combined representation of Figures 1.5 and 1.6 with all of the content-items integrated therein.

The purpose of Figure 1.10 is to show the derivative nature of the frame system (and its hierarchical and nested logic). Guided by the theoretical constructs noted earlier, each entry refers to a specific knowledge item at the

[14] The generic quality of this design for organizing knowledge will be demonstrated in Chapters 10 and 11.

intersection of a domain and a dimension. The elements of international relations and global accord (the fifth ring) are not represented in this view, but given the complexity of content, it does not provide the same level of granularity as the above two display methods. Earlier, we referred to Figures 1.5 and 1.6 as representing a first-order accounting of knowledge content. Put differently, this means that the display shows only the higher-level entries in the ontology, and not the derivative or detailed specifications. At this point, we turn to the representation of the knowledge system as a whole. A more detailed representation of the knowledge domain is shown in Appendix A.

1.6 The Value of *Mapping Sustainability*

Earlier in this chapter, we noted some basic reasons for engaging in mapping sustainable development as a knowledge domain. Having presented the logic, as well as the design principles of *Mapping* – addressing principles, structure, and architecture – we now turn to a fundamental query, namely, what is the value-added of this initiative?

By way of summary, we note elements of value-added due to the *Mapping* initiative.

One: *Mapping Sustainability* provides an internally consistent baseline of sustainable development. The science of sustainability is at an early stage of development; therefore this baseline consists of a systematic representation of the constitutive elements.

Two: *Mapping* is based on the application of a multidimensional ontology designed specifically to represent key aspects of the issue-area at hand, including attendant complexities and interconnections. *Mapping* provides not only an insurance against the temptation to engage in undue simplification, but more important, a systematic view of what must be taken into account when addressing any single domain or dimension.

Three: Conceived and written in English, the terms used throughout *Mapping Sustainability* are commonly understood by English speakers. The definitions of concepts is intended to interject a degree of precision in understanding, even when the subject itself can be interpreted differently by different communities of knowledge, policy, or practice.

Four: When *Mapping Sustainability* is rendered in another language, we generally assume that the various concepts are portable and that each language does in fact have a corresponding term. This assumption is simply wrong. In Arabic and in Chinese, for example, the sustainable development substantive vocabulary is not as fully developed as in English. This has required us to help formulate the equivalence for the terms and concepts in question. The result is as reliable a multilingual rendering of key elements of sustainable development as is currently possible.

Five: The ontology, in conjunction with and the companion GSSD Glossary of explanations and definitions, serves also as an indexing system to categorize e-materials of relevance with various degrees of granularity or detail.

Six: Computationally, the elements of the ontology consist of the tags that assign knowledge-content to the appropriate slot. The assignment process is an ongoing activity. To simplify, however, this means that when the assignment-to-slot is completed for an item, it is then incorporated in the overall knowledge-base.

Seven: The repository for the knowledge-base on sustainable development is an integral part of GSSD, and it is available for different types of uses. For example, some users may draw upon the materials for teaching purposes, others for public presentations, still others for knowledge development, and so on.

Eight: Since the ontology serves as a provider of topics identifiers and outlines for diverse purposes, it also serves as a mechanism for tracking changes in understanding and evolving knowledge over time. It is something of a 'net' (in the most literal sense) to help track evolving knowledge over time.

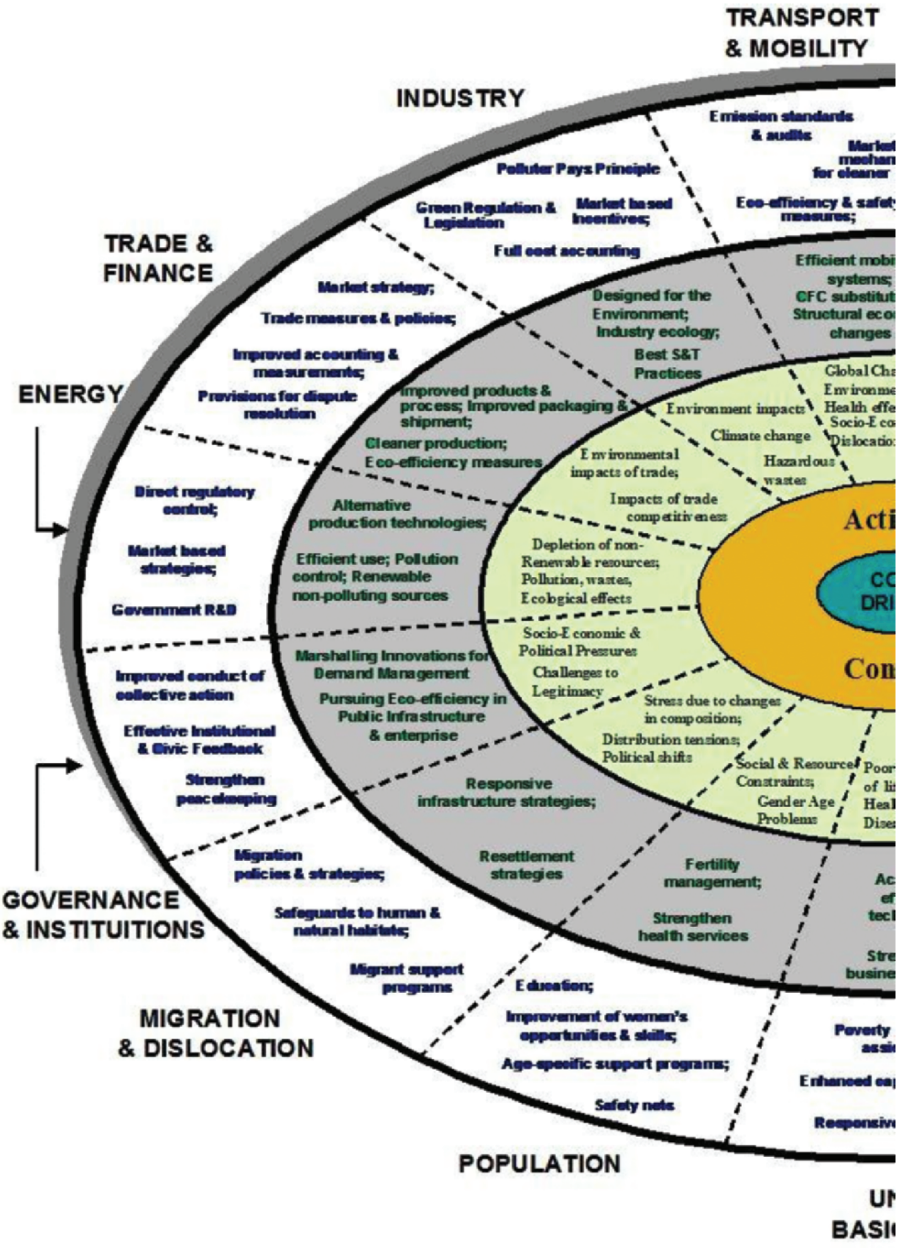
Nine: *Mapping Sustainability* provides also the knowledge platform for the provision of local content, i.e. knowledge generated at the local or various sub-national and national levels around the world. Routed through GSSD, such local knowledge represents the 'voices' of communities that are not often expressed in cyber venues that, to date, remain dominated by inputs from advanced industrial countries.

Ten: The design of *Mapping* – and its application for knowledge management – consists of the common organizing principles and represents the shared understanding that guides e-networking among a set of actors and agents converging around sustainable development as a knowledge domain.

1.7 End Note

Mapping Sustainability is the first step in the broader computational strategy for reducing e-barriers to knowledge pertaining to sustainable development. It is the foundation for generating a shared understanding of content and provides the fundamentals for engaging in e-networking to enhance both content and value of knowledge. The fundamentals of computation are predicated on advances in information technologies. And the fundamentals for reducing knowledge gaps are based on enhanced knowledge e-networking practices and strategies.

In Chapter 2 we show how *Mapping Sustainability* is transformed into a computational frame for global knowledge e-networking. We demonstrate


TRANSPORT
& MOBILITY
INDUSTRY
Emission standards
& audits
Polluter Pays Principle
Green Regulation &
Legislation
Market based
incentives;
Full cost accounting
TRADE &
FINANCE
Market strategy;
Trade measures & policies;
Improved accounting &
measurements;
Provisions for dispute
resolution
ENERGY
Designed for the
Environment;
Industry ecology;
Best S&T
Practices
Improved products &
process; Improved packaging &
shipment;
Cleaner production;
Eco-efficiency measures
Environment impacts
Climate change
Hazardous
wastes
Environmental
impacts of trade;
Impacts of trade
competitiveness
Direct regulatory
control;
Market based
strategies;
Government R&D
Alternative
production technologies;
Efficient use; Pollution
control; Renewable
non-polluting sources
Depletion of non-
Renewable resources;
Pollution, wastes,
Ecological effects
Socio-Economic &
Political Pressures
Challenges to
Legitimacy
Stress due to changes
in composition;
Distribution tensions;
Political shifts
Social & Resource
Constraints;
Gender Age
Problems
Improved conduct of
collective action
Effective Institutional
& Civic Feedback
Strengthen
peacekeeping
Marshalling Innovations for
Demand Management
Pursuing Eco-efficiency in
Public Infrastructure
& enterprise
Responsive
infrastructure strategies;
Migration
policies & strategies;
Safeguards to human &
natural habitats;
Migrant support
programs
Resettlement
strategies
Fertility
management;
Strengthen
health services
GOVERNANCE
& INSTITUITIONS
MIGRATION
& DISLOCATION
Education;
Improvement of women's
opportunities & skills;
Age-specific support programs;
Safety nets
POPULATION

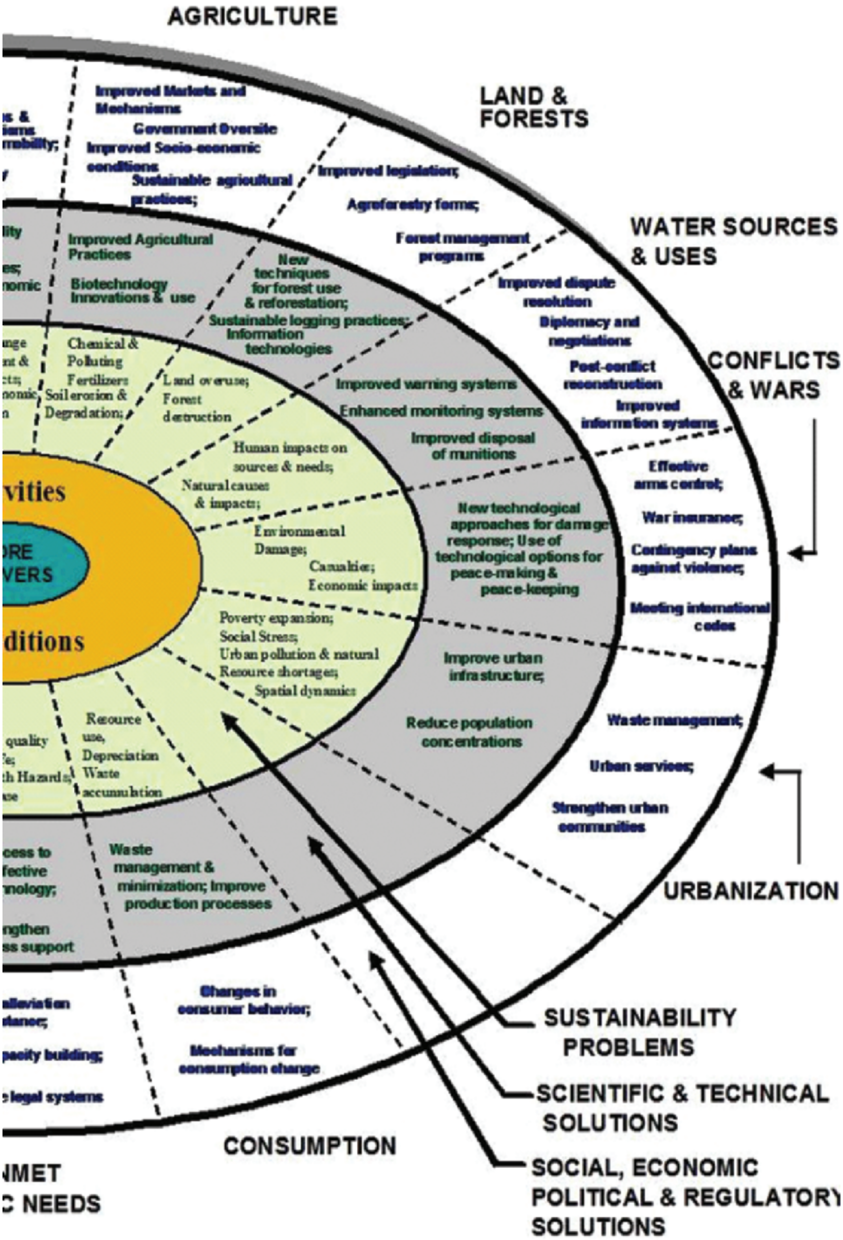


Figure 1.10 **Overview of integrated knowledge domain.**

the principles guiding computability of GSSD as an interactive web-based e-knowledge networking system, GSSD. The goal is to facilitate access to, and provision of, knowledge bearing on transitions toward sustainability. More specifically, the challenge we address is to reduce e-barriers to knowledge access, provision, sharing and distribution worldwide.

References

Alker, H. R., Jr. and Haas, P. M. (1993). The rise of global ecopolitics. (In N. Choucri (Ed.) *Global accord: environmental challenges and international responses*. Cambridge MA: MIT Press)

Boulding, K. E. (1956). *The image: knowledge and life in society* (Ann Arbor: University of Michigan Press)

Castells, M. (1996). *The rise of the network society* (London: Blackwell)

Choucri, N. (1993). Introduction: theoretical, empirical, and policy perspectives. (In N. Choucri (Ed.) *Global accord: environmental challenges and international responses.* Cambridge, MA: MIT Press)

Gourevitch, P. (1978). The second image reversed: the international sources of domestic politics. *International Organization*, 32(4), 881–912

Haas, P. M. (1989). *The fourth image reversed: epistemic communities and knowledge based bargaining as a response to uncertainty*. Delivered at the 1989 Annual Meeting of the American Political Science Association, Atlanta, GA (August 20–September 3)

Hardin, G. (1968). The tragedy of the commons. *Science,* 162, 1243–1248

Holling, C. S. (1995). Sustainability: the cross-scale dimension. (In M. Munasinghe and W. Shearer (Eds.) *Defining and measuring sustainability: the biogeophysical foundations.* Washington DC: The World Bank)

Litfin, K. T. (1998). The greening of sovereignty: an introduction. (In K. T. Liftin (Ed.) *The greening of sovereignty in world politics*. Cambridge, MA: MIT Press)

Minsky, M. (1986). *The society of mind* (New York: Simon and Schuster)

Modelski, G. (1996). Evolutionary paradigm for global politics. *International Studies Quarterly,* 40, 321–342

North, R. C. (1990). *War, peace, survival: global politics and conceptual synthesis* (Boulder, CO: Westview Press)

Ostrom, E. (1990). *Governing the commons: the evolution of institutions for collective action* (New York: Cambridge University Press)

Pollins, B. M. and Schweller, R. L. (1999). Linking the levels: the long wave and shifts in U.S. foreign policy, 1790–1993. *American Journal of Political Science,* 40(2), 431–464

Starr, C. (1997). Sustaining the human environment: the next two hundred years. (In J. H. Ausubel and H. D. Langford (Eds.) *Technological trajectories and the human environment.* Washington DC: National Academy Press)

United Nations. various years. United Nations common database (New York: United Nations)

Vitousek, P. M., Mooney, H. A., Lubchenco, J., and Melillo, J. M. (1997). Human domination of earth's ecosystems. *Science,* 277, 494–499

Waltz, K. N. (1959). *Man, the state and war.* (New York: Columbia University Press)

Waltz, K. N. (1979). *The theory of international politics* (Redding, MA: Addison Wesley Publishing)

Webster. (1976). *Webster's new collegiate dictionary* (Springfield, MA: G. & C. Merriam Co.)

Chapter 2

GLOBAL KNOWLEDGE e-NETWORKING

Identifying e-Barriers and Introducing GSSD

Nazli Choucri

Introduction

The purpose of this chapter is to show how the results of the *mapping sustainability* initiative provide the foundations for organizing the substantive materials – the knowledge content – distributed throughout a global e-networking system concerned with sustainable development. The issues addressed here are put forth as seen from the perspective of different user-types. In subsequent chapters, we will show how the architecture of the knowledge system and its conceptual foundations are utilized at the end-of-the-line, so to speak, to meet key knowledge needs and demands in different social and/or institutional contexts.

This chapter proceeds as follows: first, we identify the knowledge objectives that drive the global e-networking initiative at hand. This task presents the broad terms of reference for the book as a whole as well as the logic for its individual parts. Second, we highlight characteristic features of knowledge networking as a form e-interaction and communication, and define the key elements. Third, we turn to the computational context, noting the contributions to information technologies (IT) for transitions toward sustainable development. In so doing, we identify the key e-barriers to knowledge for sustainability, and then highlight the solution strategies we have developed in response to these barriers. Together, these factors define the boundaries of our overall research design. Fourth, we introduce the *Global System for Sustainable Development* (GSSD), a knowledge e-networking system which serves as the computational platform to incorporate the individual solutions to specific e-barriers into an integrated system. Fifth, we then focus on some key user-centered features of the system (front-stage, so to speak) and we note key operational features that reduce the e-barriers to knowledge access in various parts of the world (namely backstage properties). And finally, we

N. Choucri et al. (eds.), Mapping Sustainability: Knowledge e-Networking and the Value Chain, 29–48.

turn briefly to *who* uses GSSD, *how* it is used, and *why* those who use it choose to do so.

2.1 Knowledge Objectives and e-Networking

Issues and challenges such as these are at the frontier of current practices in knowledge management. They are also at the frontier of prevailing theory in the domain of sustainable development as well as at the frontier of cyber-space. They are especially challenging in terms of collaborative multicultural and multilingual e-networking for knowledge development purposes as well as policy making. These are all critical imperatives since we are dealing with *knowledge* and its *management,* and not with information and its observation; with *evolving* Internet resources and not with static hard copy holdings; with multiple and *decentralized sources* of knowledge generation, organization and provision, and not with the creation of centralized inputs – and all are addressed through an integrated conceptual and computational framework.

2.1.1 Knowledge Objectives

Three sets of objectives shape the implementation-side of a global knowledge e-networking system derived from mapping sustainability. As currently conceived, these objectives are driven by a vision of distributed knowledge e-networking that is framed in theoretical as well as operational terms.

First are the *scientific* goals, namely to improve the prevailing understanding of sustainability issues, contribute to the formation of a sustainability model, and facilitate access to evolving cutting edge scientific and technical information, applications and innovations.

Second are matters of *e-participation* and *outreach*, specifically helping to generate, support, and maintain an integrated and adaptive perspective on sustainability issues at all levels of development, and to enable better voicing of multiple views and diverse perspectives from all parts of the world.

Third are the *policy-centered* goals at all levels. Nationally, the policy-related purpose is to engage in assessment of progress in implementation of international initiatives, as framed for example in *Agenda 21*. Internationally, the main goal is to facilitate international e-collaboration, in large part by contributing to the reduction of e-barriers to pertaining to sustainability and enhance modalities for e-networking.

Framed thus, these knowledge-related objectives are both general in scope and specific in applications. They are compelling as well as necessary if we are to take seriously the challenge of developing knowledge-based trajectories toward sustainability. Individually and jointly, these goals frame essential tasks for the international community as a whole; they are part of a basic must-do package, the contents and details of which will be addressed further along.

2.1.2 Knowledge e-Networking

Knowledge networking involves active participation by the members (or users) of the network. Based on our actual practice, empirical strategies, and operations on a global scale, we define the properties of effective e-knowledge networking as:

> A computer-assisted organized system of discrete actors (a) endowed with knowledge producing capacity, (b) combined through the use of common organizing principles, (c) retaining their individual autonomy, such that (d) networking enhances the value of knowledge to the actors and, accordingly, (e) the stock of knowledge is further expanded.[1]

Jointly these seemingly incompatible properties generate patterns of interaction, which then create multiplier effects throughout the entire knowledge system. At each point, there could be barriers or impediments, but there could also be enabling factors.[2] In select chapters of Part II in this book, other definitions are put forth. However, they are all consistent with this basic statement.

In practice, effective knowledge e-networking facilitates two mutually reinforcing outcomes: the *globalization* of knowledge via greater diffusion, and the *localization* of knowledge via representation of distinct local technical and linguistic features. In both contexts, networking is a *critical enabler* for harnessing the value of knowledge (cross border, cultures, disciplines, etc.) and transforming knowledge into practical applications or implementations. Here, of course, there is the presumption of added value associated with knowledge e-networking.

The important point is that the diffusion of knowledge networking makes it functionally possible to engage in multidirectional and multiparty interactions (i.e. top-down, as well as bottom-up). It facilitates the flow of knowledge generated at various levels in the social order, both within and across different communities. Moreover, access to interactive knowledge networking empowers stakeholder groups to express their preferences and make explicit their inputs into decisions, while giving decision-makers access to multiple

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[1] I am grateful to Steven Millman and Gerard McHugh for insights into the formulation of this definition. See Choucri, McHugh and Millman (1999).

[2] Of relevance here is Strogatz (2001) on the subject of exploring complex networks (p. 268). To the answer for the question: "why is network anatomy so important to characterize?", Strogatz responds: "Because structure always affects function."

stakeholder communities. None of this assumes that all e-interactions are unrestricted, that filters and censorship do not exist, or that governments are not intervening in e-processes. e-Networking venues may provide new empowerment opportunities – for everyone and everywhere – that were not available earlier.

While networking in general, and knowledge networking in particular, are important for public and private enterprises, the evidence remains to be codified systematically. There is a large literature on these issues, but a limited amount of empirical evidence, and an even more limited amount of empirical evidence in the domain of sustainable development. Later on, in Part III, we address these issues in greater detail for the firm, for international corporations, and for extended enterprises. Here we highlight only the tip of the proverbial iceberg.

One inquiry is particularly noteworthy. In a recent study of fifty enterprises in developing countries, Wheeler et al. (2005) found that informal networks – including business, not-for-profit organizations, and various community-based groups – play a large role in performance, especially in relation to formal networks and established institutional mechanisms. Distributed in Africa, Latin America, Asia, and worldwide, these enterprises span a range of different economic sectors. These include agribusiness, energy, financial services, Internet and communications technology, manufacturing, and others. These cases are pre-selected as a sample of 'self-reliant' endeavors that arises with and without association with high level or multinational corporations. While sustainable local enterprises of this sort create value, what is important here that the actors are united by a shared view of "what is valuable" and this view is fundamental to their success. Even more important, however, is the related finding that networks allow for "the idea that members may define value in different ways" (Wheeler et al., 2005: 38). Noteworthy in this context is the value attributed to tangible as well as non-tangible resources and assets.

In this connection, we posit that *networking* is the operational mechanism for enabling the value of knowledge through the diffusion of its content The term *new knowledge* refers to the emergent demand for knowledge about matters that were not previously salient, on the one hand, and also implies the recognition that prevailing knowledge about salient matters is no longer as useful or relevant as previously thought, on the other.

This brings us once again to knowledge as an input into economic activity, a source of value added and a domain of understanding in its own right. The *content* of knowledge constitutes the utility of interest to us. The provision of, and access to, knowledge can amount to a major source of co advantage in non-commercial contexts. In addition, however, we need to consider *conduit* (the infrastructures and related facilities required for Internet access) as well as *capacity* (the ability to utilize e-functionalities). These are critical features that bear directly on the computational context for the challenges at hand.

2.2 Identifying E-Barriers

So far, we have focused on conceptual and knowledge-related issues – not on operational ones. In Chapter 1, we presented the potential gains from mapping. We now address the transmission mechanisms, and how knowledge flows through the conduits, made possible by advances in Information technology.

2.2.1 Synergy of IT and Sustainability

Almost everyone agrees that innovations in IT somehow contribute to growth, but there is considerable disagreement about the nature of the evidence and the ways in which those contributions make their way through the society and economy. Recent studies showing the increasing knowledge intensity of economic activities in almost all of the industrial countries contributed to an accelerated interest in e-venues for growth in the developing countries. National and international institutions alike appear to be focusing on the e-potentials for growth in private as well as public sectors, and almost every developing country is now mounting a national IT development plan.

The World Summit on Information Society (WSIS) placed IT-related issues at the center of global politics.[3] So, too, for every argument one finds about IT supporting democracy and participation there is a counterargument, namely that IT enables governments to impose, control, or limit access to the Internet. Nonetheless, the availability of cyber venues clearly increases rather than decreases to the retrieval of information, the availability of choice, and the potentials for individual as well as group 'voicing' of views and preferences.

It was John Seely Brown and Paul Duguid (2000) who first drew attention to the potential contributions of information technology for achieving sustainable development. By focusing on four specific functions in the operations of IT – namely, *de-specialization*, *de-centralization*, *de-massification*, *and de-materialization* – the relevance to sustainable development becomes more evident. In principle, therefore, IT constitutes one class of technologies that can improve rather than impede the quest for sustainable development. Some other, second order, contributions are often cited, namely the possibility of substitution functions (such as shifting from physical transformation to IT-based communication) or reducing key disconnects (notably

[3] See Allenby (2001) for one of the earliest discussions of the mutually reinforcing relationships of IT and sustainable development.

structural and policy gaps). Common among such disconnects are, for example, those between information use and the value of information re-use; between stakeholders and government; or between formal plans and actual implementation.

At the same time, there is a growing literature pointing to the downside of increased use of IT, ranging from concerns about the nature of the content that is being transmitted, or the service that is being undertaken, or the impacts that either of these might have on the user. There are also are questions about the precise amount of energy saved in due to the deployment of information technology for meeting social needs. Then, too, despite the many contributions to economic performance and the increased dependence of the global economy on knowledge products and processes, it comes as no surprise that fundamental disparities in cyber-access persist and that powerful e-barriers to knowledge access remain in place.

2.2.2 e-Barriers and Solution Strategies

Of the many observable e-barriers that impede transitions toward development, six sets are especially compelling. Devising strategies for their resolution amounts to a major challenge, one that is addressed throughout Part I of this book.

First is the range of conceptual ambiguities in the knowledge domain itself. The complexity of sustainability is demonstrated in research and policy circles, as is he diversity of views and definitions generate a range of contentions surrounding both the concept and its uses for research, policy, or strategy. By *mapping sustainability*, we presented a conceptual framework and ontology to guide our understanding of the overall issues and of their constituent elements to the extent feasible – in order to help organize existing knowledge pertaining to the broad domain of sustainable development.

Second is the explosion of information about sustainability. This explosion is giving rise to access problems and attendant difficulties of selecting relevant materials on any specific set of issues. The dilemma is basically one of managing *information flow* (or overflow), on the Internet where quantity dominates and quality is sacrificed. Our solution is to put in place a knowledge provision process that includes with quality controls and reality checks.

Third is the set of powerful infrastructure constraints that impede access to the Internet, fostering digital differences between rich and poor. Such digital differences clearly restrain sustainable development. Our solution is to establish a set of operational *partnership with knowledge providers* in order to generate a greater variety of potential knowledge for users of e-materials. This solution involves a mirror-site strategy, so that individuals are able to access knowledge-systems and knowledge-bases by connecting to servers closer to them.

Fourth is the reality that the Internet – a largely English-speaking venue in a world that is non-English speaking – generates systematic disparities in assigning meaning to e-materials. Our solution to this very real problem is to engage in multilingual knowledge e-*networking* in order to enable users and providers from various parts of the world to express themselves in appropriate language, idiom and terms.

Fifth is the set of strong biases in knowledge-provision. Given structural impediments to Internet access and the dominance of English, e-materials and resources are highly concentrated at both source (input) and retrieval (output). This means that the voices heard are mainly those from the 'north' while voices of the 'south' remain relatively silent. The solution we have developed to address this problem is the creation of *workflow strategy for content provision worldwide* based on the dual principles of global collaboration, on the one hand, and protection of individual and institutional autonomy, on the other.

Sixth, and finally, is the set of usual impediments due to cost and price. The economics of Internet access make it difficult for most people, in most places, to participate in the new cyber domain, thus compounding the implications of variability in infrastructure conditions throughout the world. Our solution strategy consists of a *pragmatic in-kind cost-sharing approach* that reduces the burdens borne by collaborating partners.

Each of these types of e-barriers is significant in its own right. Jointly, they create powerful obstacles to the effective knowledge e-access. By the same token, each of the solution strategies noted above contributes to the reduction of attendant impediments. Together, they enhance e-knowledge retrieval and provision and, by extension, strengthen the overall capacities of diverse users.

2.3 Global System for Sustainable Development

The computational strategy designed to address the six sets of e-barriers is embedded in the architecture and workflow of GSSD. More specifically, GSSD is an adaptive and evolving global knowledge system dedicated to sustainable development. A set of knowledge management, provision, search, retrieval, and navigation functionalities allow users to customize their knowledge-inputs and/or to tailor specific retrieval queries over the GSSD knowledge-base.

In partnership with collaborating institutions and colleagues worldwide, GSSD seeks to focus on selective knowledge of recognized quality supported by institutions or organizations that serve as certified knowledge providers. In other words, one of the key functions of the GSSD knowledge-base is to make it easier for users to locate knowledge of interest and, by the same token, to facilitate their provision of knowledge into global networks. The following chapters turn to these issues in greater detail. Here we note only the key features of GSSD in the most general terms.

2.3.1 Mission and Objectives

Computationally, GSSD is designed to:

(1) make evolving knowledge about sustainability more accessible to agents of change for public policy, business strategy; and creative ventures by facilitating access to cutting-edge analysis, innovative technologies, and multidisciplinary knowledge;
(2) facilitate knowledge sharing through customized search engines, quality-controlled knowledge retrieval tools, non-diverse multilingual capacities, and decision-tools to identify options available in technologies, policies, and strategies;
(3) provide theoretical context and framework for use of advanced information and communication technologies to support sustainable development by strengthening capacities for knowledge, decision, policy and practice.

2.3.2 GSSD Functional Capabilities

GSSD provides seven types of e-capabilities (or functionalities) that constitute an integrated and evolving knowledge system. Simply put, GSSD can be seen as:

- a strategy for integrating and organizing knowledge related to the domain of sustainable development, in multidimensional, multisector, and international terms;
- an integrated and wide-ranging international as well as multidisciplinary knowledge-base on sustainable development;
- a method to represent this knowledge by a plurality of interrelated concepts, and interrelationships that are organized in internally consistent and hierarchical form;
- a set of selection and retrieval functionalities consisting of search engines and browsers which operate over the system's quality-controlled knowledge-base;
- enhanced capabilities enabling alternative multilingual knowledge provisions, search, and navigation venues;
- a workflow consisting of synchronization and replication providing a 'cloning' process for all mirror sites;

- a platform for housing reports on new and innovative approaches to the management of sustainability at all levels and in all contexts.

These functional capabilities are integrated in a computational system. The system itself is anchored in a set of human–machine relationships, including material features, physical properties, human operators and management skills.

2.3.3 GSSD Physical Structure

A view of the human–machine features of the system is useful at this point. Figure 2.1 shows the raw building blocks that enable the key functionalities. It is often difficult to envisage *who* does *what* and *how* and *when* as we refer to the functionalities of any computational system. Since GSSD operates as a network of networks and can only be implemented as a set of mirror sites in collaboration with partners and institutions in different locations, the elements in Figure 2.1 are intended to convey the physical requirements for e-networking at each and every one of the mirror sites, in each and every location. This feature is a central to our overall strategy for 'leveling the playing field.'

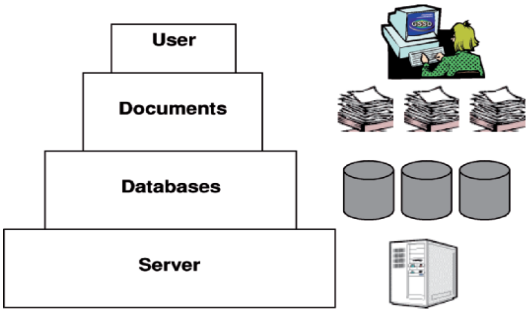

Figure 2.1 **Raw building blocks of GSSD.**

2.4 GSSD e-Networking Functionalities

In order to provide a more informative view of GSSD functions we use an integrative visual representation, presented in Figure 2.2. The remainder of this chapter reviews the functions available to a user by organizing this discussion around a multiple screen view. At the center of Figure 2.2 is the

GSSD English language home page.[4] Each of the individual screen views can be called via the select buttons.

Figure 2.2 **Multiple screen view of key GSSD functions.**

The diversity of functionalities provided – to be reviewed in some detail below – reflects not only the features of the system as a whole, but far more important, the strategy of seeking to respond to the needs of different types of users. Alternatively, one may envisage the same individual user seeking to access a range of different functionalities the specific requirements at the time.

While the intellectual value of GSSD clearly lies in its knowledge-base and domain content, the operational value added is due to the multidimensional perspective available to the user in any given issue. Of relevance in the following discussion is not so much *what* one sees if one opens the site, but rather *why* one sees the presented material, and *what else* is available by navigating through the system.

[4] As we note elsewhere, access to the English Language homepage is undertaken via the GSSD system home page. In the example, the user has located the home page and has selected 'English' as the language in the mirror site closest to him or her.

2.4.1 Overview and Guide to System Functions

A brief note on the separate views in Figure 2.2 provides some orientation for the remainder of this section. Starting from center-left and moving clockwise, we begin with *Using GSSD* that covers in more condensed and short cut fashion some of the most important conceptual issues addressed critical to the domain of sustainability. Here we define what is 'sustainable development,' and point to the core concepts and their constitutive elements, the organization of the knowledge-base, the search options and functions, as well as other features of the site.

Search takes the user (or reader) to the options available for navigation and retrieval, as well as browsing over the GSSD knowledge-base.

What's New is used periodically for sharing materials of special relevance for various uses and users.

Reports points to select papers and research reports generated by the GSSD researchers and collaborators as a means of reducing the gap between the availability of new research and results, and their diffusion and transmission to others.

Submit Site provides the mechanism for knowledge provision, indexing, cross-referencing and housing in the system's knowledge-base. *Submit Site* and *Search* are companion functions – connecting knowledge provision and providers (supply) with knowledge uses and users (demand).

Contact Us is designed to do precisely that – to facilitate communication and exchange. It also maintains a record of individual and institutional contributors and collaborations over time.

Given the rapidly changing nature of content, technology, and strategic interests, this record provides a view of the GSSD initiative since its inception in terms of a history as well as sociology of knowledge

2.4.2 Using GSSD

This segment highlights the conceptual, theoretical, and functional features of GSSD. It can be viewed on a stand-alone basis as well as a pointer to other sections of the site and other functions. It is the core of the system's intellectual backbone or nerve structure. A screen view of *Using GSSD* is in Figure 2.3. Again, the figure is largely for recognition purposes.

To borrow a notable vision from the late Karl W. Deutsch's famous book, *The Nerves of Government* (1963), it is fair to say that *Using GSSD* provides viewers, readers, and users with a guide to the substantive and operational nerves of the system. From the user perspective, the sections on *Introduction, GSSD Function and Architecture,* and *Guide to Core Concepts* are perhaps among the most substantive in terms of showing how the frame

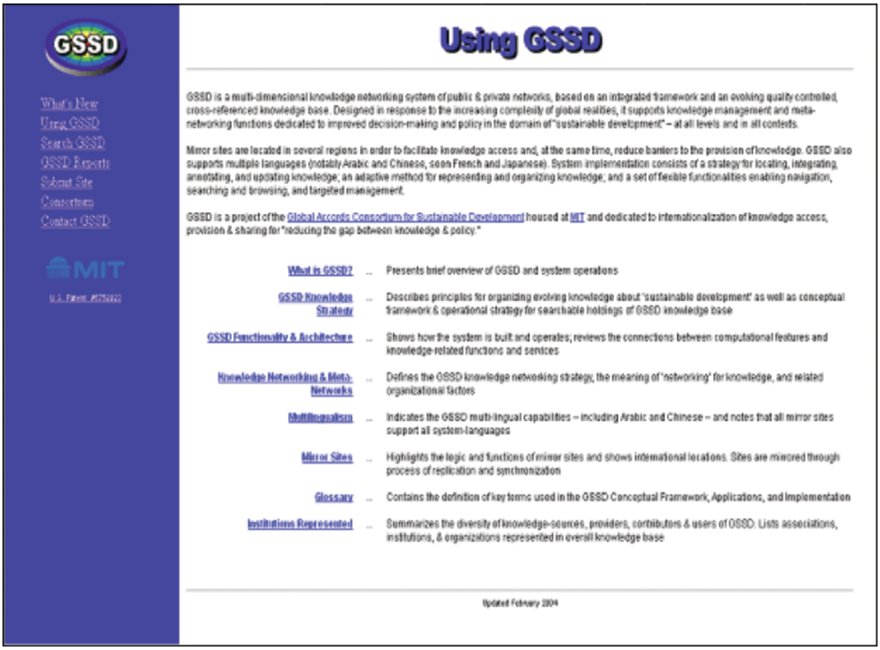

Figure 2.3 **Screen view of *Using GSSD.***

system of mapping sustainability, developed in Chapter 1, serves as the intellectual structure for knowledge e-representation and e-organization. In other words, these site-segments focus on the knowledge-domain of the system. It notes to the user why the subject of sustainable development is important at this point in time, and what are its theoretical implications and contributions.

Much of the actual applications of the foregoing for purposes of identifying, using or contributing to the rapidly growing Internet resources bearing on sustainability – most broadly defined – is summarized in *GSSD Functionality and Architecture.* The *Guide to Core Concepts* essentially consists of the ontology for the knowledge domain. It is reproduced in Appendix A to this book. The static-format of knowledge profiling – the detailed contents for each of the fourteen topics or slices, organized issues or rings, as well as cells, concepts, and sub-concepts – is used operationally as the indexing mechanism for populating the e-knowledge materials on sustainable development. It is also used for interactively for purposes of knowledge provision, search, retrieval, and other system queries.

More specifically, there are two major contributions derived from the *Guide to Core Concepts*. First, we provide a detailed knowledge standard for indexing of the contents of each of the fourteen slices (essentially a subject profile which represents the elements in the ontology). Second is to use this indexing standard or convention in order to (a) search for relevant Internet resources as potential candidates for inclusion in the GSSD knowledge-base; (b) provide a standardized method for referring to, and reflecting, the contents of selected resources; and (c) enable systematic cross-referencing across topics that are usually treated in disparate or unconnected contexts.

Jointly, these factors constitute the overall standards for addressing multidisciplinary knowledge with diverse forms of knowledge representation. Overall however, on strictly intellectual grounds, the most powerful source of value-added is the knowledge-domain ontology for sustainable development.

2.4.3 Search GSSD

The retrieval of knowledge from the GSSD repository can be done in a content driven manner. For example, for the user who wishes to use GSSD largely as a selective cyber-library, *Search GSSD* puts forth a number of strategies and options, as well as information about the conceptual framework, the indexing system, abstracting procedures and so on. The screen views here are seen from the reader's or user's perspective. He or she may not wish to know the details pertaining to conceptual issues or technical matters, so the bare minimum is covered to enable educated usage.

Users who call upon *Search GSSD* may have a wide range of interests and motivations.[5] They often range from highly focused and knowledgeable in their own domain, seeking to explore adjacent domains of sustainability, on the one hand, to those that have broader interests and use the search options for exploratory or experimental purposes – and possibly every variation thereof. To facilitate any knowledge-driven search process, it is helpful to have access to alternative options with different degrees of specificity and different extent of conceptual guidance. Figure 2.4 shows the basic screen view of the first order options. Again, the view is for recognition purposes.

Depicted in this figure from left to right are the Text Search (available in Simple or Advanced forms), All Holdings (spanning the entire knowledge-base), Industry Holdings (referring to a customized knowledge-base focusing on industrial sectors of economic activity, and the search over the *Alliance for Global Sustainability* (AGS) materials. With the exception of the *Text Search*, the other options are all graphical in form.

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[5] Parenthetically, recalling Figure 2.2, here we note that the Consortium Button links to the institutions and collaborators that were instrumental to the development and implementation of GSSD throughout its early experiments and pilot phase. Consisting of governmental institutions, corporations, research foundations, and academic institutions, its informal core constituted the founders and core contributors of GSSD, including the Global Environment Facility, MISTRA (Sweden), AT&T, Xerox, Sony Environment Center (Europe), and others.

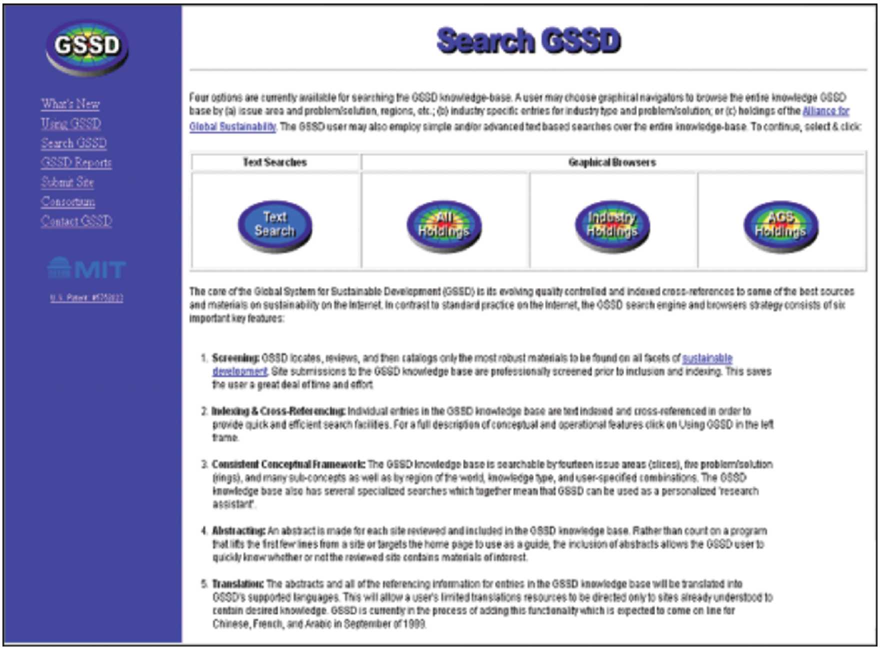

Figure 2.4 **Screen view of** ***Search GSSD*****.**

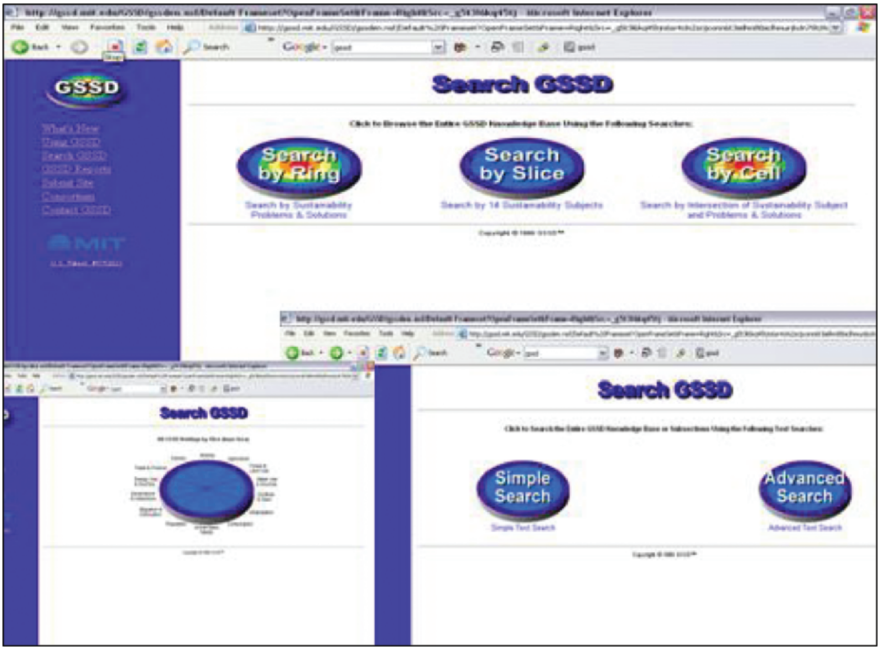

Figure 2.5 **Screen view of more detailed graphical browsers and search options.**

An added view of the search options is represented in Figure 2.5, derived from a combined screen shot. The top part of the figure shows which concepts-driven search, that is, by *slice* (domain), *ring* (dimension) and *cell* (concept).[6] These options are graphical in nature, used as browsers, and generally applied to *All Holdings* (unless specified differently by the user). The lower segment of this combined screen view shows the dedicated search for industry holdings on the left, the two text-based searches on the right.

Turning briefly to *Advanced Text* search, Figure 2.6 shows a screen view of the entire mode as the user scrolls down to the items desired. It individual interest, search style, or specific needs tend to be particularistic. For illustrative purposes, we show an example of the knowledge-base queried.

In this illustrative case, we are interested in exploring the database for *Conflict and War. A* couple of moves may provide direct access to materials required. By selecting the Conflict and War slice, fusing *All Holdings* for instance, and the focusing on the 'sustainability problem' ring – we are now doing a slice/ring search.

The following type of results are returned: first a listing of all returns that meet this *general* slice/ring query,' with a brief identification of relevant concepts; then if the user selects the second item on that list, for example, the appropriate *Abstract* is returned. If the abstract is of interest to the user, then the next step is for the user to click directly on the url of the original site itself. At this point, the user has obtained a considerable amount of information about the nature of the relevant e-resources, in both general and specific terms.

Figure 2.7 shows a screen view of the hypothetical retrieval in response to a user query. By clicking on the noted url, the user is directed to the original source.

2.4.4 Submit Site

Given that the knowledge-base for the sustainability domain is evolving, as well as is distributed and dynamic, facilities must be available for submission and quality control of selected material into the knowledge repository. *Submit Site* enables web-based inputs of knowledge-content. The operational protocol (facilitates cross-indexing and cross referencing when *Search GSSD* is called upon. It is the conjunction of *Submit Site* and *Search GSSD* that provides the functionality for the interactive knowledge-base site in ways that directly reflect the user's needs.[7]

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[6] The graphical browsers are designed to follow the GSSD conceptual framework. The *Guide to Core Concepts* provides a useful reminder of the content representation for the knowledge-base.

[7] By referring to the knowledge-base as a cyber-library, we use a conventional idiom to convey non-conventional functions.

Figure 2.6 **Screen view of *Advanced Text Search*.**

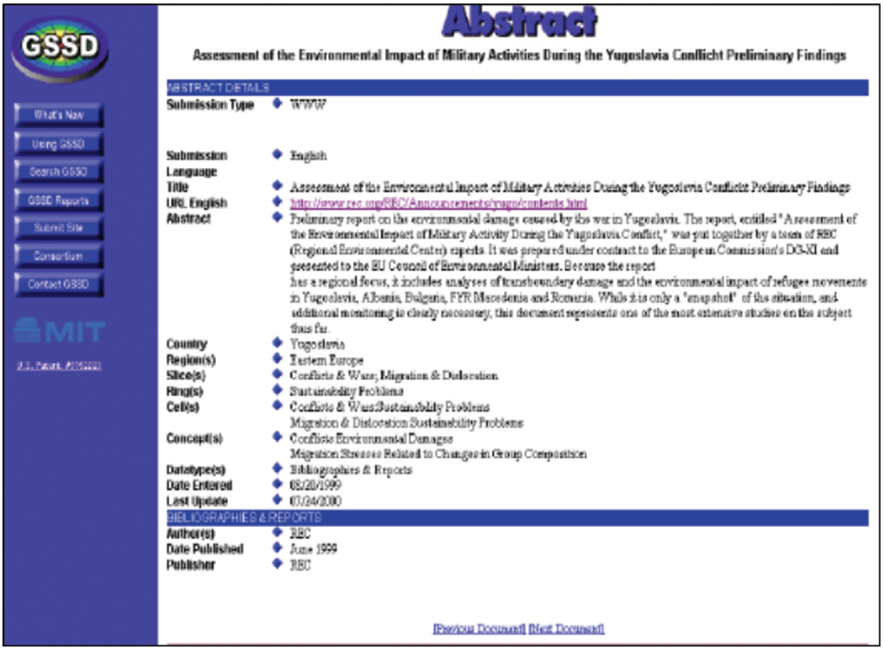

Figure 2.7 **Screen view of *Advanced Text Search Result* (example).**

2.4.5 Reports

Reports points to the new knowledge and research developments of the GSSD team, its collaborators, and their related ongoing projects. Central among these is the MIT Press Series on *Global Environmental Accords: Sustainability and Institutional Innovation.* This series consists of the most innovative research on environment and sustainability in the social sciences. In many ways, it provides the intellectual correlates strengthened by the contents of the *Series* supports as well as by ongoing research initiatives associated with the entire GSSD enterprise. As such, the knowledge-base is enhanced a regular basis.

The preview of new research undertaken within the broad GSSD context is found in *Research* and in *Science, Technology & Policy.* These are mainly pre-publications reports or phases of ongoing research, and are available to interested GSSD users.

2.5 e-Knowledge Uses and Users

Who uses a global e-knowledge networking system like GSSD? Why and how? Simple as these questions might seem, the answers are somewhat more complex. There are multiple *user-types* with different *goals and motivations* and often using different parts of the system, hence different *system targets*. At the most general level, there are four generic user-types stand out: (a) access users for search, retrieval, or content-related purposes; (b) input users for provision of the knowledge-base; (c) system-wide users who are essentially partners in the global initiative; and (d) co-developers who are users motivated by the challenge of improving performance and creating new functionalities.

2.5.1 Access Users

Professional access-users come from several very different constituencies, each with different goals and priorities, as well as demands and requirements. Among these user-types are (i) researchers, educators and students who use GSSD largely as a cyber library, drawing on search and browse options; (ii) individuals in the public sector, at national, international, inter-governmental levels, who are interested in, or have responsibilities for, program development, policy formulation, or stakeholder assessments, for example, and consult GSSD for the cross-referencing, indexing or conceptual structures, as well as for its Reports; (iii) decision-makers, i.e. persons who are responsible for formulating action-strategies or making choices about policy directions and trajectories, in both the private and public sectors; (iv) policy leaders, for agenda setting, consensus-building – beyond matters of stakeholder representation – in diverse institutional contexts; (v) professional associations interested in or connected with any of the topics (slices) or issues (rings); and (vi) any of the above who are GSSD current collaborators on theory, content, policy, or practice.

2.5.2 Inputs Users

This set of users consists principally of knowledge providers. They are the participants in and the collaborators for maintaining and improving the evolving knowledge-base. Their principle usage is *Submit site.* They may be known provider, or anonymous web users. They may be one time input users, or multiple time users. *Submit Site* is often shaped by their own concerns following visits to *Search GSSD.* In essence, these are knowledge providers, who seek to use the system to diffuse their knowledge-base, data, information, theory, policy positions and the like. While they do follow the basic *Submit Site* directives into the knowledge-base, they cannot be providers for the GSSD *Reports* section.

2.5.3 System-Wide Users

In the most general sense, system-wide users are (a) mirror site administrators and staff; (b) content participants in GSSD multilingual operations; or (c) managers of local content provision. Chapters 3 and 4 address the organizational and technical requirements associated with system-wide users.

2.5.4 Development Users

Cumbersome as this designation might be, it covers some specific roles and functions pertaining to extension of knowledge management capabilities, inclusion of new languages, adding operational efficiencies, and a range of activities that can best be labeled as frontiers issues. A particular variant of co-development is reflected by system developers who use the intellectual architecture of GSSD as a standard and platform for their own products, which may be distributed subsequently through GSSD. There are also cases where the basic conceptual framework appears to be used by others strictly for purposes of organizing and communicating their own materials.

2.5.5 Partners and Partnerships

By definition, distributed knowledge management involves some degree of collaboration on a worldwide basis. Such collaboration requires a particularly diverse set of partners, in order to represent different stakeholders in the global system, at different levels of development. The GSSD collaborators are homogenous. They are nearly as diverse as diverse as the configuration of the international community.

For the most part, the partners consist of different user-types (as summarized above), with special contributions, requirements, and responsibilities. In general, however, they are all interested in exchanging information, data and knowledge, exploring common problems encountered in Internet-based information management, anticipating evolving directions in technology and applications, and enhancing ways of expanding GSSD abilities and functions to meet the needs of diverse users which have different demands.

The common goal shared by GSSD partners is to address innovative responses to sustainability challenges – at all levels of development, in all parts of the world. They seek to provide multiple forms of networking facilities across stakeholder communities to help identify innovative approaches, enabling technologies, as well as new institutional, financial and regulatory mechanisms for meeting sustainability challenges that confront us all, in both rich and poor countries. Four of the chapters in Part II are devoted to the challenges of e-partnering.

2.6 Conclusion

This chapter focuses on the other side of *Mapping*, namely the transformation of a knowledge frame into a computational system for the purpose of facilitating access of knowledge about sustainable development. At the same time, however, we fully appreciate the powerful barriers that impede access to the Internet for users in many parts of the world. Aside from matters of censorship, government control, or other politically induced impediments, there are notable e-barriers of a structural nature.

Accordingly, in this chapter we address the characteristics of six sets of barriers, first by highlighting our solution strategies. The computational aspects of the solution-strategy are designed in an integrated form and implemented via GSSD. By way of illustrating the basic GSSD functionalities we presented a multiscreen to help guide a simplified tour of its operations.

Against this background, Chapter 3 focuses on the development and application of a global workflow strategy customized specifically for multilingual knowledge content. The work flow represents the collaborative process in practice. Accordingly, we signal the steps that each partner takes in order to generate an integrated, distributed, multilingual knowledge e-networking system. We consider some key user-centered features of the system and note key operational features that reduce the e-barriers highlighted earlier. In this way, we address the front-stage as well as the backstage properties of the system. In Part II we focus on the institutional and organizational innovations that have been made in order to routines' the workflow among the e-partners (Chapter 5), and reflect on the same issues as seen by the partners themselves (Chapter 7). The juxtaposition of views and experiences itself is revealing as well as informative.

References

Allenby, B. R. (2001). The information revolution and sustainability: mutually reinforcing dimensions of the human future. (In B. R. Allenby, W. D. Compton, D. J. Richards (Eds.) *Information Systems and the Environment*. Washington D.C.: National Academy Press)

Brown, J. S. and Duguid, P. (2000). Th*e social life of information* (Cambridge, MA: Harvard Business School Press)

Choucri, N., McHugh, G. and Millman, S. R. L. (1999). Defining knowledge networking. *GSSD-MIT Working Papers Series*.

Deutsch, K. W. (1963). *The nerves of government* (New York: The Free Press of Glencoe)

Strogatz, S. H. (2001). Exploring complex networks. *Nature*, 410, 268–276.

Wheeler, D. K., McKague, K., Thomson, J., Davies, R., Meddaye, J. and Prada, M. (2005). Creating sustainable local enterprise networks. *MIT Sloan Management Review*, Fall, 33–40.

Chapter 3

GLOBAL WORKFLOW STRATEGY

Creating and Managing Multilingual Knowledge e-Content

Nazli Choucri, Farnaz Haghseta, and Toufic Mezher

Introduction

In Chapter 2, we reviewed the design and implementation of GSSD, a knowledge e-networking system focusing on transitions toward sustainable development. Central to this effort are defining the knowledge-objectives, delineating the logic for knowledge e-networking, identifying critical e-barriers and designing solution strategies to help reduce structural impediments to knowledge access.

Operational Aspects of e-Collaboration

In this chapter we extend the collaborative strategy from knowledge e-networking activities, *per se* and examine the fundamentals of creating and managing a distributed global system. In so doing, we address conceptual, computational, and other implementation aspects of distributed e-networking across languages, regions, and cultures.

Given that our major objectives are to engage in and expand diverse forms of international collaboration around knowledge management and networking, GSSD seeks to help improve our understanding of the challenges and opportunities for sustainability. While the application pertains to sustainability, the connectivity issues are generic in nature, as are the complexities of international collaboration and the management of distributed knowledge systems.

The overarching challenge consists of the creation, maintenance, and management of a multilingual knowledge-base. In other words, the challenge involves defining the overall strategy, the technical requirements, and the management and organizational aspects of the e-networking process. The challenge is also evaluating a work-in-progress as we learn from earlier

N. Choucri et al. (eds.), Mapping Sustainability: Knowledge e-Networking and the Value Chain, 49–66.

experience, and seek to adapt, adjust, and otherwise enhance overall e-performance and collaboration.

More specifically, we highlight four anchors for global e-collaboration. First is the *provision of knowledge* in terms of content-submission to the knowledge-base. Second is the nature of the *workflow process*, namely how new knowledge content that is submitted in diverse locations worldwide is processed throughout the system – from the initial input, to web published status, in all language-databases and all servers in all locations. Third is the design and implementation of a *multilingual strategy* for distributed networking systems worldwide. And fourth, is examples of *customized* design responses are needed to address different situations on-the-ground.

The Workflow Process

The managerial and computational innovations reported in this chapter revolve around the creation of the workflow. The *workflow* is defined as the process through which new knowledge content is routed through the system. Specifically, the workflow process refers to the path through which each individual knowledge item is guided – from site selection, to submission of abstracts, to translation into GSSD's supported languages, and finally to publication on all GSSD mirror sites. The workflow consists of the process as well as the protocol governing the activities of all partners as they organize the knowledge content and its flow throughout the e-network.

To be effective, when a workflow involves interactions among members of a distributed e-network, it must be designed to enable customization as needed. One size seldom fits all. Accordingly, in this chapter we show how GSSD operates as a globally distributed endeavor by defining the diverse functions of knowledge provision, distribution, and translation, and then by specifying the steps that must be taken in order to ensure overall performance. In so doing, we provide the backstage view of what actually happens computationally when knowledge is transmitted from *Submit Site* and then routed from the initial provider to the GSSD system as a whole.

The issues addressed here are interconnected. On the one hand, we show the management and design issues central to the workflow process; and on the other we provide the basis for system-transparency – in case a reader wishes to know *how* the submission process is done, and *why* it is done this way. Thus, we provide the basic knowledge required for others to understand, assess, replicate and most certainly improve upon the actual *practice* of e-collaboration that we have developed.

Given that GSSD search functions operate across languages, and that the abstracts are rendered *multilingual* as well, the knowledge management process requires a certain degree of precision in rendering and coordinating knowledge items across language databases. Since all languages are available in all mirror sites, at all times, the challenge is to maintain cross-location consistency such that the mirror properties are retained throughout the network.

In short, our purpose in this chapter is to render matters of *system design* and *operational strategy* for a distributed global e-system as transparent as possible. The challenges associated with such an effort are daunting, and a certain degree of trial and error – with much error – is a pervasive feature of the entire enterprise. Then, too, given that cyberspace is an English-speaking venue for a world where most people do not speak English, constructing multilingual capabilities is an especially relevant endeavor.

3.1 Selection and Content Provision

The value of knowledge lies in its content. In the absence of a robust method for valuing content, it is incumbant upon us to articulate the 'quality rules' for knowledge provision. This section begins with a discussion of methods and mechanisms for content selection, review, and submission into the knowledge-base. Most of the issues addressed can be seen as methodological and proceedural in nature, but they are at the very heart of any distributed knowledge system.

In this connection, recall that *Mapping Sustainability* in Chapter 1 provides the framing system for sustainable development as an area of knowledge. The knoweldge content therefore consists of systematic observations of the domains of human activities as well as the dimensions associated with each domain. Recall also that Appendix A, at the end of this book, presents at the 'Guide to Core Concepts,' in the familiar form of tables of content. This knowledge display serves as the bridge between the theory underlying this initiative analysis on the *conceptual* plane and the methdological features at the *implementation* level.

The issues addressed here pertain to the profiling of knowledge, to its abstracting and recording, and to the practical application of conceptual guidelines. Increasingly the international community as a whole, and the scientific, educational, and knowledge communities more specifically, are recognizing the imperatives of decentralization and the invariable attendant 'push' toward localization. More fundamentally, we show some of the practical, strategic, and essential tasks that accompany any collaborative knowledge-based initiative – particularly those of global scale and scope.

3.1.1 Identifying Content

To begin with, Internet-resources must be identified as relevant to GSSD's knowledge interests and overall goals, then specific features of knowledge are summarized into individual abstracts, and then these are classified according to the GSSD knowledge system index-structure and Guide to Core Concepts, and finally they are reviewed for consistency and quality prior to web publication.[1] In general, individual sites whose documents are abstracted for the knowledge-base must be available at no cost to the user, and, preferably, with no advertisements.[2]

Given that the focus is always on content, large sites need to be disaggregated into smaller, more focused content and then differentiated into further elements, as relevant.[3] Pages of links are useful, but they must be reviewed and can often be spidered. By following all the links to outside sites, it should be possible, except for the very largest sites, to link directly to the original sites rather than through a links page.[4]

3.1.2 Sources of Knowledge

The knowledge-base of GSSD consists of organization-supported *holdings* selected from the following types of sources:

(a) *Formal Institutions*, which include well known leading organizations focusing on science and technology, or institutions of governments and governance, business and industry, as well as major representatives for civil society (notably non-governmental organizations). We assume that the institution itself is responsible for assuring quality and reliability. In essence, we consider reputation and the existence of some accountability process at the source.

(b) *Content-Specific and/or Scientific Institutions*, which include the organizations described above, plus civil society affiliations, such as the Population Council, the Energy Defense Council, United Nations Development Program, Government of Brazil Ministry of Energy, etc.

(c) *Intermediation Service Entities* such as public service or private sector third party associations of institutions or publications, such as the

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1 The index structure refers to the details in the contents of the Guide to Core Concepts.

2 Exceptions can be made if absolutely essential.

3 In the case of a large site that is being disaggregated into individual topic-board sections, an abstract should still be created for the main page. (In the case of site reorganization, the links to smaller sections of the site may become dead links, but the address of the main page will most likely stay the same.)

4 Often it is also useful to make separate abstracts for relevant sites. This practice minimizes the work required by the GSSD user to find the information he/she is looking for.

e-journals or e-reports of the World Business Council for Sustainable Development.

(d) *Specialized Submissions*, or e-materials created by individual researchers, scholars, and other non-profit professionals.

3.1.3 Coverage

The types of e-materials (i.e. knowledge content) to be considered for inclusion in GSSD include the following:

- Agreements
- Bibliographies, reports, and journals
- Case studies
- Definitions/theories
- Events
- Indicators/data
- Models
- Organizations

The GSSD Glossary of terms, presented as Appendix B at the end of this book, includes definitions of the above, as well as definitions of all key terms relevant to the GSSD knowledge content and its organization.[5]

3.1.4 Knowledge Management

Management of the GSSD knowledge-base consists of two distinct but related tasks. First is the organization and classification of knowledge items. Second is the periodic review and updating of the overall knowledge-base. This task includes the identification of *dead links*, namely, e-addresses no longer in operation, either because the address has changed, or because the content is no longer relevant. Once the dead links are identified, the GSSD team locates and replaces the materials as appropriate.

3.1.5 Organization and Classification

Two procedural and system features are critical operational guides for these aspects of content provision. First is use of the sustainable development

[5] Each candidate knowledge entry (abstract item) must have at least one of the following criteria: be distinctive and identifiable, provide some specific rather than general statements, except of course when dealing with policy statements; have some possibility for validation or replication; and point to specific content pages, except for abstracts linking to home pages. Excluded from consideration are daily news items, popular magazines, opinion papers, etc.

ontology derived from the framing system and the ontology rules – in terms of slices, rings, cells, concepts, sub-concepts, and the fifth ring, i.e. international response and global accords – to provide the semantic and theoretical frame for 'tagging' each abstract. Second is the methodological requirement that each *knowledge abstract* must, to the extent possible, use the content-driven differentiation at the intersection of slices and rings. This refers to the detailed specifications within each of the categories in the Guide for Core Concepts. Finally, the dominant bias in this process is that of *exclusion* – on quality and relevance grounds – with the corollary that inclusion is not an operational directive.[6] The strategy is to purposively maintain a streamlined knowledge-base.

3.1.6 Reviewing and Updating

By definition, a dynamic knowledge-base is always changing, and we would expect it to evolve over time. This is the case with GSSD as new materials are included and outdated materials are either updated or removed entirely. Since the knowledge-base consists of indexed and abstracted materials of e-resources already in the public domain, retaining clean files is an important challenge. At this point we turn to quality control guidelines – in terms of *what* to do and, equally important, what *not* to do – in order to avoid inadvertent problems in the process of adding content to the knowledge-base. These same principles also govern our decisions when making changes to existing content in the context of the discussion in Chapter 1. At issue here is the process through which the 'slots' in the framing system are 'filled' and the ways in which the extensions are made from individual knowledge items–to enhance the design and contents of a knowledge-base. Thus, in order to maintain, update, and revise the GSSD knowledge-base, and to assure quality and reliability in the process, we have developed a set of guidelines coupled with working procezdures. Presented in Appendix C, these elements they constitute a guide to content management.

3.2 Workflow for Multilingual Content

Once knowledge-content has been submitted for inclusion in the GSSD knowledge-base, it is subject to the process of knowledge-management. This

[6] Users always have the option of going directly on the Internet and search for their topics of interest, using any of the existing search engines. Recall that in Chapters 1 and 2 earlier we highlighted the key features of the GSSD strategy, notably that its coverage of content is focused, exclusive, and quality controlled.

processs governs the flow of content from its initial identification and submission all the way to its final inclusion and multilingual represetnation in the knowledge-base. The entire process consists of a methodology that has been developed specifically for meeting the GSSD objectives. Since knowledge provision, management, and sharing is a *distributed process,* we must take into account the implications of multilingual and multicultural realities, with all the attendant diversity decentralization.

Initially, GSSD was designed as a knowledge e-networking application focusing on sustainable development and intended to foster the distribution and provision of content, in local contexts, multilingual formats, and distributed geographic locations all over the world. However, a wide range of technological, organizational, and institutional challenges have led to a substantial redesign of the system. As a result, the development of an innovative global workflow application has become a central feature of knowledge e-networking. Thus, the new organizational and institutional priorities and the related technical requirements transformed GSSD into a unique technical application for managing global workflow processes.

3.2.1 Multilingual Workflow Process

When content originates from a single language and location, it is routed through the GSSD workflow-process toward its destination via global workflow until it is converted into all supported languages and resides on all mirror sites of the GSSD network. Clearly, the effective operation of any global knowledge e-networking system depends upon an efficient and effective workflow among the participating actors. In our case, we need to enable users to add content to the knowledge-base, which can then be retrieved by GSSD users.

The concept of *knowledge e-networking* is founded upon collaboration among knowledge-producing actors who retain their autonomy in the course of participating in the e-network, and that this autonomy is a source of value to the actors as well as to the entire e-network itself. Several computational challenges are associated with the effort to support the autonomy of the actors.

Once the content is published to the web, it becomes an extractable part of the GSSD knowledge-base, and is available through GSSD functionalities. This means that a certain degree of intellectual discipline has been exercised regarding the quality of the content and that the submission process has met the basic system requirements. See Appendix C for details. Against this background, Figure 3.1 provides a highly stylistic view of the multilingual workflow process.

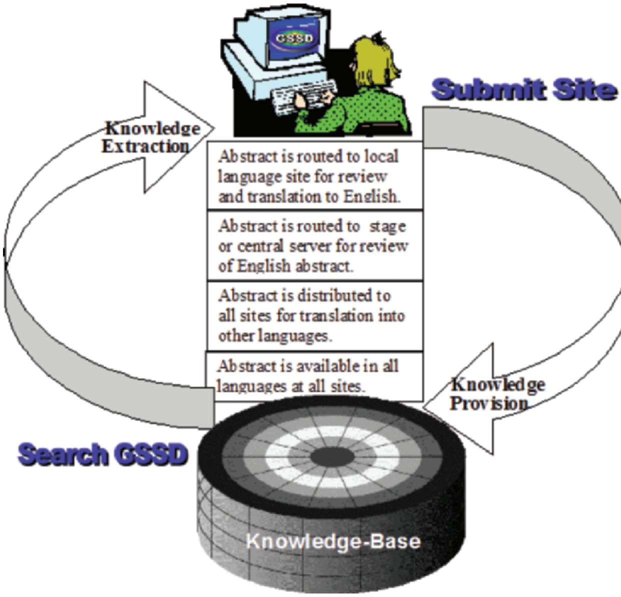

Figure 3.1 **Workflow process: a stylized view.**

For illustrative purposes, we stress the importance of the *original language* of the knowledge-item in question, as well as the *location* of the submission site in the e-network. These are key identifiers that, in turn, determine the precise routing of the submission through the workflow process to its final inclusion in the GSSD knowledge-base.

3.2.2 Routing Knowledge-Content

A more detailed representation of the workflow process is in as signaled in Figure 3.2 which follows the same general sequence of steps noted in Figure 3.1. Consisting of four main segments, the workflow process proceeds as follows: for content–abstract consists of four main steps. Each of these steps is noted in Figure 3.2 along with a representation of the routing process. The steps are as follows:

(1) An abstract–content is first routed to its *local language* site for review and translation into English. For example, if a Chinese abstract were routed to the French server, it would be routed to the Chinese server for translation.

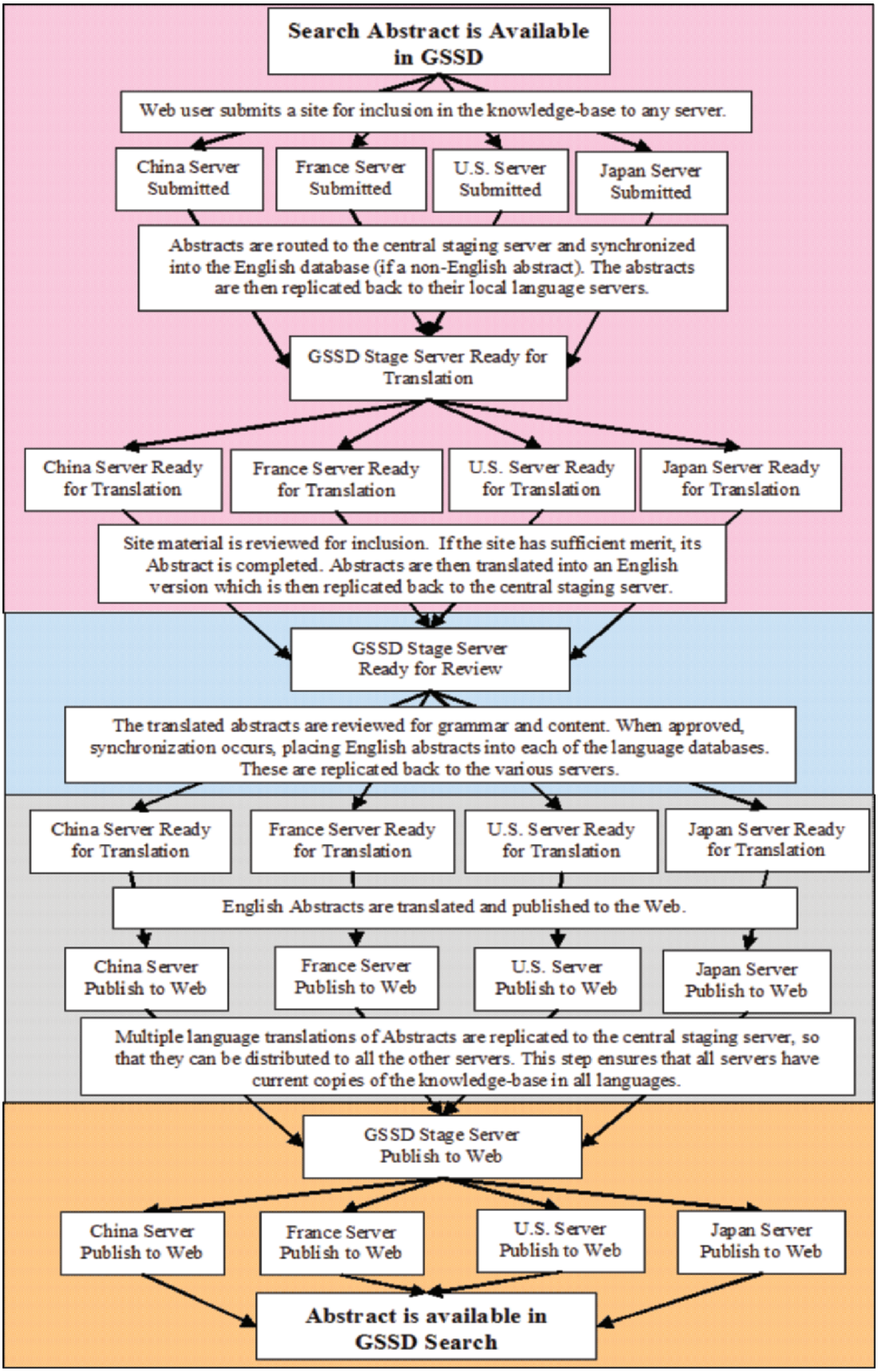

Figure 3.2 **Routing knowledge content: four steps of the global workflow process, differentiated by horizontal lines.**

(2) The abstract is then sent to the central staging server, known as *GSSD Stage*, for review of the abstract in English.
(3) Once the English abstract is reviewed for accuracy, the GSSD Stage server *distributes* the English version of the abstract to all other language sites.
(4) The abstract–content is translated into all *other languages* supported by the system.

When the workflow is completed, the abstract of the new submission has gone through the entire system. Its content is now available in all GSSD-supported languages.

In the discussion so far, we have referred to a general case and to the core principles of the workflow process. However, the strategy allows us to customize the workflow at each step, to meet specific contingencies, while at the same time retaining the integrity of the workflow. We now turn to an illustration of the customization process by comparing four different cases and noting the implications for specific steps in the routing of a submission from its initial entry point until it is integrated in the GSSD knowledge-base.

3.3 Customized Workflow: Four Cases

Given that the workflow is sensitive to the *language of origin*, a certain degree of customization is built into the design of the workflow. At the same time, however, customization does not violate the basic workflow principles for rendering and retaining congruence across all languages in that it is different for English-originated content versus content that is initially submitted in another language.

For illustrative purposes we present a comparative view of four cases with different routing processes that correspond to different situations on-the-ground. Recall that, as noted earlier, the common locale of conversion for consistency is the GSSD Stage Server, and that Stage constitutes the focal point for ensuring congruence across languages and locations.

3.3.1 Case I: English Content Submission

In the first case, the abstract is in English as its point of origin. As Figure 3.3 shows, the workflow process clearly indicates a highly streamlined sequence.

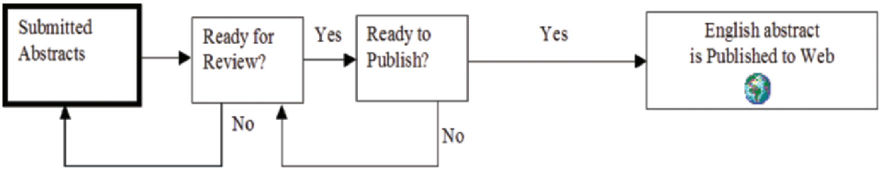

Figure 3.3 **English content-submission.**

3.3.2 Case II: Content Submission Other-than-English

In the second case, the initial content submitted is not in English. Since most of the world's population is not English speaking, providing a process for managing the flow of what will invariably become an increasingly growing number of new participants in e-systems of worldwide. Figure 3.4 shows the routing for Other-than-English submission.

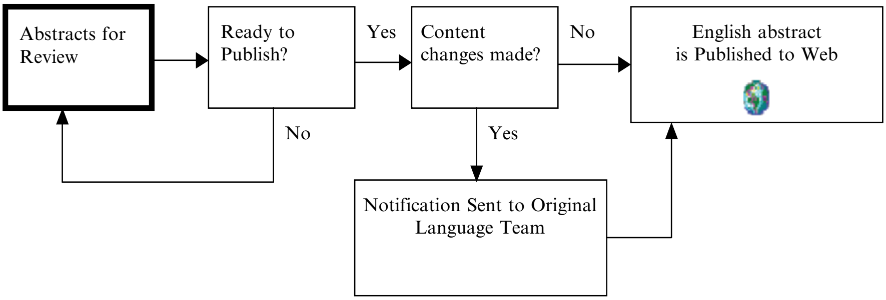

Figure 3.4 **Other-than-English content-submission.**

3.3.3 Case III: Non-English Original Requires English Version

This is a case where the original submission is in Chinese or Arabic, or any other-than-English language, and the contents need to be represented in English (Figure 3.5). This requires the Translation of *** Abstracts into English in order to meet the Stage requirements, and of course, also in order to be placed in the English database.[7] They are also technologically challenging in the representation of meaning, since neither of these are a based on the western alphabet.[8]

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[7] The asterisks in this text, namely, *** can represent any non-English language.

[8] Recall that in Arabic, for example, a specific letter may look different if it were located at the beginning, the middle or the end of a word. This issue is fully understood among linguists, teachers, and educators, but is especially daunting for representational systems designed for computational purposes.

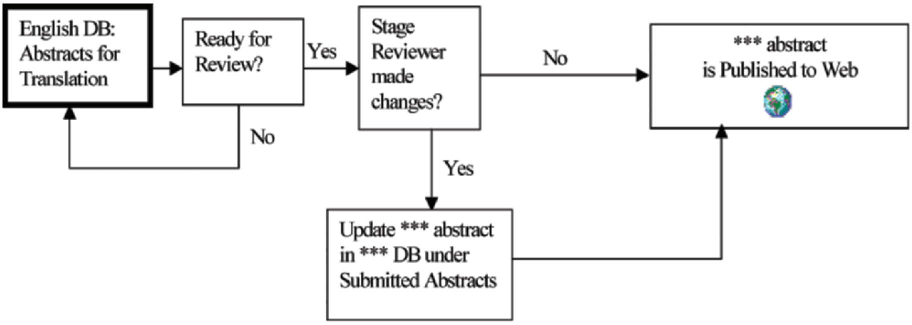

Figure 3.5 **Non-English submission requires English version.**

3.3.4 Case IV: English Submission Requires Other-than-English Version

In this last case, the original content-submission in English needs to be rendered and then published in the non-English languages, including, but not limited to, Chinese and Arabic. The workflow for this case is shown in Figure 3.6.

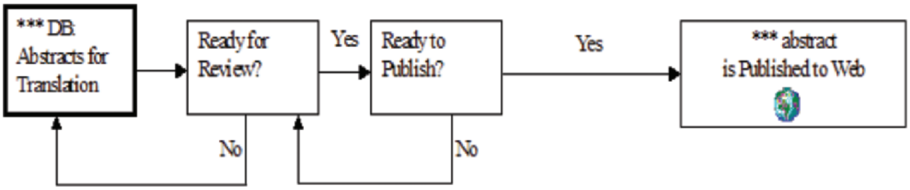

Figure 3.6 **English submission requires other-than-English versions.**

A reminder here is in order, namely that partner in the entire database system (which includes all of the individual language databases as well as the Stage database) must retain its mirror status at every point in time. At first glance, the differences among these four cases may not stand out, but by observing the initial condition at the onset (on the left in each of the above figures) and tracing these to other end of the workflow process (at the right side of the figures) the differences become more evident.

3.3.5 Convergence Glossary

One of the most persistent challenges is to assure the accurate rendering of meaning across languages. This challenge is especially daunting in cases where the sustainable development vocabulary is not fully developed. In such cases, the Convergence Glossary required for accurate content representation must be developed.[9] This development is essential in order to implement the workflow. The Convergence Glossary consists of the computational representation as distinct from the GSSD Glossary.

The Convergence Glossary is thus is a fundamental feature of the entire GSSD approach to knowledge generation, sharing, management and distribution. The integrity of the workflow process is critical to the robustness of the system as a whole, given the distributed nature of knowledge provision as well as the collaborative management strategy.

As of this writing, there are no precedents for multilingual knowledge provision in non-western languages concurrently for management and sharing on a distributed basis globally. There are few precedents, if any, for the use of western and non-western languages in one integrated and synchronized knowledge-base. Finally, there are limited precedents, at most, for the sustained provision of local knowledge into global networks.

Currently, the knowledge-base consists of Arabic, Chinese, and English. The GSSD team is in the process of updating the French version, and expanding the system and the databases to Japanese and Spanish. Given that the core strength of GSSD lies in its ability to develop and maintain a multilingual and distributed knowledge-base devoted to sustainability issues, extending the language coverage is a key priority.

3.4 Computation and Implementation

So far, we have addressed the workflow process given the diversity in the language of origin, namely, *what* must be done when the submissions are in English versus non-English, and *when* should they be rendered into different languages. We now turn to the question of *how,* namely the computational process by which the GSSD system sustains a knowledge-base that is multilingual in content and distributed in nature.

At this point, we turn to the key operational steps, the logic, and the sequence for developing and managing the design of the GSSD knowledge-base. These issues are important, first, in order to share with others as clearly as possible the methods that we have developed and implemented, and second, to provide foundations on a road map for future efforts that can improve upon, and enhance, these new practices.

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[9] The Convergence Glossary is also called the Domino Global Workbench (DGW).

3.4.1 Globalization and Localization

The design of GSSD as a multilingual web application involves turning *one* web application, written in *one* language, into *many* copies of the application in *different* languages – but all linked together conceptually and coherently. The goal is to retain consistency of content and meaning for both knowledge provider and retriever. While the overall GSSD enterprise is governed by the realization of, and the quest for, knowledge *globalization*, this process of consistency-seeking is one of knowledge *localization.* Three sets of e-capabilities, and attendant e-functionalities, are central to the localization process.[10] To be effective these must follow protocol and procedure.

First is application of the *Domino Global Workbench* (DGW), a tool that enables us to automatically create an application in different languages, provided that we first generate a Convergence (or DGW) Glossary of the translated terms. The Glossary serves as a bridge between the language of the original application and the new version created by the process. This step is especially important in the domain of sustainable development where the core concepts are not always available in all languages and a certain degree of conceptual articulation is often needed. In other words, this step involves the development of the vocabulary for managing the knowledge content.

Second is deployment of the *DGW Glossary* which consists of the database that holds all the terms (all text and graphics) that make up the design of the application.[11] Once this Convergence Glossary is created, researchers can then translate the terms in it quickly and easily, with only minimal training on Lotus Notes. DGW then uses this Convergence Glossary to create the translated databases.

Third is *replication* and *synchronization*, two computational steps that render cross-site consistency of content and retains the GSSD mirror sites as identical versions of each other.

These three sets of computational functions are required to keep the application consistent across languages, across servers, and across mirror sites.[12] These features are central to the entire process of multilingual knowledge creation, management, and e-networking. Consisting of both human–computer interactions as well as human–human coordination, they constitute the core mechanisms for distributed global knowledge e-networking.

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[10] Recall that this process is implemented via the Lotus Domino and related software.

[11] Note that the DGW Glossary (or the Convergence Glossary) is different from the GSSD Glossary. The former is a computational functionality; the latter is about displaying equivalence of meaning, as well as all other concept or vocabulary related issues.

[12] The tasks are usually the responsibility of the GSSD system administrator.

3.4.1.1 Creating a New Language

The DGW tool helps us to manage the localization (i.e. translation) of the GSSD system and render the knowledge-base into local languages and idioms. DGW automatically extracts terminology from the GSSD system and stores it in a Glossary ready for translation. Localized versions of GSSD are built automatically using the translated Glossary. The latter is required to create and maintain consistency of meaning across languages. Also, to accommodate any future changes in the GSSD design, the DGW 'update features' transmit changes easily to the localized versions of content.

3.4.1.2 Working with DGW Glossary

The DGW Glossary is a database that contains all terms in the GSSD design, in the originating language, English, and all translations of terms into supported languages. Each term in the Glossary, in each language, is a separate document. If 12,000 terms being translated into four languages, then 48,000 documents are in the Glossary. Figure 3.7 shows a screen view of the Convergence Glossary, largely for recognition purposes.

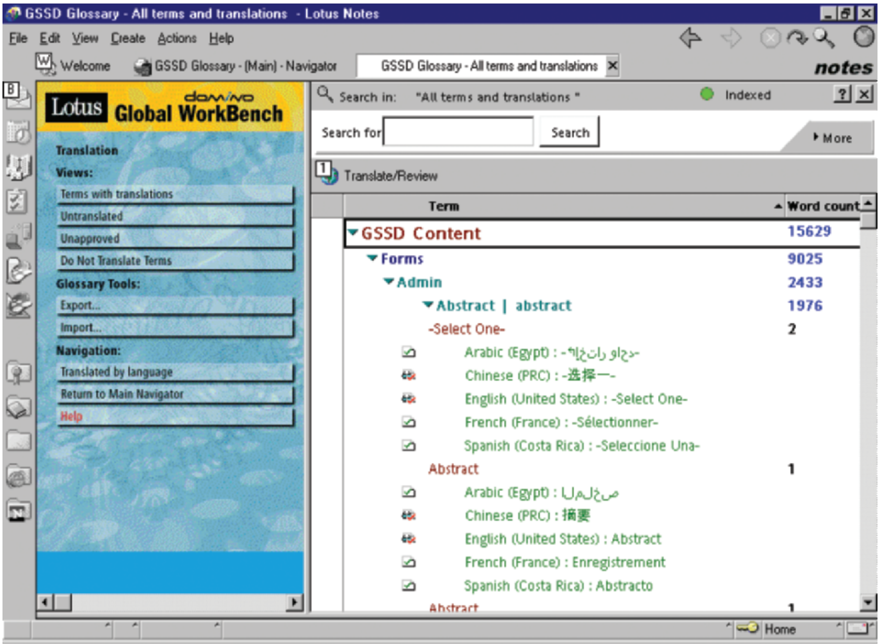

Figure 3.7 **Screen view of convergence (DGW Glossary).**

The DWB Glossary provides another key function. It forces the partners to be as explicit as possible about their understanding of key terms – especially in a domain that is rapidly changing as that of sustainability. In essence, serving as the computational mechanisms for eliminating language barriers, the Glossary provides the groundwork for developing a universal set of multilingual ontologies on sustainability issues.

3.4.2 Replication and Synchronization

As noted earlier, replication and synchronization are two computational processes that fundamental to the operation and maintenance of a multilingual distributed knowledge e-networking system. These processes are usually managed by the GSSD system administrator and constitute the mechanisms by which all sites remain identical in content and languages regardless of location.

Replication refers to the process that transfers changes made in one replica of a database to another replica, thereby keeping the databases located on different servers consistent with each other. A replica is a copy of a database configured in a way that enables replication in the Lotus system. The replication model is a hub and spoke system. The MIT Staging Server acts as the hub. It is not live to the web and functions as the central, up-to-date repository of the application. The spokes are the live mirror sites, which contain replicas of the application. The Staging Server replicates with these servers on a scheduled basis, to ensure that all mirror sites have consistent and updated content.

Viewed in these terms, replication is essentially a process of transformation-for-consistency. During the process of replication, the staging server at MIT (GSSD Stage) interacts with each mirror site to identify what has changed at the Live Site and on GSSD Stage, and then sends or receives those changes as relevant.[13] At the end of the replication process, the GSSD application is identical on each server. For example, a user looking at the application on the Chinese server will see the same content as a user looking at the MIT server. This is the point at which processes of globalization and localization converge, in theory and in practice.

GSSD Stage regularly replicates with each Live Server. This means that any change made in any server anywhere is then automatically rendered also on every other site. Any changes, introduced in any of the system-locations propagate through the entire GSSD network. For this reason, each computational

[13] Changes include modifications, additions, as well as deletions. For example, if an abstract in one replica is deleted from the knowledge-base, then during replication, all other replicas of that abstract are also deleted.

feature as well as the overall replication process requires careful implementation.

Synchronization refers to the process that through which consistency of content across languages is maintained. When a document is created and reviewed in the English language database, and the synchronization process is undertaken, a copy of that document is created in all other language databases. This function enables human translators render the content from English into their local languages. This is the only point at which human translation takes place. Since the translation is specifically of knowledge-abstracts, the resort to human skills is focused as well as limited. The GSSD system uses English as the reference language, which means that all content in GSSD needs to be in English system-database before it can be processed into other languages.[14]

Once a document is synchronized, it becomes virtually linked to its counterparts in all language databases. In other words, the operating system identifies it as the *same* content document located in multiple language databases. For example, if a synchronized document is deleted in its originating language database, then the corresponding documents in the other language databases will be automatically deleted during the next synchronization process.

Finally, synchronization is undertaken routinely on a regular schedule on the GSSD Staging Server at MIT. Any changes due to synchronization on GSSD Stage will be replicated to the Live Servers in the next replication process.

3.5 Conclusion

This chapter focuses on the challenges of creating and managing multilingual knoweldge content. It demonstrates the transition from a basic knowledge e-system to global knowledge e-netowrk via application of the workflow process. Most of the issues addressed so far are methodological in nature, supported by screen views for the purposes of illustration. At the same time, however, this chapter represents the operational manifestation of some of the concepts and theory underpinning sustainability presented in Chapters 1 and 2.

The ‘Guide to Core Concepts’ in Appendix A serves as a link between the theoretical segments of this overall initiative at the *conceptual* plane, on the one hand, and the methdological features at the *implementation* level, on

[14] Note that the English language database is distinct from the English system database. The former is comparable to any other language database. The latter serves as the convergence needs. The fact that they are both in English should not obscure the difference in the function within the overall workflow process.

the other. While seemingly only technical and procedural in nature, the issues addressed in this chapter are at the very heart of a distributed knowledge system. They pertain to the selection of knowledge, to its abstracting, to the practical application of conceptual guidelines, and to the indexing of content.

The value of knowledge lies in its content. In the absence of robust methods for valuing knowledge content, it is incumbent upon us to articulate our operational rules for knowledge provision. Increasingly, the international community as a whole, and the scientific, educational and knowledge community more specifically, are recognizing the imperatives of decentralization in knowledge provision and access and the importance of a concerted ‘push’ toward localization.

From the user’s perspective the details of the workflow – notably replication and synchronization – need not be examined in any great detail. But for a system manager, mirror-site partner, or other partner types (noted in Chapter 4) the details have operational implications.

More fundamentally, this chapter shows some of the practical, strategic, and essential tasks that accompany any collaborative knowledge-based initiative – particularly those of global scale and scope – and to transform this collaboration into its multilingual e-rendering. In short, the challenge is to establish and maintain the capacity to engage in knowledge provision, as well as knowledge retrieval, over an integrated knowledge-base originating from diverse, distributed, and decentralized sources.

Chapter 4

GLOBAL e-PARTNERSHIPS AND STRATEGIC COLLABORATION

Nazli Choucri, Farnaz Haghseta, and Carlos I. Ortiz

4.1 The Fundamentals

This chapter focuses on three fundamental and interrelated issues. The first pertains to the *roles and functions* necessary to maintain and sustain distributed knowledge e-networking worldwide. The second focuses on the nature and types of *cyber-partnerships* that constitute GSSD as a global e-knowledge networking system. And the third revisits the strategy we developed to *transcend e-barriers* in the deployment of knowledge for sustainable development.

Addressing the first issue, we show the organizational system and the management division of labor required to make a distributed knowledge networking system work effectively, while maintaining a necessary degree of autonomy, flexibility, and adaptability. In other words, we address who does *what*, *when*, *how*, and *why*. Through a review of role-based responsibilities, we illustrate the basic system functions for the collaborative operations. The roles presented here – in terms of definitions, functions, and responsibilities – hold irrespective of the specific partnerships or modes of collaboration that may be in place at any one point in time or in any part of the world.

Addressing the second issue, we highlight specific challenges of partnering by focusing on select activities and deliverables (with examples for illustrative purposes) and uses flow-diagrams to represent the processes involved in customizing each type of partnership. In addition, we offer guidelines for enabling new GSSD partners by translating the roles and functions described in the first part of this chapter into the specific activities that must be undertaken by different partner types such that the individual as well as the collectivity benefits from the collaborative enterprise.

N. Choucri et al. (eds.), Mapping Sustainability: Knowledge e-Networking and the Value Chain, 67–82.

Addressing the third issue, we revisit the issue of e-barriers to knowledge for sustainability and the strategies we have developed to reduce these barriers. By definition, distributed knowledge e-networking and collaborative management involve decentralization, diversity, and differentiation, as well as addressing complexity, emphasizing clarity, and facilitating coordination.

While sustainable development as a knowledge domain is the focus of this book, we recognize that the standard economic growth paradigm still remains dominant nationally and internationally. It continues to shape the types of *human activities* undertaken and pursued as well as the *content of knowledge* about human activities. At the same time, however, fundamental changes worldwide are creating new conditions and shaping new perspectives that may well call into question the robustness of the basic economic growth paradigm. For the first time in human history, pervasive e-connectivity enables the articulation of a wide range of views and the voicing of alternative perspectives. When coupled with new e-technologies, these powerful enablers create possibilities for framing alternatives to the dominant perspectives in national policy and global strategy.

Of the many features of contemporary realities, at least two are especially relevant for our concerns. One is appreciating the *complexity* around us. The other is recognizing the *diversity* in all domains of human life, in social as well as natural arenas.

4.2 Managing a Global e-Knoweldge System

Given that GSSD provides the user with choices of language as well as server location, the screen view of the system's home page, shown in Figure 4.1, signals the choices at the point of access. This figure also conveys the distributed nature of the system as a whole. We now turn to the roles and functions to support distributed e-collaboration, the responsibilities that must be put in place for sustainable met, and the ways in which these enable collaborative e-networking. The discussion proceeds from the collaborators' point of view, namely those institutions or individuals responsible for making GSSD functionalities available to their constituencies, and not from the general user's point of view.[1]

[1] Such modes reflect the various activities required for the establishment, maintenance, and routinization of an evolving knowledge system. Also addressed here are key features of GSSD's current operating system (based on Lotus-IBM technologies) and basic system requirements for operation of the system.

Figure 4.1 **Screen view of GSSD home page.**

4.2.1 Roles in Modular Terms

By focusing on the issue of *roles* in the management of a distributed knowledge system, we consider not only *who* are the key actors, but also *what* is it that must be done (and by whom) so that the users can be well served. In this context, the w*ho* consists of the knowledge partners serving as founding partners of this global e-network. On balance, the major role-types consist of the following:

- *Content administrator*
  Responsible for managing the static and dynamic content and overseeing the workflow process
- *Content provider and reviewer*
  Supervises and reviews knowledge content by applying the GSSD knowledge rules to enable user effective access and retrieval
- *Content translator*
  Translates all abstract-content into GSSD-supported languages and resolves the ways in which differences in meaning especially when the basic glossary vocabulary for expressing or representing aspects of a new issue or technology is not yet fully developed
- *System designer*
  Designs the key operating functions that enable the system to be altered as needed in order to accommodate different languages, contexts, and requirements, while still retaining overall system cohesion

- *System administrator*
  Maintains both content and physical integrity of the e-network, ensures the smooth flow of communication across mirror sites, partners, and distributed locations, and is directly responsible for managing responses to system problems and undertakes 'trouble shooting' activities, as needed

At the same time, however, distributed knowledge systems are often managed by individuals operating in more than one role.[2]

4.2.2 Knowledge of e-Management

Table 4.1 shows role types, descriptions, and tasks, as well as the Lotus-IBM software components utilized in the current GSSD version.[3] Three of the five essential roles pertain to *knowledge issues* in terms of content and management, while two relate to *system operations* and network management, We stress, however, that the system as a whole – its intellectual features, concepts and theory, as well the overall architecture and operations – are independent of the platform or software at hand.[4] Given that our goal is to facilitate knowledge management capabilities and operating practices, not to build note briefly only two operational conditions and system requirements central to the Lotus environment.[5]

The first of the role types is the *Common Platform-Client Environment* which consists of the Lotus Notes client software, a Notes *user ID file* and *password*, and the appropriate access to relevant databases.[6] These elements are fairly straightforward in nature and once routinized, they remain operative as long as needed.

[2] For example, one individual may be responsible for undertaking multiple roles (e.g., as both a content provider and translator) or multiple people may be responsible for fulfilling the functions assigned to one role.

[3] Table 4.1 represents the operators of the system, and as such may not be of interest to users or readers.

[4] Since administration of all GSSD mirror sites currently relies on the Lotus operating platform, there are some common problems and challenges often encountered that require some attention at this point, these are largely of a technical nature, bearing on the features of the commercially available software which GSSD currently uses.

[5] Earlier versions of GSSD were written in Mac Common Lisp with an application system developed at the MIT Artificial Intelligence Laboratory. The Lotus system is commercially supported and available worldwide, thus providing relatively robust support for GSSD applications. When GSSD was conceived, designed, and implemented, and the initial test phase completed, the only platform to support its operations was that provided by Lotus-IBM. There was no alternative at the time, and the Lisp system developed at the MIT-AI Lab neither served as our test bed, had little documentation and no previous tests of robustness, nor was there any evidence that the system could scale.

[6] For more on the Notes application, please refer to technical documentation provided by Lotus-IBM Corporation.

Table 4.1 **GSSD operational roles and functions.**

Role Type	**Role Description**	**Functions and Regular Tasks**	**Software Currently Used**
Content Administrator	Manages all content on GSSD	Submit, modify, and review abstracts, and edit static pages	Lotus Notes
Content Provider and Reviewer	Enters and reviews content (abstracts) on GSSD	Submit, modify, and review abstracts	Lotus Notes
Content Translator	Translates content on GSSD	Translates content between English and local languages	Lotus Notes
System Designer	Designs database elements and web pages	Creates databases, templates, and agents	Lotus Designer, Domino Global Work-bench
System Administrator	Manages the users, databases, and serv-ers connected to the GSSD Network	Installs and manages servers on the local network; manages user access control and security features	Lotus Notes Adminis-trator

The second pertains to the identity of the *GSSD Documents in the Lotus System*. In the *Notes* environment, documents are defined as individual sets of information, which are analogous to index cards. In this context, each document contains a variety of fields with content (knowledge type, information, etc.). The GSSD design relies on two basic document types, static and dynamic. Static documents include content that rarely changes once it is incorporated into the system, such as *Reports* and *Slide Shows*. Dynamic documents include content that require period updating and/or maintenance such as *Abstracts*, as well as any information or knowledge that require dynamic representation, in its content or its display.

These dual features appear quite simple. However, the actual operations of the system and its reliability are directly related to the discipline and diligence exerted at the system installation phase and initial implementation phases.

The issues addressed so far in this chapter constitute of the view of key features, behind-the-scene, required to support knowledge e-networking ane strategic knowledge management. They also pertain to the human and physical infrastructures that enable the knowledge content on sustainable developed to be created, distributed, translated, and located in the GSSD knowledge-base.

4.3 Partnership Essentials

GSSD exists due to the commitment of the global partners who contribute to the technology, content, design, and translations necessary to make the system operate. In each case, the partners establish a formal relationship with GSSD at MIT, which helps enhance the entire GSSD network without undermining their own individual autonomy. Given there are few precedents for such activities devoted to sustainable development as a knowledge domain, we consider this effort as a powerful learning-by-doing initiative and highly dependent on the commitment and contributions of the partners.

4.3.1 Modes and Activities

In this context, 'modes' means the contribution and style of operation and 'activities' refers to the specific tasks in question, as displayed in Table 4.2. It is important to make a distinction between general GSSD roles and requisites, on the one hand, and operational GSSD partnership responsibilities, on the other. The former addresses more general functions that must be performed for the system to operate effectively. GSSD Partners contribute to all of these functions. The latter looks at the higher-level significance of Partners to the operation of GSSD and describes current operating partnerships.

Two of the five partnership types at this time, namely, the *Content* and the *Translation* partnerships, focus on content-related issues, and two others, the *Mirror Site* and the *Development* partnerships, deal mainly with system operations and management. The fifth type, the *General Supporters* partnership, reflects a more general collaborative rubric, reflecting the interests of the partners in question.

4.3.2 Illustrating Three Cases[7]

The GSSD system manages left-to-right phonetic character sets (such as Russian or Latin), right-to-left phonetic character sets (such as Arabic or Hebrew), and ideographic character systems (such as Chinese or Korean). Even mixed character systems can be used, such as Japanese, which utilizes two separate phonetic character sets (Hiragana and Katakana) as well as an ideographic set (Kanji). Three cases illustrate the current partnerships:

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[7] The fourth case, not covered here, involves GSSD-France, located initially at Ecoles des Mines at St. Etienne in France. The project leader jointed the French government as a Cabinet member, thereby placing networking matters on hold pending organizational adjustments.

Table 4.2 **GSSD partnerships by types[8].**

Partnership Type	Description of Partnership	Example of Partner
Content Partner	Locates appropriate content for the GSSD knowledge-base, then abstracts, indexes, and publishes to the web. Also reviews submissions from local web users, and may be responsible for their own organizations' content.	Ministry of Science & Technology, Beijing, China
Translation Partner	Translates both GSSD interface design elements, static pages, abstracts, and documents.	American University in Beirut, Lebanon and Écoles Des Mines, St. Étienne, France
Mirror Site Partner	Maintains a Live Server, and integrated into the GSSD system, which contains a replica of the GSSD system.	University of Tokyo, Tokyo, Japan
Development Collaborator	Provides development support, in terms of technology, expertise, collaboration, etc.	Lotus-IBM, USA
General Supporter	Provides general support in terms of participation ('equity sweat'), in-kind or financial contribution.	Baker & McKenzie, AT&T, and Xerox Corp.

(1) *GSSD-Arabic*: At the American University in Beirut, Lebanon is one of the leading educational institutions in the Arab World and in the Middle East region as a whole. It has long been a pioneer in the region, and as the host of Arabic GSSD, it serves as the focal point for the provision of local knowledge in Arabic and the subsequent incorporation into the overall GSSD knowledge-base.[9]
(2) *GSSD-Chinese*: The core GSSD partner is the Ministry of Science and Technology, Administrative Office for Agenda 21 (ACCA21), responsible for the management of China's own national strategy for sustainable development – at local, regional, and national levels. ACCA21 oversees the provision of local knowledge, the distribution of global knowledge, as well as all aspects of mirror site in China.[10]
(3) *GSSD-Japanese*: GSSD-Japan mirror site located at the Tokyo University in conjunction with the *Alliance for Global Sustainability* (AGS), and is at early stages of development. The system operates in English

[8] Partner examples are of August 1st, 2000.
[9] See Chapter 7 for a more complete discussion of GSSD-Arabic.
[10] See Chapter 8 for a more complete discussion of GSSD-China.

but its Japanese language function, as well as all multilingual capabilities, multilingual functionalities are yet to be rendered operational.

By way of illustrating the operational logic of e-partnering, the following section presents a 'walk-through' of system operations. In so doing, we trace the path undertaken by a new collaborating institution.

4.4 Forging New Partnerships

Entering into a new partnership with GSSD, with the general expectations and responsibilities associated with involves the application of relatively broad guidelines.[11] The general steps, summarized in Figure 4.2, serve as an outline for tracing the key steps for different partnership types. The flowchart logic in Figure 4.2 defines the key elements in the process. The partnership types are noted at the top of the figure, and the relevant steps are signaled accordingly.

4.4.1 The Content Partnership

The Content Partners are the core of the GSSD knowledge-base. They are responsible for producing the submissions and/or screening new entries submitted by web users. Content Partners may be interested in populating a particular issue area of sustainability, such as conflict or energy, or a particular industry or industrial process, or may be responsible for incorporating their own organization's site materials into the GSSD knowledge-base.[12]

4.4.2 The Translation Partnership

Human-translation is undertaken for the following types of documents: (a) static and dynamics pages when a language is added to the system and (b) individual abstracts when new abstract items are submitted are routine features of GSSD operations. Retrieval of any items in the GSSD knowledge-base can be done through the use of any of the system's languages. Given that the 'founding languages' for GSSD are Arabic, Chinese, and English, the Translation Partners help to maintain the GSSD web interface and keep the knowledge-base current in each of the GSSD supported languages.

[11] Information about operational features of the partnerships and/or the nature of the guidelines for each of these partnership modes can be obtained from the authors.

[12] The exact steps for becoming a Content Partner vary from organization to organization, but the general steps that follow provide a good guideline.

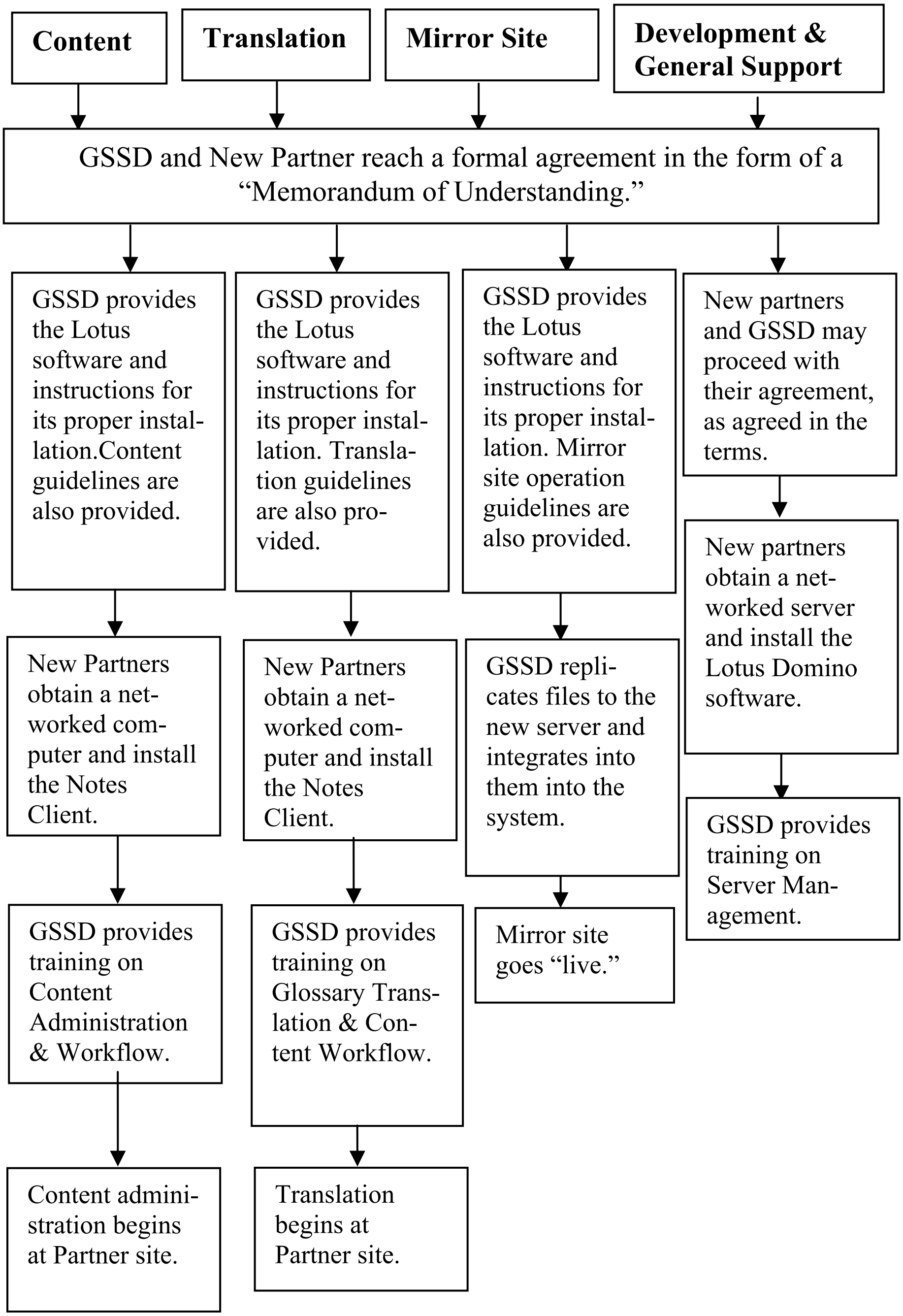

Figure 4.2 **General steps for forging new partnerships.**

The translation of GSSD abstracts-content into multiple languages reduces the impacts of an important e-barrier to knowledge access. Typically, the cost of full-document translation is too high for standard web surfing. The ability to obtain synopses of site content in one's own language reduces significantly the financial and human resources necessary to access e-resources available in cyber venues. By exploring the contents of knowledge-abstracts, the user can identify in advance the sites of interest and select the materials for translations, as relevant.[13]

4.4.3 Mirror Site Partnership

Mirror site partners establish and maintain a server which houses an exact duplicate of the GSSD application, in all supported languages. The duplicate files, or replicas, are scheduled for automatic update updated in order to ensure that all mirror sites contain the same system functionalities and knowledge-base. In some cases, the mirror site strategy helps to overcome some problems associated with intermittent Internet connectivity, by providing better access to the GSSD system closest to of the user. In China, for example, early in the collaborative profess, we found that bandwidth (the speed with which information moves over an Internet connection) was relatively good within its borders, but bandwidth between China and other countries often less so. In such cases, an English speaker in China would use GSSD-English on the Beijing mirror server rather than seek access to the MIT mirror in Cambridge, Massachusetts. Similarly, a Chinese-speaking user in Europe may probably prefer to use the GSSD-Chinese on the mirror server in France.

All of this will undoubtedly change over time, with better bandwidth and infrastructure and lower cost of Internet access. Overall, providing users worldwide with access to alternative locations and languages is a powerful enabler for enhancing knowledge e-networking.

4.4.4 Development and General Partnerships

The relationship between sponsoring partners and GSSD takes many forms. System supporters often prefer to select their own modality. Development and General Partners can provide the experience, labor, hardware, software, and/or financial support necessary to keep GSSD moving forward. Notable examples include the then Lotus Corporation, which provided GSSD with software and technical expertise, the *Alliance for Global Sustainability* (AGS), which facilitated research with financial support, and MIT's Department of Political Science, which continues support the GSSD initiative in notable ways.

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[13] The decision to engage in full-translation of any text can be made by the user at any point and is outside the GSSD scope.

4.5 Transcending e-Barriers

At this point, we revisit the e-barriers introduced earlier in Part I and we highlight ways in which the overall GSSD strategy is designed to reduce their impacts. The goal is to transcend attendant constraints on user-access to e-knowledge pertaining to domain of sustainable development, broadly defined.

A combination of factors impedes access to knowledge and e-networking pertaining to sustainable development. Some are due to the nature of the domain itself; others are related to the often cited digital divide, and still others reflect the reality that knowledge provision on cyber venues is usually dominated by the industrial countries. Earlier, we identified and addressed six sets of e-barriers. These consist of (i) conceptual ambiguities related to 'sustainable development'; (ii) explosion of materials on the Internet; (iii) constraints created by realities-on-the-ground; (iv) dominance of English on cyber venues; (v) biases in knowledge provision; and (vi) financial burden of cyber access. Proceeding sequentially, we now review key features of our strategy for transcending each of these e-barriers.

4.5.1 Developing a Conceptual Design

Given well documented conceptual ambiguities surrounding most if not all aspects of 'sustainable development' – including disagreements about basic definition and critical features – the provision of conceptual clarity emerges as a necessary requisite for moving forward. The complexity of definitional issues is evident in both in research and policy circles, as is the diversity of views and definitions generate a range of contentions surrounding both the concept and its uses. The challenge, therefore, is to provide internal consistency, coupled with clarity of conception and definition.

By undertaking a detailed *mapping* initiative, presented in Chapter 1, we put forth both the logic and the framework for representing the knowledge domain, as well as the rules for generating *ontology for sustainable development.* The ontology helps to guide our understanding of the overall issues and of their constituent elements to the extent feasible and organize existing knowledge pertaining to the broad domain of sustainable development.

Recall that the framing rules consist of two sets of features for each item of knowledge content – namely *domain* and *dimension* – as well as a detailed content differentiation within each of these features. Jointly, they provide an indexing system for organizing knowledge about ways in which human activities generate problems, and the nature of the solutions that are framed in response. In addition, we introduced a third, overarching, framing feature that encompasses the forgoing, namely, the representation of knowledge about *coordinated international actions* designed to help manage transitions toward sustainable development. These actions consist of the multilateral initiatives and moves designed to address and help manage sustainability problems at all levels and in all parts of the world.

Coordinated international actions include legally binding commitments (i.e. international treaties and conventions), as well as non-binding understandings or expressions of desired directions of policy (such as *Agenda 21* and the *Millennium Development Goals*). Earlier, in Chapter 1, we noted the most salient types of coordinated international actions to date. Over time, of course, we would expect these actions to reinforce emergent trajectories toward sustainable development.

Framing sustainable development as a knowledge domain serves as the foundation for the entire GSSD computational design and its implementation. It consists of the directives for indexing knowledge-content and for enabling search and retrieval of content. Thus, while this initiative may not entirely resolve the conceptual ambiguities surrounding sustainable development, it does provide considerable order in the knowledge domain and its representation.

4.5.2 Managing the Explosion of e-Content

A rapid Google-search for *sustainable development*, undertaken on April 26, 2006, yielded 197,000,000 returns. This fact signals the volume of materials at hand, but it provides no information about nature, type, quality, content, reliability, and so forth. It is not unusual for a user to spend considerable time online searching for relevant materials on any specific set of issues. From a knowledge management perspective, the generic dilemma is basically one of designing discriminating categories for dealing with what appears to be information overflow. In response, we developed a *knowledge provision process* to help the select relevant content, guided by quality controls derived from *mapping sustainability.*

This entire initiative is predicated on the explicit intent of protecting intellectual quality and institutional integrity. This means that we utilize specific criteria for selecting content-materials and self-consciously discriminate in favor of reliability. Some observers might construe this approach as a censorship strategy. Yet users can always opt for Google or other search engines in order to caste a wider net, unconstrained by GSSD quality controls.

In short, the knowledge-provision process, presented in Chapter 3, consists of specific criteria and decision-rules for all content-providers and content-submissions. Once submitted to GSSD, any knowledge item is reviewed for content and for completion in the fields in the submission form. This process helps to routinize the knowledge provision process and contributes to consistency in knowledge representation, retrieval and integrity.

4.5.3 Recognizing Realities-on-the-Ground

Powerful infrastructure constraints often impede access to the Internet in many parts of the world. These are well recognized and well documented. Digital differences between rich and poor are routinely noted in any review of the global economy, and almost every international institution dealing with developmental issues has noted these differentials as obstacles to change. Even with robust infrastructure prevailing organizational may be such as to impede access to cyber venues.

Our approach to this type of e-barrier is to implement a mirror-sited strategy, whereby the GSSD-MIT system that resides physically on an MIT server is replicated in other locations worldwide. And, as indicated earlier in this chapter, GSSD computational and organizational technologies ensure that the mirror sites remain identical in system operations and knowledge content. Mirror sites also allow users to connect to the server closest to them, to download materials as needed and even to keep the entire knowledge-base offline for detailed search – and then connect to the Internet for retrieval of the full document, if required, or to engage in further search and retrieval. Such a strategy is contingent on a set of operational partnerships with GSSD collaborators so as to facilitate overall knowledge provision, on the one hand, and enhance the utility of knowledge use on the other.

Earlier in this chapter we noted the various partnership types that sustain a distributed system as GSSD, as well as the types of roles of functions that must be undertaken in order to provide the institutional or organizational foundations for computational efficacy. Much of the management of a distributed knowledge networking system involves the goodwill and efficiency of individuals with different skills and interests, and of institutions with differing missions and priorities.[14] This diversity amounts to a valued resource in its own right.

4.5.4 Transcending the Dominance of English

As we are often reminded, about 385 million people in this world speak English as their native language; but roughly 6.5 billion speak something else. The Internet is an English-speaking venue – in a world that is non-English speaking. Differences among languages invariably involve differences in *understandings* created by linguistic disparities, as well as differences in expression and articulation.

[14] Select chapters of this book are authored by such individuals – located in such institutions – recording their own views and experiences, as well as suggestions for next generations of initiatives such as GSSD. Other chapters address the challenges of retaining the replica strategy for the mirror-sites.

Our solution to this very real problem is to develop a strategy for *multilingual knowledge* e-networking. First, a shared understanding of core concepts must be established across languages. Second, a computational logic is needed for rendering consistency across languages for each of the knowledge-items in the database. Third, computational capabilities must be available in order to implement search and retrieval across languages.

All of these elements are essential in order to enable users and providers from various parts of the world to express themselves in the appropriate language, idiom, and terminology, and these elements enable the computational features of the system to recognize the differences among languages. If these requisites are met, then the synchronization and replication of content across all mirror sites can be undertaken and rendered robust.[15]

4.5.5 Reducing Bias in Knowledge Provision

In general, e-barriers such as those addressed above reinforce prevailing biases in e-knowledge-provision. For example, given structural impediments to e-access and the dominance of English, e-materials and resources are provided by users in industrial countries. This conjunction of factors means the voices expressed and the messages that are heard come mainly from the 'north.' Aside from the issue of equity in global expression – so critical in its own right – the bias of overrepresentation creates an echo effect about the nature of the problems and the types of solution, irrespective of empirical foundations.

The approach we developed to address the bias problem consists of the design, development, and implementation of a workflow process coupled with a systematic knowledge provision process. In Chapter 3, we introduced a customization strategy for the workflow process in response to different situations on-the-ground and different realities facing the various collaborators. The workflow itself constitutes (a) a key element of the collaborative process, (b) an essential requisite for computational purposes, and (c) a fundamental feature for content-consistency across multilingual databases.

Also in Chapter 3, we put forth guidelines for knowledge provision, as well as computation and organization capacity to allow anyone to participate creating the GSSD knowledge-base, and to engage in retrieval, search, and knowledge access in languages other than English. While the *workflow*

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[15] Recall that much of the discussion in Chapter 3 addressed these issues, and the appendices to that chapter provided added information.

process is designed to support global collaboration, it also protects individual and institutional autonomy for all participants.[16]

4.5.6 Designing Cost-Effective Strategies

The sixth and final impediment addressed in this book pertains to matters of cost and price. Despite trends toward homogenization (not necessarily harmonization), the costs of Internet access vary greatly across countries as does the cost of hardware and software. The economics of Internet access make it difficult for most people, in most paces, to participate in the new cyber possibilities, thus compounding the impacts of infrastructure variability and reinforcing any prevailing bias in provision.

Shaped by differences in government policy, economic conditions, structural features and other factor, we cannot reduce such variability at-the-source, so to speak. What can be done, however, is to structure collaborative partnerships in ways that build upon pragmatic in-kind cost-sharing approaches. Contributions of this sort reduce burdens borne by the collaborating partners. For the most part, such cost-sharing supports all human and machine requirements for operating the mirror sites.

4.6 End Note

This End Note serves as a conclusion to Part I of this book. Focusing on *mapping sustainability,* Chapter 1 provided the conceptual framework for the design and development of sustainable development as a knowledge domain. The subsequent chapters presented the computational features that support the operations of a global knowledge e-networking system. Overall, Chapters 1–4 are theoretical and analytical, as well as methodological and computational. Jointly, they report on our strategy for transcending the barriers to e-knowledge and implementing a collaborative e-networking system with global reach.

The chapters of Part I all contribute to the theory, methodology, and strategy for supporting a collaborative of knowledge e-networking system predicated on the view and vision introduced earlier. Recall that this vision defined the knowledge e-network as:

[16] Recall that in Chapter 2, we defined the key elements of a global e-knowledge e-networking system in ways that include a common framework as well as supports collaboration while at the same time, reinforce, the individual autonomy of the participants in the networked.

> A computer-assisted organized system of discrete actors, with (a) knowledge producing capacity, (b) combined through the use of common organizing principles, (c) retaining their individual autonomy, such that (e) networking enhances the value of knowledge to the actors and, accordingly, (d) knowledge is further expanded.

Part I provided an overview of the ways in which we have addressed some fundamental e-barriers to knowledge bearing on sustainable development – in conceptual and computational terms, as well as application and implementation. Accordingly, we put forth the ontology of sustainability, along with a detailed a profiling of the domain content. In terms of method, we concentrated on applications of e-technology as well as computational issues, the design and management of a distributed workflow process coupled with key organizational requisites for worldwide e-collaboration.

Part II presents a closer look at some of the challenges associated with applications and implementation, and the ways in which the conceptual design is transformed into operational venues of knowledge e-networking.

PART TWO

Chapter 5

ORGANIZATIONAL INNOVATION

Global Workflow and Institutional e-Networking

Farnaz Haghseta and Nazli Choucri

Introduction

To date, much of the attention on the role of e-technologies for facilitating development has focused on increased knowledge intensity of economic activity. By the same token, much of the attention to knowledge e-networking has addressed matters related to infrastructure, the nature of the Internet, or situational impediments facing users in various parts of the world. Less appreciated, however, are the organizational and institutional barriers to knowledge e-networking worldwide.

This chapter indicates how human-centered factors impede technological developments and how such impediments can delay the deployment of new applications in response to new demands shaped by new realities. In this connection, the GSSD experience is probably not idiosyncratic. It highlights classes of human-centered features as well as organizational issues that are increasingly important in the domain of knowledge e-networking, especially in the context of distributed global collaboration.[1] More specifically, this chapter focuses on three sets of institutional challenges that are a generic nature, and thus relevant to different contexts, locations, and domains.

The first set of challenges pertains to the nature of the *initiating institution* that serves as the focal point for framing and generating a global e-network. In this case, the institution is GSSD at MIT. The challenge consists

[1] This chapter should be considered in the context of the issues addressed in Chapter 7 focusing on GSSD-Arabic. The discussion of multiple challenges, problems trials and errors associated with the implementation of GSSD-Arabic reflect the organizational disconnects between the initiating GSSD institution (MIT) and the collaborating technical partner (Lotus-IBM). It also shows the ways in which all partners have contributed to the development and implantation of the overall global system – each operating within attendant and immediate institutional constraints, and each seeking to create the best uses and best leverages of their own capacities.

N. Choucri et al. (eds.), Mapping Sustainability: Knowledge e-Networking and the Value Chain, 85–99.

of the nature of its research personnel. The GSSD project continues to be managed on a day-to-day basis by MIT undergraduate and graduate students. Motivated by of the opportunity to participate in an innovative venture, these students consider the GSSD project as part of their educational experience. GSSD does not employ a permanent staff, and relies almost entirely on the participation of students. This situation is typical at MIT, a major research university, where groundbreaking initiatives are closely connected to the students' educational experience. As always, the research directors give priority to student schedules and educational requirements. This situation inevitably introduces delays in a research problem that often coincide with the academic calendar.

The second set of challenges are those central to the collaboration with Lotus-IBM around e-product development and the technological obstacles that impede the deployment of an emerging technology. In addition, the multilingual aspects of the GSSD mission, buttressed by the nature of its overall vision, confronted Lotus-IBM with a new situation, one that had not been encountered earlier by the product developers assigned to this project.[2]

The third, and most important set of challenges, pertains to the organizational and technological capabilities that had to be established in order to render distributed knowledge e-management possible. Given the realities of the Lotus-IBM personnel issues and vision of the GSSD team at MIT, this third challenge called for large-scale and system-wide strategy in order to realize the very basics of distributed knowledge e-networking and to engage each of the partners around the world effectively in the pursuit of this goal.

In the absence of a more viable alternative, the GSSD team reframed the approach proposed by Lotus, and designed an entire distributed networking system. This technical challenge was undertaken while protecting the basic vision for the project as a whole.

In the last analysis, the successful re-design of GSSD and the development of a new institutional framework enabled the establishment of the knowledge e-network, the operation of the mirror sites, and the collaboration of the various participants in the management of an evolving e-knowledge-base.

Since all of the organizational challenges encountered in the course of product revolved around e-development, reutilization, evolution and management of the knowledge-base, this chapter draws upon this experience as the focal point for discussing each of the three sets of challenges noted above. Together, they highlight almost all of the critical institutional problems

[2] While the developers sought to derive a high degree of reliability for their product, internal personnel issues provided obstacles that were difficult to overlook. As an example, during the course of this collaboration, the Lotus-IBM technical liaison personnel to the project have changed six times over the last two years.

encountered and the innovations generated in the effort to reduce the resulting impacts.

5.1 The GSSD Knowledge-Base

Given the complexity of the institutional issues in any distributed system we begin with the basics, namely the distinction between the essential technical and physical supports, on the one hand, and the critical interactions among the partners, on the other. The system as a whole is contingent on their effective operation.

5.1.1 Technical and Physical Supports

As noted earlier, the GSSD system is supported by a physical infrastructure composed of four basic elements. The most basic component is the *server*, which relies on Lotus-IBM Domino software for operation. The server hosts a set of Lotus-IBM Notes called *databases*, which contain GSSD content in various languages. Each database is comprised of *documents*. There are two basic types of documents, static and dynamic. Static documents include content that rarely changes once it is incorporated into the system, such as reports. Dynamic documents include content that require periodic updating and/or maintenance, such as abstracts.

Abstracts, which are the main building blocks of the GSSD knowledge-base, contain information on sustainability-related e-resources. These documents are created and maintained by *users*. As shown in Chapter 2 earlier, users themselves develop and maintain the GSSD knowledge-base.

5.1.2 Organization and Partners

GSSD relies fundamentally on its partners, who are distributed all over the world, to develop and organize localized content related to sustainable development in their local languages. Partners are also crucial in providing translation of localized content. The partners are responsible for the oversight of the entire system as illustrated in Figure 5.1. Each of the circular diagrams represents a mirror site location and each location houses an entire GSSD system.

In institutional terms, the GSSD network is much more than just a physical network of servers distributed across the world, as it is also an operational and interactive knowledge network. Once GSSD partners develop localized content and submit the materials to any of the mirror sites – or via the Web – these can then be transmitted through the system, translated into other languages, and distributed to other mirror sites.

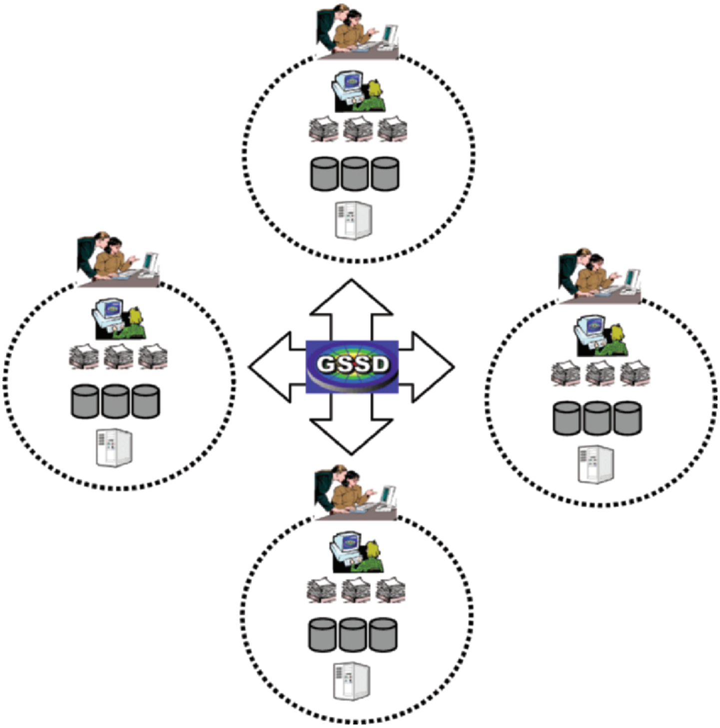

Figure 5.1 **Overall structure of the GSSD knowledge network.**

This entire system consists of a *network of network.* It allows for the effective development of localized knowledge, which can also be shared with the rest of the global knowledge network, leading to utilization, modification, and creation of an integrated knowledge-base.

5.2 Organizational Challenges

5.2.1 Diverse International Partners

The diversity and institutional nature of our partners present considerable challenges for GSSD administration. Cross-institutional management in itself is particularly challenging since each institution has its own policies and goals. GSSD partners are also distributed across countries. Differing cultural norms present an additional layer of complexity to GSSD management.

The institutional imperatives of GSSD partners translated into a series of technical requirements for GSSD. For example, it is important for partners to maintain control and ownership while asserting a certain level of independence from the main GSSD administrators and developers at MIT. As a result, the design has been configured as a "hub and spoke" system, where the "hub" represents the main administrative and development activities which take place on the Stage server, and the "spokes" represent the mirror sites which are essentially independent from each other, yet still maintain a direct line to the hub for necessary updates and upgrades.

5.2.2 Institutional Impediments

The requirements of a hub and spoke conception, in conjunction with the need for a distributed network characterized by the autonomy of the collaborators, resulted in a significantly more complicated technical design of the system than initially expected. Consequently it was resisted by Lotus-IBM, who believed that the system worked fine "as is." In fact, the Lotus technical staff did not grasp the complexity of their own product in a large-scale distributed application with different non-western languages.

This situation led to a set of significant disconnects between the GSSD team and the product developers at Lotus-IBM. In addition, the technical staff assigned to GSSD-MIT experienced considerable turnover, which resulted unavoidable delays. All of this was taking place as the new Lotus relationship with IBM was being realized.

5.3 Organizational Disconnects

A significant body of literature devoted to the impact of technical factors on organizational structure and processes addresses on the role of information technologies in redefining organizations. Several studies have focused explicitly on Lotus-IBM tools, including the IT application that we used to develop and enable GSSD.[3] An important empirical finding is that an entity initiating collaborative computing technologies, such as Lotus-IBM Notes, is unable to enact organizational changes on its own and that its responses are reactive rather than anticipatory. This finding is significant, as it points to constraints on corporate flexibility especially when confronting new operation conditions or applications defined by situational factors.

A number of organizational characteristics, such as cultural factors (such as how people understand and appreciate technology), and institutional properties (such as incentive systems or personnel-related norms) significantly influence how advances in information technology are implemented and used in organizations. In IT-producing firms, organizational constraints

[3] For example, see Orlikowski (1992, 1995).

of the sort we described above generate multiplier effects. This means that the usual factors that impede the effective use of IT in large corporations provide further constrain the development of new IT products. The GSSD experience appears to confirm these findings. More important, it illustrates the very real challenges involved in cross-organization collaboration.

In short, the organizational and institutional constraints noted above seriously impaired our ability (and that of our development partners) to utilize the new Lotus-IBM technology for distributed multilingual e-networking (i.e. our development partners' own technology) to its greatest potential. This situation shaped the vision for a new e-product, one that would have to be developed without the leadership of the IT product-developer itself.

Paradoxically, it is these organizational failures and the powerful impediments that they created actually enabled a valuable transformation of the GSSD system – from the Lotus-IBM application, then new, into an improved and more effective tool. The core of the new tool consists of the formalization and customization of the global workflow processes, on the one hand, and the consolidation of groupware technology, on the other.

To be fair, Lotus-IBM had not yet encountered e-networking applications in two non-western languages at the same time, and neither was represented in the usual Latin alphabet. The GSSD vision was simply too novel as an envisaged application.

More important, however, is the fact that the development and implementation of the new GSSD groupware technology is due to the belief among the GSSD partners that the management of diversity was essential to effective cooperation, that collaboration is a key to the project's success, and that this success is contingent of innovations in the management of distributed knowledge e-networking. Interestingly, this cooperative cultural feature of the GSSD networking vision entirely consistent with and enabled by the Lotus-IBM architecture and e-products, but it was considerably less consistent with the technical developer's operational norms-in-practice.

5.4 New GSSD Design

The organizational issues and institutional imperatives of GSSD partners translate into a series of technical features. For the knowledge-base itself, the abstracts of individual documents, constitutes the basic content. To ensure that the system operates in its intended manner, the set of technical requirements were formulated by the GSSD team, and then directed to the Lotus-IBM developers to be incorporated into the new system design. The technical requirements consist of the following elements:

- *Submission*: When an abstract is submitted at one mirror site, it is transmitted to all other mirror sites. When an abstract is submitted in one language, it is eventually available in all other GSSD-supported languages.
- *Translation*: Abstracts are translated once the English-Stage version of the abstract is completed. Abstracts are published once the English version of the abstract is published.
- *Changes*: When a change is made to an abstract, that change is propagated to all language versions of the abstract. A change made to an abstract is propagated to all other mirror sites.
- *Imperatives*: Simultaneous changes to an abstract are not allowed; these are typically referred to as "locks" in database terms. The user interface needs is user-friendly to ensure that the complexity of the backend operations is transparent to the users. The design takes the least amount of disk space and requires minimum bandwidth, to encourage maximum utilization of the system.

These requirements are essential for the distributed nature of the global e-networking system. In retrospect, most of the technical problems confronting GSSD in its development phase stemmed from the inability to address the above requirements adequately.

In the course of product development, GSSD confronted two choices: either to compromise its project goals and priorities by adapting to the limitations suggested by the Lotus developers and accept their system as is, or to pursue the initial vision and its design and implement the requirements with the GSSD team that consist of graduate and undergraduate students – rather than with the professional developers of Lotus-IBM.[4] Only the first of these options seemed viable to GSSD-MIT. Eventually, the GSSD team created the new design and resolved the technical problems noted above.

Once the design and its technological features were undertaken, the challenge was to ensure implementation on all mirror sites and involving all of the participating partners worldwide. At this point in this story of organizational challenges, the focus of activity shifted away from Lotus-IBM and GSSD-MIT to the MIT team and the other GSSD partners, GSSD-China, GSSD-Arabic, and early phases of GSSD-French.

[4] In the following section, the solution-strategy developed by the GSSD team was framed by its system administrator, and reported in a Master's Thesis for MIT's Technology and Policy Program. See Haghseta (2003).

5.5 From Knowledge e-Network to Global Workflow

As noted, the technological and organizational challenges encountered in the course of this project issues that have arisen over the last several years have resulted in a substantial redesign of the GSSD system. A significant result of this work is the development of the global workflow process. Initially, GSSD was designed as a knowledge networking application, intended to foster the distribution and provision of sustainability-relevant knowledge, in local contexts, multilingual formats, and distributed geographic locations. However, the organizational and institutional priorities, and the subsequent technical requirements, helped to formulate a new experiment which transformed GSSD into a unique technical application for knowledge e-networking in a collaborative mode.

5.5.1 Global Workflow

At this point, we return to the workflow, introduced earlier in Part I. The purpose of this section is to review the workflow process we developed in response to the institutional problems identified above. Recall that the workflow is defined as the management of content that flows between users, databases, and servers that are distributed across languages and geographical spaces. Thus, content submitted to GSSD originates, in and from, a specific location. By the end of the workflow process, this content is converted into all supported languages and resides on all mirror sites of the GSSD network.

In this connection, there are three possible workflow scenarios for submitting an abstract:[5]

- *Local submission*: An abstract is submitted to a mirror site in the local language of that mirror site (e.g., a French abstract is submitted to the GSSD France server).
- *Non-local submission*: An abstract is submitted to a mirror site in a non-local language of that mirror site (e.g., a French abstract is submitted to the GSSD China server).
- *Multi-local submission*: An abstract is submitted to a mirror site which supports multiple languages (e.g., an Arabic abstract is submitted to the GSSD staging server, which supports both Arabic and English translation).

To clarify this process, we present an example of the workflow process step-by-step in a scenario consisting of a French abstract submitted to the

[5] The above differentiation was developed during the design of the new global workflow process, and helped to define the various combinations of pathways that were possible for an abstract submitted to the GSSD global system.

French server, which is then published in all supported languages and available on all mirror sites.

5.5.2 Example of Global Workflow

In this example, we assume that there are three languages in the system, each with its own database. In addition, there are three servers distributed across the world: China, US (Stage server), and France. Servers are also known as mirror sites. Each step is numbered, and the sequence as a whole represents the overall process. In the Scenario below, we follow the computational steps as *a French abstract (denoted as Fr below) is submitted to the French server (local language).* The light shading of the Fr symbol (Fr) indicates its unpublished status. The darker shading (Fr) indicates that the abstract is published at that point in the workflow. We proceed thusly:

1. *The abstract is automatically located in "Submitted" status in the French database (DB).* As soon as this abstract is submitted, it is read-only in the system.

China Server	*Stage Server*	*French Server*	
Chinese DB	Chinese DB	Chinese DB	
English DB	English DB	English DB	
French DB	French DB	French DB	Fr

2. *The abstract is replicated to all servers.* As a result, there is a copy of the abstract in the French DBs of all servers in the GSSD network.

China Server		*Stage Server*		*French Server*	
Chinese DB		Chinese DB		Chinese DB	
English DB		English DB		English DB	
French DB	Fr	French DB	Fr	French DB	Fr

3. S*ynchronization takes place on the Stage server*. Synchronization results in the abstract being copied to the English DB in "Ready for Translation" status. The abstract in the French and English DBs are synchronized with each other. This means that the system recognizes them as the same abstract, even though they will later be in different languages.

China Server		*Stage Server*		*French Server*	
Chinese DB		Chinese DB		Chinese DB	
English DB		English DB	Fr	English DB	
French DB	Fr	French DB	Fr	French DB	Fr

4. *The abstract is replicated to all servers.* As a result, there is a copy of the synchronized abstract in the English and French DBs of all servers in the GSSD network.

China Server		*Stage Server*		*French Server*	
Chinese DB		Chinese DB		Chinese DB	
English DB	Fr	English DB	Fr	English DB	Fr
French DB	Fr	French DB	Fr	French DB	Fr

5. *On the French server, the French team opens the English DB and observes that there is a French abstract that needs to be translated into English (under the heading "Abstracts for Translation").* When they are done translating it into English, the abstract is marked as "Ready for Review." (The En indicates an unpublished English abstract.)

China Server		*Stage Server*		*French Server*	
Chinese DB		Chinese DB		Chinese DB	
English DB	Fr	English DB	Fr	English DB	En
French DB	Fr	French DB	Fr	French DB	Fr

6. *The translated abstract is replicated to all servers.* As a result, there is a copy of the English abstract in the English DBs of all servers and a copy of the French abstract in the French DBs of all servers in the GSSD network.

China Server		*Stage Server*		*French Server*	
Chinese DB		Chinese DB		Chinese DB	
English DB	En	English DB	En	English DB	En
French DB	Fr	French DB	Fr	French DB	Fr

7. *The reviewer on the Stage server opens the English DB and sees that the translated abstract is "Ready for Review."* The abstract is reviewed for English grammar, etc. as well as for content. If any changes were made to the English version of the abstract, a message is sent to the French team to check the original French version. At this point, the English abstract is published on Stage.

China Server		*Stage Server*		*French Server*	
Chinese DB		Chinese DB		Chinese DB	
English DB	En	English DB	En	English DB	En
French DB	Fr	French DB	Fr	French DB	Fr

8. *Synchronization takes place.* Synchronization results in a copy of the English abstract being placed in the remaining language DB with the status “Ready for Translation.” The French abstract is also changed to “Ready for Review” status, with a link to the published English abstract and the note submitted by the English reviewer regarding changes made.

China Server		*Stage Server*		*French Server*	
Chinese DB		Chinese DB	En	Chinese DB	
English DB	En	English DB	En	English DB	En
French DB	Fr	French DB	Fr	French DB	Fr

9. *The published English abstract is replicated to all servers*. Also, there is a copy of the English abstract in the Chinese DBs of all servers under “Ready for Translation” and a copy of the French abstract in the French DBs of all servers under “Ready for Review.”

China Server		*Stage Server*		*French Server*	
Chinese DB	En	Chinese DB	En	Chinese DB	En
English DB	En	English DB	En	English DB	En
French DB	Fr	French DB	Fr	French DB	Fr

10. *The French see the French abstract in “Ready for Review” (it is no longer “read-only”), where they can now make changes to it and prepare it for publication*. They check the English link in the abstract and the note submitted with the abstract to check for changes. Once the changes are made in order to match the English abstract, the French translation manager reviews and publishes the French abstract.

China Server		*Stage Server*		*French Server*	
Chinese DB	En	Chinese DB	En	Chinese DB	En
English DB	En	English DB	En	English DB	En
French DB	Fr	French DB	Fr	French DB	Fr

11. *The Chinese team opens the Chinese DB in China, finds the English abstract under “Ready for Translation,” and translates the English abstract into Chinese*. Once the abstract is translated, it is placed under “Ready for Review.”

12. *The Chinese translation manager reviews and publishes the Chinese abstract*. (The Ch indicates a published Chinese abstract.)

China Server		*Stage Server*		*French Server*	
Chinese DB	Ch	Chinese DB	En	Chinese DB	En
English DB	En	English DB	En	English DB	En
French DB	Fr	French DB	Fr	French DB	Fr

13. *Replication occurs.* As a result of replication, the synchronized abstract is now distributed amongst all databases and published in all supported languages.

China Server		*Stage Server*		*French Server*	
Chinese DB	Ch	Chinese DB	Ch	Chinese DB	Ch
English DB	En	English DB	En	English DB	En
French DB	Fr	French DB	Fr	French DB	Fr

The workflow process for this abstract is now complete. The scenario depicted above illustrates the extent of collaboration and cooperation needed to ensure successful operation of GSSD. There are several necessary technical steps, but also several requirements for human intervention throughout the workflow.

Even though these abstracts are located in different language databases and different servers, the GSSD system still recognizes them as the same synchronized abstract. Therefore, if the abstract is deleted at some point after publishing, all copies of that abstract will be subsequently deleted during the next synchronization and replication process.

5.5.3 Relevance of GSSD Global Workflow

The new GSSD framework and its implementation offers promise for new IT applications that promote sustainable development, but can also be utilized in other domains where collaboration is required. This is especially relevant for user-groups who require reliable distributed networks and a workflow process that responds to their distribution and diversity, and such as multinational companies and international institutions, for instance. Later on in Part II we provide a specific example of such a case.

This new global workflow methodology has wide applicability because it operates on the premise that a partnership or organization is distributed across multiple geographic locations and languages. Such characteristics are becoming more and more prevalent and are shaping the needs of complex, multinational, and international institutions.

Furthermore, this workflow innovation is particularly significant in today's global reality because it recognizes the importance and the value of their diversity among the partners, and provides a platform harnessing gains due to differences as well as similarities perspectives – irrespective of location or situation, These features contribute to leveling the playing field for all parties in the e-network, enhance synergy and cooperation as relevant, and ensure an increasingly effective workflow process.

5.6 Contributions to it for Sustainability

The GSSD system contributes to the body of research findings in the IT and sustainability in a number of ways, only two of which we note below:

First, GSSD provides a valuable case experience of an interactive IT technology that successfully leverages IT enables capabilities, while addressing some of the barriers that impede transitions toward sustainable development.

Second, the global workflow application is an innovative response in support of global GSSD vision. As such, it demonstrates the practical and flexible features provided by advances in information technology, as well as the potentials and possibilities.

Third, the GSSD-related challenges addressed in this chapter are essentially human-centered in nature and help us appreciate the importance of human-to-human interactions in the course of developing new e-products and processes.

Experiences such as these generate important lessons in e-networking theory and in practice. In the absence of precedents for this type of worldwide collaborative initiative, any innovations in the technical or physical aspects of networking must be matched by commensurate advances in institutional and organizational contexts.

GSSD represents an application in information technology that leverages multiple positive linkages between IT and sustainability. These linkages create synergies due to the implementation of the convergent capabilities or functionalities that include: (a) a potentially powerful tool that contributes to social empowerment through *provision of knowledge* about sustainability challenges and local initiatives; (b) a *computational platform* for integrating a vast amount of valuable and relevant information related to various aspects of sustainability; and (c) a *knowledge networking architecture* that utilizes the power of the Internet and related IT tools to strengthen and ensure continued evolution of the GSSD knowledge-base.

Among the GSSD features designed to enhance understanding and reduce distortions in communication, interaction, knowledge provision, as well as knowledge access and retrieval three sets are especially notable. First is an operational definition for sustainability and a *conceptual framework* that reduces, even prevents, ambiguity while supporting the analysis of inherently complex sustainable development issues; second is a well-defined and structured *quality control process*, which maintains and ensures high quality and reliability in the GSSD knowledge-base while also allowing it to be populated in a distributed and collaborative manner; and third is an effective set of capabilities to directly *address digital* and *knowledge divides*.

This third set of design features includes multilingual support and inclusion of a wider audience with diverse demographic and cultural characteristics; an interface that enables the development and provision of local content, to help support local action initiatives related to sustainable development; and extensive search capabilities available to everyone on a "non-premium" basis.

5.7 Conclusion

This chapter illustrates some of the operational challenges involved in the development and deployment of GSSD as a global knowledge e-networking system. In particular, we highlight the importance of human-centered constraints associated with implementing information technology initiatives in complex and globally-distributed institutions and organizations. Advances in information technology play a significant role in overcoming barriers to knowledge e-networks if, and only if, potential challenges, even limitations, are identified and addressed effectively.

The key task for researchers and policymakers is to assess how to utilize changes in information technology to advance institutional and organizational goals and to minimize the risks. For example, the GSSD project relies on Lotus Notes, one of the most prevalent "groupware" technologies. Would some of the organizational and institutional challenges described in this chapter be better served by a different technological platform?

Applications of information technology do not automatically create the transformations needed for an effective knowledge e-network. However, they allow do us to effectively utilize the greatest natural resources available for these endeavors: human intelligence, creativity, and ingenuity.

References

Haghseta, F. S. (2003). *Information, technology and sustainable development: understanding linkages in theory and practice*. S.M. Dissertation. Cambridge, MA: Massachusetts Institute of Technology.

Orlikowski, W. (1992). Learning from notes: organizational issues in groupware implementation. *Center for Coordination Science Technical Report* #134, MIT Center for Coordination Science: Cambridge, MA.

Orlikowski, W. (1995). Evolving with notes: organizational change around groupware technology. *Center for Coordination Science Technical Report* #186, MIT Center for Coordination Science: Cambridge, MA.

Chapter 6

INFORMATION AND COMMUNICATION TECHNOLOGY IN THE ARAB REGION

Toufic Mezher

Introduction

In recent years, major advances in information and communication technologies (ICT) combined with the rapid growth of global networks such as the Internet, have transformed businesses and markets, revolutionized learning and knowledge-sharing, generated global information flows, empowered citizens and communities in new ways that redefine governance, and created significant wealth and economic growth in many countries.[1] This trend, labeled as the digital revolution has been made possible by the potent combination of dramatic increases in the power and versatility of technologies, at significantly lower costs with enormous creativity in the applications of these tools and networks in all aspects of the economy and society. The ICT sector is one of the highest growing sectors in the world economy. It is one of the chief contributors to world economic growth, to job creation, and to productivity enhancement.

Recent developments in the ICT sector have been especially revolutionary. Information and knowledge are expanding in quantity and accessibility. In many fields, future decision-makers will be presented with unprecedented new tools for development. In such fields as agriculture, health, education, human resources and environmental management, or transport and business development, the consequences could be revolutionary. ICT has enormous potential, especially for developing countries, in furthering sustainable development. The whole world is now focusing on the role of ICT as an essential tool for socio-economic development. It can potentially be a powerful enabler

[1] In this chapter, information and communications technologies (ICT) refer to electronic means of capturing, processing, storing, and communicating information. It is based mainly on digital information and comprises computer hardware, software, network infrastructures, and related services.

N. Choucri et al. (eds.), *Mapping Sustainability: Knowledge e-Networking and the Value Chain*, 101–121.

of development goals because its unique characteristics dramatically improve communication and the exchange of information in order to strengthen and create new economic and social networks (Aboge, 2001).

Building a knowledge society today is very important for economic and social development of developing and poor countries. ICT is the main driver or the tool for building that knowledge society. Knowledge resides in people rather than in the information infrastructure. The knowledge economy relies on the diffusion and use of information and knowledge, as well as its creation. That is why its success depends on the ICT infrastructure. Today, we live in a very competitive and dynamic global economy and holding on to the status quo is not an option anymore (Mansell and When, 1998; Information Society Commission, 2002). No region or country can afford to ignore its ICT sector.

This chapter reviews the role of ICT for a country in a realm of global competitiveness, highlights the role of ICT in Arabic countries, and identifies some of the key features impeding the full development of ICT in the Arab countries. Finally, some strategies and recommendations are put forth for building competitive economies based on ICT infrastructure supporting knowledge creation and dissemination.

6.1 ICT in a Global Context

The concept of a *digital divide* gained headway in the early nineties with the explosion of Internet and dot-com companies. Developed countries capitalized on this new economy by constructing modern ICT infrastructure and by creating innovative environments for the private sector to grow. Developing countries were not able to follow suit because of old and badly damaged ICT infrastructure, not to mention political and economic corruption (Warschauer, 2003). If we consider the Gross Domestic Product (GDP), a leading indicator of economic prosperity, we see that economic disparity between countries is increasing. In 1995, the GDP in the twenty richest countries was 37 times that of the poorest twenty countries. In 1960, the gap was only 18 times (WDR, 2001). Another study by the United Nations Development Program (1999) shows that GDP ratio between the same two groups increased from 30 to 1 in 1960, to 60 to 1 in 1990, and 70 to 1 in 1997. Figure 6.1 shows this gap (UNDP, 1999).

A related view is obtained in Table 6.1, which shows 2005 statistics on the world Internet usage as compared to population in different parts of the world (IWS, 2005). Note that the Middle East and Africa have the *lowest*

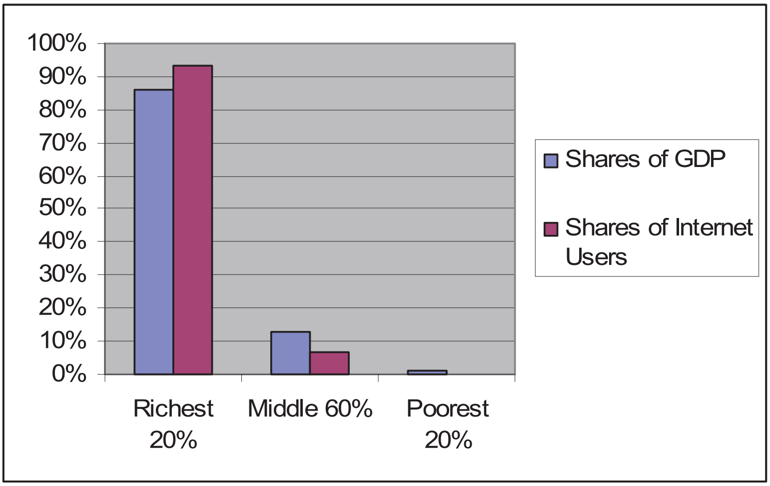

Figure 6.1 **Shares of global GDP and Internet users among world population. Based on data from UNDP, 1999.**

Internet penetration in the world even though they have the largest usage growth compared to others. While the data show that many developing and poor countries are realizing the importance of ICT, the road ahead is still very long. It is clear that the Middle East region (made mostly of Arab states) is lagging in significant ways.

Table 6.1 **World Internet usage and population statistics.**

World Regions	**Population (2005 Est.)**	**% of World**	**Internet Usage, Latest Data**	**% Internet Pene-tration**	**Usage % of World**	**Usage Growth 2000–2005**
North America	331,473,276	5.10	225,801,428	68.10	22.20	108.90
Oceania/ Australia	33,956,977	0.50	17,690,762	52.90	1.80	132.20
Europe	807,289,020	12.40	290,121,957	35.90	28.50	176.10
Latin America	553,908,632	8.5	79,033,597	14.30	7.80	337.40
Asia	3,667,774,066	56.40	364,270,713	9.90	35.70	218.70
Middle East	190,084,161	2.90	18,203,500	9.60	1.80	454.20
Africa	915,210,928	14.10	22,737,500	2.50	2.20	403.70
World Total	**6,499,697,060**	**100.00**	**1,018,057,389**	**15.70**	**100.00**	**182.00**

Based on data from World Internet Stats (www.internetworldstats.com).

As noted in earlier chapters of this book, English remains the dominant language on the Internet, even though many studies have shown a drop from 81% to 68% from 1997 to 2000. This dominance is due to the fact the early designers and users of the Internet were the Americans. Table 6.2 shows the ratio of speakers of a language to web pages in that language (Warschauer, 2003).

Table 6.2 **Ratio of speakers of a language to web pages in that language.**

Rank	Language	Number of Web Pages	Number of Speakers (000)	Speakers/ Web Page
1	English	214,250,996	322,000	1.5
10	Japanese	18,335,739	125,000	6.8
26	Hebrew	198,030	12,000	60.6
31	**Arabic**	**127,565**	**202,000**	**1,583.50**

Based on data from Warschauer, 2003.

Since citizens of many countries around the globe do not speak English, especially in developing and poor countries, it is important to build websites in native languages in order to disseminate information and knowledge. In this connection, the Arabic language is ranked lowest in Internet usage, which also means that there is significant lack of information and knowledge available online in that language. It also signals the poor condition of ICT infrastructure throughout the Arab world.

6.2 ICT in the Arab Region

The implications of the above can best be understood by viewing the Arab states within a broader context. The Arab countries as a whole account for 5% of the world's population and 2% of the world GDP. Despite its relatively high average GDP per capita by international standards, the Arab world still accounts for less than 2% of the world's Internet users. This simple fact suggests that the traditional source of the digital divide – namely poverty reflected in lower income per capita – does not appear to be the major impediment of ICT deployment in that region (ITU, 2002).

In the context of the digital divide itself, it is important to note the prevailing gaps between countries within the Arab world, as shown in Table 6.3. There are marked variances between countries in their efforts to adopt ICT tools and grow their networked economies. For instance, the United Arab

Emirates (UAE) and Bahrain have a well-established Internet presence given their status as an ICT hub in the Middle East (created by massive foreign ICT investments). Also important is the case of Lebanon. Despite poor government support and mediocre capital injected in the ICT market, it has an enormous potential for development and adoption of key technologies. This is due to its skilled workforce and the openness of its market. By contrast, the trends in, and the limited ICT-related performance, of Egypt are shaped by its huge population, the concentration of development around the main cities, and the wide gap between rural and urban areas. At the other end of the region's spectrum is Israel, the most advanced country in the region. Israel has a penetration rate of almost 50% of the total population. The contrast is Yemen that has the lowest penetration among all the countries in the region. Finally, what is startling in the Middle East as a whole is that only four countries have more than 5 ISPs. Such simple statistics reflects the prevailing monopoly in many countries, and the essential features associated with market closure (IWS, 2005; ITU, 2002).

Table 6.3 **Selected ICT indicators in the Arab world, 2001.**

Country	Population	Internet Users	% Population Penetration	ISPs
Algeria	32,530,000	180,000	0.55	2
Bahrain	688,345	140,200	20.37	1
Chad	9,833,000	4,000	0.04	1
Egypt	77,510,000	2,420,000	3.12	50
Iran	68,020,000	420,000	0.62	8
Iraq	26,070,000	12,500	0.05	1
Israel	6,280,000	3,130,000	49.84	21
Jordan	5,760,000	212,000	3.68	5
Kuwait	2,340,000	200,000	8.55	3
Lebanon	3,830,000	300,000	7.83	22
Libya	5,770,000	20,000	0.35	1
Morocco	32,720,000	400,000	1.22	8
Oman	3,000,000	120,000	4.00	1
Qatar	863,051	75,000	8.69	1
Saudi Arabia	26,420,000	2,540,000	9.61	42
Somalia	8,590,000	200	0.00	3
Sudan	40,190,000	56,000	0.14	2
Syria	18,450,000	60,000	0.33	1
Tunisia	10,070,000	400,000	3.97	1
UAE	2,560,000	900,000	35.16	1
Yemen	20,730,000	17,000	0.08	1

Based on data from World Internet Stats (www.internetworldstats.com).

Against this background, we can now evaluate ICT in the Arab region. This coverage includes a review of the *environment*, the degree of *readiness,* and the current *usage* of ICT. We turn to each of these factors in turn.

6.2.1 ICT Environment

The concept of ICT Environment refers to the conduciveness of the overall socio-economic and political context for ICT development, and the extent of its articulation or 'maturity' in the Arab region. ESCWA has undertaken two studies, one in 2003 and one in 2005 (ESCWA, 2003, 2005), comparing ICT maturity levels of different countries, and placing these at one of four levels: Level 1, indicates the absence of a clearly articulated vision and national ICT strategy, and limited implementation plans and initiatives; Level 2, which indicates the existence of a clearly articulated vision and national strategy, albeit with limited implementation plans; Level 3, which indicates the existence of a clearly articulated vision and advanced national strategy, in addition to moderately effective implementation plans; and Level 4, which indicates a clearly-articulated vision and advanced national strategy, and effective implementation plans.

Table 6.4 shows the distribution of 'maturity levels' for ESCWA countries. Many countries are moving forward and have reached Level 4 like Bahrain and Jordan. Others are doing an excellent job and have moved forward since

***Table 6.4* Ranking of ESCWA members according to ICT strategy and policy maturity levels.**

Country or Territory	**Year**	
	2003	**2005**
Bahrain	Level 2	Level 4
Egypt	Level 2	Level 3
Iraq	Level 1	Level 1
Jordan	Level 3	Level 4
Kuwait	Level 2	Level 3
Lebanon	Level 1	Level 2
Oman	Level 2	Level 2
Palestine	Level 1	Level 1
Qatar	Level 2	Level 2
Saudi Arabia	Level 1	Level 3
Syrian Arab Republic	Level 1	Level 2
United Arab Emirates	Level 3	Level 3
Yemen	Level 1	Level 1

Based on data from ESCWA, 2005.

2003 and today they can be classified as Level 3. Such countries are Egypt, Kuwait, Saudi Arabia, and the UAE.[2] The remaining countries are still at Level 1or Level 2. These are countries that have to undertake radical changes in their ICT policies and strategies in order to develop the next two levels of ICT maturity.

One note about Lebanon is of special relevance here. Following the termination of civil strife in 1990, the country had an excellent vision of building the ICT sector, through the leadership of the late Prime Minister Rafic Hariri. It did invest in ICT infrastructure and was the leader in the region in Internet and Global System for Mobile (GSM) Communications Services. The country did acquire the technology and built its human ICT infrastructure since the mid-nineties. But by the late nineties, Lebanon lost its competitive edge. This has resulted in brain drain of Lebanese ICT experts to neighboring and international countries. Today, the two GSM companies are owned by the Lebanese government but operated by two non-Lebanese regional companies. Thus, while development toward greater ICT maturity may be policy, the reality can reflect marked deterioration instead.

6.2.2 ICT Readiness

ICT Readiness describes maturity level as well as infrastructure conditions. This includes consumers' access to telephone fixed lines, mobile services, Internet access, and personal computers penetration. The MADAR Research Group, a leading ICT research group in Dubai, created an ICT Index – consisting of four parameters, namely of the number of personal computers (PCs) installed, the number of Internet users, the number of mobile phones, and the number of fixed lines in the country. The Index is calculated by summing the values of these four parameters and dividing the sum by the country's population figure. A higher Index score indicates more aggressive ICT adoption in the country under question (MRG, 2006). Table 6.5 shows the ranking of ESCWA countries according to the ICT index (ESCWA, 2005; MRG, 2006).

The ranking is consistent with maturity levels discussed earlier and provides a confirmation of the inferences we have drawn. More specifically, Bahrain, the UAE, and Kuwait remain the most advanced countries in the region because of their ICT investment as shown in Table 6.6 (ESCWA, 2005). Only Bahrain is spending 6% of its GDP on ICT, which is equal to the world average. Many countries are investing more nowadays on ICT but this is still not enough for their economic and social development.

[2] The city of Dubai is at Level 4.

***Table 6.5* Ranking of ESCWA members according to the ICT Index.**

Rank	Country or Territory	Popu-lation (000)	PCs (000)	Internet Users (000)	Fixed Line Subscribers (000)	Mobile Phone Subscribers (000)	ICT Index
1	Bahrain	708	145	202	192	650	1.68
2	UAE	4,320	850	1,437	1,200	3,700	1.66
3	Kuwait	2,750	450	590	490	2,109	1.32
4	Qatar	790	142	125	200	490	1.21
5	Saudi Arabia	22,866	2,250	3,400	3,695	9,176	0.81
6	Jordan	5,470	400	550	638	1,624	0.59
7	Lebanon	4,500	420	600	704	900	0.58
8	Oman	2,410	130	201	243	806	0.57
9	Palestine	3,670	170	380	332	854	0.47
10	Syria	17,980	430	700	2,657	2,480	0.35
11	Egypt	73,500	1,900	3,900	9,600	7,557	0.31
12	Iraq	25,400	480	450	960	1,598	0.14
13	Yemen	20,350	190	210	750	1,100	0.11
	Total	**184,714**	**7,957**	**12,745**	**21,661**	**33,044**	**0.41**

Based on data from ESCWA, 2005.

***Table 6.6* ICT spending in the ESCWA region.**

Rank	Country or Territory	GDP (*Billions of $*)	ICT Spending (*Billions of $*)	ICT Spending (*% of GDP*)
1	Bahrain	10.00	0.60	6.00
2	Palestine	4.46	0.21	4.71
3	Jordan	11.20	0.52	4.64
4	Iraq	21.10	0.85	4.03
5	United Arab Emirates	91.00	2.80	3.08
6	Lebanon	21.77	0.58	2.66
7	Saudi Arabia	251.00	6.20	2.47
8	Egypt	75.15	1.78	2.37
9	Syrian Arab Republic	23.13	0.53	2.29
10	Kuwait	50.00	1.10	2.20
11	Oman	24.50	0.50	2.04
12	Qatar	28.46	0.52	1.83
13	Yemen	12.83	0.20	1.56
	Total	**625**	**6.39**	**2.62**

Based on data from ESCWA, 2005.

6.2.3 Fixed Lines

Governments in the region control and operate most of the fixed lines services. Figure 6.2 shows growth rate in fixed lines services. Egypt, Syria, Yemen, and Qatar have the highest growth because these governments only invested recently in fixed lines in order to reach remote areas. Figure 6.2 shows that the UAE (28%), Bahrain (27%), and Qatar (25%) have the highest fixed lines penetration in the region where the regional average is about 12%. Iraq has one of the lowest penetration rates of 4% but the annual growth was 25%. Iraq still has not reached maturity in terms of fixed lines service whereas most countries in the region already have (ESCWA, 2005).

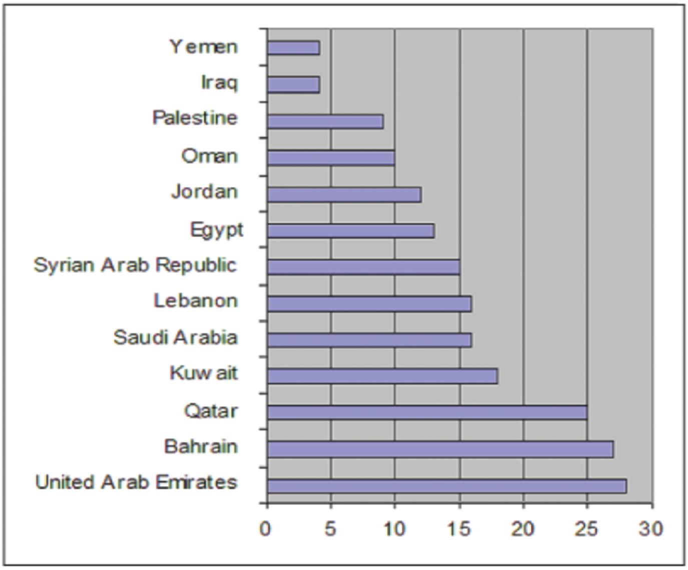

Figure 6.2 **Fixed lines penetration rates in ESCWA countries. Based on data from ESCWA, 2005.**

6.2.4 Mobile Service

The last two years have witnessed an explosion in mobile service subscribers across the region. Many consumers are opting for mobile serving over the fixed lines because of the increased competition in this sector. Many mobile service providers are affiliated with well-known international service providers such as Orange, France Telecom, and many others. This competitive environment has benefited consumers with cheaper fees over the fixed lines services.

Table 6.7 shows the growth rate of mobile service in ESCWA countries and many countries who have introduced mobile services very recently are showing higher annual growth rate than others. Iraq mobile services grew 1,353% between 2004 and 2005. This reflects the need for consumers to have a communication device to use in their daily lives. Mobile services infrastructure is easier to install and operate than poorly damaged existing fixed lines services. Lebanon only shows a 7% growth rate. There are two reasons for this relatively slow mobile service growth rate. First, mobile services in Lebanon started in 1994.

By now, a market saturation has occurred, where many sellers compete for consumers who already have service. Second, the cost of owning and using a GSM phone line is Lebanon is one of the most expensive in the world. The Lebanese national debt is about 200% of the GDP, and to the government, GSM services are a major source of income that will help in paying its debt.

Table 6.7 **ICT growth rates in ESCWA countries between 2004 and 2005.**

Country or Territory	Fixed Lines (%)	Mobile Lines (%)	Internet (%)	Personal Computers (%)
Bahrain	3	48	12	17
Egypt	9	30	44	19
Iraq	25	1,353	80	60
Jordan	2	23	28	21
Kuwait	0.2	30	47	32
Lebanon	0.57	7	14	31
Oman	3	37	15	17
Palestine	5	29	27	21
Qatar	8	30	39	14
Saudi Arabia	6	31	31	12
Syrian Arab Republic	10	109	30	10
United Arab Emirates	5	25	15	26
Yemen	9	38	50	15

Based on data from ESCWA, 2005.

Figure 6.3 shows that Bahrain (92%), the UAE (86%), Kuwait (77%), and Qatar (62%) have the highest penetration rate in the region and they have similar rates compared to North American and European countries. The average penetration rate in ESCWA countries is 18% and the world average is 26%. Yemen, Iraq, Syria, and Egypt have the lowest penetration rate but this is expected to increase in the next coming years, this is reflected in their growth rates, because mobile service were recently introduced and more investments are forecasted (ESCWA, 2005).

6.2.5 Internet Services

The Gulf Region countries have one of the most advanced Internet infrastructures in the ESCWA region. They have a Fibre Optic Gulf (FOG) backbone, which links Bahrain, Kuwait, Qatar, and the UAE, with a capacity of 5 billion bits of data per second (Gbps) per fiber pair. There are two other major links, namely: the Fibre Optic Link Around the Globe (FLAG), which connects Europe to Southeast Asia via the UAE, and the Europe 3 Cable System, which connects Southeast Asia, the Middle East, and Western Europe with a capacity of 40 Gbps.

The UAE, which enjoys one of the most advanced Internet infrastructures in the region, uses 10 STM-1 cables with a capacity of 1.5 Gbps in addition to satellite services. As for Saudi Arabia, the Internet bandwidth is 1,556 million bits of data per second (Mbps) and uses a mixture of cables, satellite and broadcasting stations. Saudi Arabia is also home to the ARABSAT satellite, which provides Internet connectivity among other broadcasting services.

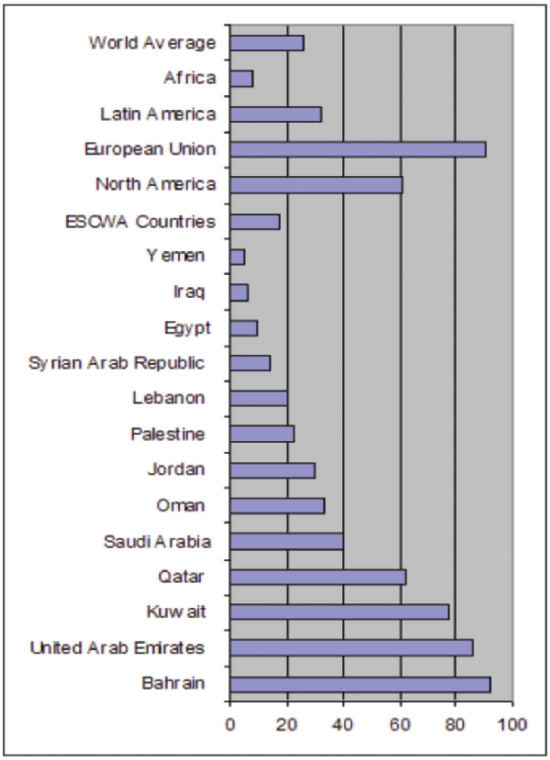

Figure 6.3 **Penetration rates of mobile lines in ESCWA and other countries. Based on data from ESCWA, 2005.**

In Egypt, the Internet bandwidth increased from 850 Mbps in 2003 to reach 2,060 Mbps in 2004. Meanwhile, in Jordan, the Internet bandwidth provided through submarine cables reached 465 Mbps. Other important developments in Internet backbone links are the Public Data Network (PDN) project in the Syrian Arab Republic, which increased Internet capacity to 500 Mbps by mid 2005 and is expected to reach 2.1 Gbps by year end 2005. Finally, Yemen Telecom's agreement with Alcatel, which will provide the first digital subscriber line (DSL) network of 3,000 lines in the first phase of installation (ESCWA, 2005).

Earlier, in Table 6.3, we showed that many countries have few ISP providers and only some of them have multiple providers. Egypt, for example, has more than 50 ISPs while the UAE has only one provider. Figure 6.4 shows that the UAE, Bahrain, and Kuwait have over 20% penetration rates where the average penetration rate of ESCWA countries is around 7%. The average world penetration rate is 13%. Internet penetration rates in the region are still way below North American and European countries. More initiatives are needed to increase Internet users. Some countries have low

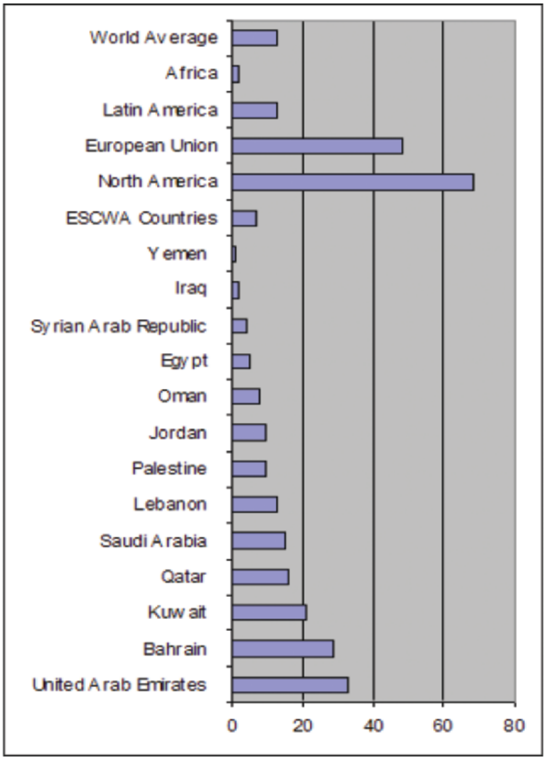

Figure 6.4 **Penetration rates of Internet users in ESCWA and other countries. Based on data from ESCWA, 2005.**

penetration rates but have high annual growth. For example, Iraq, Egypt, and Yemen have annual growths of 80%, 50%, and 44%, respectively. Internet services were recently introduced in these countries (ESCWA, 2005). The low penetration rate is mostly due to the high cost of Internet services in the region. In order to increase Internet penetration, the government of Egypt, for example, is offering consumers free Internet connection via a telephone line, but the consumer must pay for the telephone line.

6.2.6 ICT Usage

ICT usage includes identifying the level to which ICTs are used in the public sector (e-government), in the private sector (e-commerce), and in the educational sector (e-learning). Here we consider ICT applications in government agencies, health care, business, and education. But before going into each in detail, it is important to note how Arabic users are accessing the Internet. According to the ITU, 72% are accessing Internet from home and 22% from work. Internet in the region is mostly used for chatting, for e-mail, and for downloading information from the web (ITU, 2002).

6.2.7 ICT Applications in Government Agencies

To measure the effectiveness of e-government, the following criteria have been chosen to determine the level of integration of ICT applications in government: (a) computerizing public administration; (b) digitizing information; (c) e-government plans; (d) e-procurement applications; (e) computerizing customs processing; and (f) computerizing taxation and revenue management systems. Many regional countries only recently started posting information on the web. Only a few countries have started some form of e-government applications. But all countries are planning to improve and develop their e-government applications because of their importance to ICT development. Some countries are slower than others. Table 6.8 presents a ranking of e-government readiness of ESCWA countries from a global perspective. The ESCWA organization developed a ranking procedure for the different countries in order to reflect the overall success and commitment of each country in terms of creating and implementing adequate e-government strategies and services (roughly similar to the ESCWA ranking noted earlier). These consist of: Level 1, the absence of a coherent strategy and the lack of implementation efforts with very weak digitization and automation processes; Level 2, the existence of a clear strategy but no clear implementation or plan of action, and some digitization and automation of processes and information; Level 3, a clear e-government strategy with advanced levels of implementation, and a variety of services and information available over the Internet with high level of digitization and automation of governmental processes; and Level 4, a clearly implemented e-government strategy at all levels with full automation and digitization of information and services, and high quality of services provided over the Internet (ESCWA, 2005). Table 6.9 shows the maturity levels of ESCWA countries between 2003 and 2005. It is noticeable that no country has yet reached Level 4.

Table 6.8 **Ranking of e-Government Readiness of ESCWA countries.**

Regional Rank	Country or Territory	Global Ranking
1	Bahrain	46
2	United Arab Emirates	60
3	Jordan	68
4	Lebanon	74
5	Qatar	80
6	Saudi Arabia	90
7	Kuwait	100
8	Iraq	103
9	Oman	128
10	Egypt	136
11	Syrian Arab Republic	137
12	Yemen	154
13	Palestine	–

Based on data from UNPAN, 2004.

Table 6.9 **Maturity levels of e-government in ESCWA countries.**

Country or Territory	Year	
	2003	2005
Bahrain	Level 3	Level 3
Egypt	Level 2	Level 2
Iraq	Level 1	Level 1
Jordan	Level 3	Level 3
Kuwait	Level 2	Level 2
Lebanon	Level 3	Level 3
Oman	Level 2	Level 2
Palestine	Level 1	Level 1
Qatar	Level 2	Level 3
Saudi Arabia	Level 2	Level 2
Syrian Arab Republic	Level 2	Level 2
United Arab Emirates	Level 3	Level 3
Yemen	Level 1	Level 1

Based on data from ESCWA, 2005.

6.2.8 ICT Applications in Education

ICT in education is a basic component in building future generations and a knowledge-based society. In the Arab world, the percentage of young people (<20 years old) is greater than the percentage of older people (>55 years old). These younger generations are the future users of ICT and it is essential to start their ICT education in schools. Integrating ICT applications in the process of education can help accelerate preparedness and transformation to a knowledge-based economy. Such integration can be measured through the following criteria: (a) e-learning; (b) e-schools; and (c) virtual universities (ESCWA, 2005).

e-Learning is defined broadly as the delivery of training content through a computer network infrastructure. Many countries have developed a plan of action to introduce or develop e-learning. For example, in Egypt, the Ministry of Communication and Information Technology, in collaboration with various governmental and private sector entities, introduced an e-learning ICT skills development programs for small- and medium-sized commercial establishments. In Jordan, the Education Reform for the Knowledge Economy Initiative that was launched in 2002 was aimed at providing e-learning for both basic and university education. In Kuwait, the Education Net Initiative is considered one of the most important priorities for developing education and represents a cornerstone of the long-term plan of the Ministry of Education to revamp the education sector. The Initiative aims to connect all schools and libraries over one network and to provide all public schools with computers by 2006. Among ESCWA members, only Yemen has no clear plan of action to introduce ICT and e-learning to its educational sector.

The main characteristics of e-schools include the availability of Internet connectivity and computers in classrooms, and the integration of ICT technology in the education process. Classroom connectivity is still the exception in the ESCWA region. Even with several ambitious plans for introducing ICTs in curricula, Internet connectivity remains limited with all ESCWA members, with the exception of Bahrain and Jordan. Bahrain has achieved a relatively good connectivity rate of three Internet connections per school and plans to increase that rate to 12 connections. Furthermore, the Jordan Broadband Learning Network, which aims to connect all public schools, universities and knowledge stations to one network, is expected to be implemented by 2006. Virtual universities provide e-learning channels for university and higher education. They are portals for various types of educational programs including remote education and continuous education. There are few universities in the region that can be considered virtual. These are the Syrian Virtual University (SVU); Avicenna Knowledge Centre in Egypt, and the Arab Open University.

The ESCWA organization developed a ranking procedure for the different countries in order to reflect the overall success and commitment of each country in terms of education. The ranking approach used is similar to the ones noted earlier in related contexts, however the specific factors taken into account differ as needed. These levels are: Level 1, where no clear policy of integrating e-learning systems in the educational system exists, with a lack of connectivity and Internet availability in schools, no organized or accredited distance learning activities and overall deficiency in e-educational services; Level 2, efforts forward e-learning policy, sporadic Internet connectivity with no plan for expansion, existence of pilot e-school projects but without a clear plan of action to generalize the experiment, limited accessibility to Internet services through universities, and no clear national e-education plans; Level 3, active e-learning and e-school projects with implementation and plans of action, well-developed ICT infrastructure in educational facilities, well-developed distance learning programs and active services by virtual universities, existence of a national e-education plan; and Level 4, already implemented e-school and e-learning systems, existence of well-developed and integrated virtual and distance learning programs, existence of a national e-education plan. Table 6.10 shows the maturity levels of ESCWA countries between 2003 and 2005. Like e-government, no country has reached Level 4.

Table 6.10 **Maturity levels of ICT applications in education in ESCWA countries.**

Country or Territory	**Year**	
	2003	**2005**
Bahrain	Level 3	Level 3
Egypt	Level 2	Level 2
Iraq	Level 1	Level 1
Jordan	Level 3	Level 3
Kuwait	Level 3	Level 3
Lebanon	Level 2	Level 2
Oman	Level 2	Level 2
Palestine	Level 1	Level 1
Qatar	Level 1	Level 2
Saudi Arabia	Level 2	Level 2
Syrian Arab Republic	Level 2	Level 2
United Arab Emirates	Level 3	Level 3
Yemen	Level 1	Level 1

Based on data from ESCWA, 2005.

6.2.9 ICT Applications in Commerce and Business

The use of ICT in commerce and business in the ESCWA region is growing at a relatively fast pace especially in countries in the Gulf region. Interestingly, e-commerce is growing at a sluggish pace between regional companies and those in ESCWA member countries; it is growing at a much faster rate between international companies and those in the ESCWA region. An example of this effect can be seen in that international companies require their regional distributors and agents to communicate with them through electronic means. The banking sector is taking the leadership role in adopting advanced ICT technologies to cover e-commerce and e-business applications, and to give customers quality e-banking and ATM systems. Quality e-banking is available in most ESCWA countries except in Yemen, Syria, and Iraq. The biggest e-commerce market in the region is in Saudi Arabia followed by UAE. Most of the e-commerce transactions in the ESCWA region are directed outwards, between international companies and their local distributors. e-Commerce laws have been enacted only in Jordan and Bahrain (ESCWA, 2005).

The ESCWA organization developed a ranking procedure for the different countries in order to reflect the overall ICT implementation in commerce and business. Once more, we refer to ESCWA's ranking system, adapted to these sets of issues. These are: Level 1, a lack of adequate technological and financial infrastructures to support national efforts for the development and dissemination of ICT applications in business and commerce; Level 2, a suitable framework for developing and disseminating ICT applications in business and commerce, and for formulating relevant national strategies and plans, however, it has yet to benefit fully from these initiatives; Level 3, the existence of strategies, plans and evidence of their implementation, however, societies in these countries have yet to reap the full benefits of such strategies; Level 4, benefiting fully from the deployment of ICT applications in the government and private sectors nationwide.

Displayed in Table 6.11 are the maturity levels of ESCWA countries between 2003 and 2005. Unlike e-government and e-learning, two countries in this category achieved Level 4 status, Bahrain and the UAE. Given its fully liberalized banking sector, Bahrain is considered one of the leading financial centers in the world and a key destination for the international banking industry. It was one of the first countries to legislate an e-commerce law, and enjoys one of the most advanced banking technology infrastructures in the world. And the UAE, and particularly Dubai, is at the forefront of the region in terms of adopting the latest technologies to support the development of its economy. Furthermore, the UAE is home to branches of most international banks and financial institutions, in addition to featuring a number of preeminent local banks. Moreover, e-commerce in the UAE is comparatively mature and widely prevalent, both locally and regionally (ESCWA, 2005).

Table 6.11 **Maturity levels of ICT applications in commerce and business in ESCWA countries.**

Country or Territory	Year	
	2003	**2005**
Bahrain	Level 2	Level 4
Egypt	Level 2	Level 2
Iraq	Level 1	Level 1
Jordan	Level 2	Level 3
Kuwait	Level 3	Level 3
Lebanon	Level 2	Level 3
Oman	Level 3	Level 3
Palestine	Level 1	Level 1
Qatar	Level 3	Level 3
Saudi Arabia	Level 3	Level 3
Syrian Arab Republic	Level 3	Level 2
United Arab Emirates	Level 3	Level 4
Yemen	Level 1	Level 1

Based on data from ESCWA, 2005.

6.3 Conclusion

6.3.1 ICT Moves Supporting the Knowledge Economy

While the majority of ESCWA member countries have established ICT policies and strategies, most of them suffer from: (i) a lack of a methodical analysis with regard to the state of the respective societies; (ii) failure to deliver deeply into the real needs of these societies; (iii) absence of detailed plans aimed at executing such policies and strategies; (iv) insufficient funds for the implementation and execution of such strategies; and (v) failure to establish necessary mechanisms aimed at monitoring progress and at seeking remedies. The data in this chapter clearly indicate that the ESCWA member countries need to exert further efforts in establishing their knowledge societies. With the sharp rise in oil revenues in 2006, countries of the GCC currently have a real opportunity to achieve this objective. It is obvious that more serious work is needed in order to build a knowledge economy in the Arab world.

In parallel, however, countries in the region should embark on another important path, namely that of engaging in political, economic, and social reform. This includes allowing the key freedoms of opinion, speech, and assembly through good governance. Moves such as these will ensure the sustainability of building knowledge societies in the region.

6.3.2 Policy Formulation and Reforms

Based on the evidence in this chapter – and a general understanding of the politics and economics of the ESCWA countries, we propose here a set of actions that can serve as a remedial strategy to improve the overall ICT-related situation.

Accordingly, among the salient policy interventions required at this time, we highlight the following: first, we should examine present and future needs of the societies, and establish new policies, or correct existing policies, in line with the results of such studies. Second, we should increase the role of the private sector and civil society establishments in terms of planning, remedying and monitoring policies and strategies. Third, we need to allocate the necessary financial resources to realize ICT-focused policies and strategies. Fourth, we should promote and prioritize the formulation of laws and regulations that protect personal data and information privacy, including copyrights and intellectual property rights. Fifth, we should complete the privatization of the telecommunications sector, especially in relation to new services such as mobile phones and the Internet. Sixth we should promote and accelerate legislation in e-business and e-commerce. Seventh, we should shift rapidly toward knowledge-based production. The final policy intervention proposed here is to establish mechanisms for monitoring, measuring reporting on the pace and progress of policies and strategies.

6.3.3 ICT Use and Local Content

Also with the understanding that evidence in the chapter calls for identifying ways of improving current conditions, we note here some priority steps. First is building an up-to-date and advanced ICT infrastructure while increasing ICT access to low income families is vital. Inequalities can be the source of tension in a society, and inequality spawned by an inability to accessing the knowledge network is no different. Second, we must promote the use of e-government services across the region. This can be achieved by increasing local Arabic content through greater ICT access in all sectors, especially in education. Third, we must support Arabic cultural centers aimed at establishing content-rich websites. Fourth, we must provide knowledge content in local language and translate foreign knowledge to local language. Fifth, we must establish strategies to build an Arab software industry in the region. Sixth, we must create domestic partnerships between those that are e-literate and those that are not, and to the extent possible consider ways of using ICT for promoting social inclusion. Seventh, we must render ICT strategies compatible, and not competitive, with knowledge strategies.

6.3.4 Education and Awareness

Specific moves in this domain consist of the following types of actions: Increase ICT awareness in all sectors using all existing media channels, with added attention to rural areas. Link ICT awareness to literacy programs in order to eradicate illiteracy as well. Increase investments and incentives in human resource training and in the purchasing ICT hardware and software for public, private, and education uses. Promote and develop e-learning programs and curricula across all levels of education and in all sectors. And, disseminate high quality education with tied to achievement and to and life-long learning.

In addition, it is important to indigenize the generation and diffusion of science. Telecenters projects should make a difference in people's lives. ICT training should include uses of techniques as well as applications to improve people's lives. Telecenter projects should reach "people" as individual human beings, and not as "numbers," or anonymous aggregates thereof. Experiments with Computer Clubhouses in poor communities and rural areas suggest that such projects help youth build on their own interests, and create an environment of respect and trust (Schon et al., 2001).

Each one of these moves is significant in its own right. Jointly, they can be powerful indeed. However, none can be successful without cooperation and collaboration among the public, private, and educational sectors, nor can any be successful without the support of the non-governmental organizations in each country (ESCWA, 2005). Clearly, it is now essential to understand and exploit possible catalytic effects of ICT development. Finally, "champions" and other agents of change must now involve community leaders, educators, managers, and organizers rather than only computer experts, technologists, or technocrats.

References

Dutta, S., El-Hage, C., Sabbagh, K., and Tarazi, P. (2002). Challenges for ICT development in the Arab world. *Arab Symposium for Communications*: Beirut, Lebanon.

ESCWA: *Economic and Social Commission for western Asia*. (2003). Regional profile of the information society in western Asia.

ESCWA: *Economic and Social Commission for western Asia*. (2005). Regional profile of the information society in western Asia.

ISC: Information Society Commission. (2002). *Building the knowledge society*. Retrieved May, 2006, from http://www.isc.ie/about/reports.html.

ITU: International Telecommunication Union. (2002). Retrieved May, 2006, from http://www.itu.int.

IWS: Internet World Stat. (2005). *World Internet usage and population statistics*. Retrieved May, 2006, from http://www.internetworldstats.com/stats.htm.

Mansell, R. and Wehn, U. (1998). *Information technology for sustainable development*. (New York: Oxford University Press)

MRG: MADAR Research Group. (2006). Retrieved May, 2006, from http://www.madarresearch.com/.

Schon, D., Sanyal, B., and Mitchell, W. (2001). *High technology and low-income communities*. (Cambridge, MA: MIT Press)

UNDP: United Nations Development Programme. (1999). *Human development report*. Retrieved May, 2006, from http://hdr.undp.org/reports/global/1999/en/.

UNPAN: United Nations Online Network in Public Administration and Finance. (2004). UN global e-government readiness.

Warschauer, M. (2003). *Technology and social inclusion: rethinking the digital divide*. (Cambridge: MA: MIT Press)

WDR: World Development Report. (2001). *Attacking poverty*. (Washington D.C.: World Bank)

Chapter 7

GSSD-ARABIC

Innovations in Multilingual e-Networking

Toufic Mezher

Introduction

In many ways we can consider the previous chapter as the context and the situational logic for the issues addressed in this chapter. We begin by examining the thirst for knowledge in the Arab world and the demand for greater access to existing sources of knowledge. This demand pertains to knowledge in general, and to knowledge about sustainability and sustainable development in particular.[1] To some extent there is notable digital content in the Arabic language, but it dwarfs the knowledge needed to build knowledge economies throughout the region.

The first part of this chapter extends the earlier discussion of Information and Communication Technologies (ICT) in the Arab region and focuses on the current status of Arabic language content in the Global System for Sustainable Development (GSSD). The purpose of this section is to highlight central tendencies and dominant patterns, not to signal problems for their own sake. At issue is the nature of the *demand* for Arabic language content on the Internet. Against this background, the remainder of the chapter addresses the *supply* side, presenting a *project-profile* of our experiences in the course of developing an operational GSSD-Arabic. The challenge before us is to reduce barriers and to transcend obstacles in order to develop an e-presence in the Arabic language. If this can be done effectively – given current technology – then the access to global knowledge content, the provision of local content, and the participation in knowledge e-networking strategies, can all be used to contribute to the emergence of a knowledge economy in the Arabic-speaking countries of the world.

[1] See the chapters in Part I of this book for definitions and context.

N. Choucri et al. (eds.), Mapping Sustainability: Knowledge e-Networking and the Value Chain, 123–141.

This chapter must be seen in the context of Part I of this book, where both the theory and implementation of GSSD is presented. Most of the issues addressed here – and the implied evolution of the sociology of e-knowledge pertaining to worldwide multilingual knowledge networking – can only be appreciated with prior understanding of the 'history of design' for GSSD. On a more practical vein, many of the challenges and dilemmas addressed further along can be better understood in institutional and organizational context discussed in Chapter 5. Also relevant is the experience reported in Chapter 8 by the China team for GSSD-China.

It is in this multiple context that we present a synthesis of the GSSD-Arabic experience and show the type of problems, conceptual and computational, that needed to be resolved in order to create an operationally-reliable knowledge e-networking system for use by Arabic-speaking users. Given the innovative nature of GSSD-Arabic and the absence of precedent for such an initiative, this chapter details the historical development of GSSD-Arabic since the inception of the GSSD initiative. It constitutes an important step for closing the knowledge gap in the region, for enhancing knowledge about sustainable development and for providing a voicing-venue for Arabic-speakers in the region and elsewhere.

7.1 Digital Arabic Content

7.1.1 The Current Status

While Arabic speakers represent 5% of the global population, Arabic web pages constitute a very small segment of what is available on the web. Indeed, it is so small as to further reinforce the marginal presence of Arabic on the Internet. There are 1,583 speakers per one Arabic web page compared to 1.5 speakers per one English web page (Warschauer, 2003). Statistics of this sort underline that the Arabic presence is far less than even the very small rate of Arabic speakers among total world Internet users, which stands at some 1.8% (ESCWA1, 2005). Despite these low figures, there are notable and successful initiatives that seek to contribute the level of Arabic content on the Internet. Arabic was added in 1997 as a new language for GSSD. Earlier chapters of this book were devoted to the theory, method, and operation of GSSD and need not be repeated here. Another initiative of note is ArabDev, a project whose main objective is to improve economic and social development of local communities in Arab countries through applications of ICTs. Today in the Arab world, all media organizations have their own websites where consumers can get access to different kinds of information and news. These projects and many others in the Arab world still represent a very small fraction of the total web content, and cannot as yet make a difference in the content ratio of Arabic to non-Arabic websites. The frail presence of the Arabic language on the Internet, coupled with weak regional Arab e-commerce activities, has limited even weakened further the Arabic-language software development efforts, especially those related to Arabic search engines, archiving, information retrieval, and machine translation.

7.1.2 The Significant Barriers

Some of the obstacles facing the development of digital Arabic content on the Internet include the low penetration and a premium that consumers are expected to pay for access to e-information. In addition, there is a very low level of e-government projects, little importance given to Arabic content on the Internet, absent or insufficient legislation on digital copyright and e-commerce, and heavy censorship and filtering of digital content in many ESCWA countries (ESCWA1, 2005; ESCWA2, 2005). All of these factors inhibit a 'take-off' in then e-domains. The observations in Table 7.1 show the share of Arabic web pages in ESCWA countries. This distribution also shows the value that different countries place on the use of Arabic in e-venues,

Table 7.1 **Share of Arabic web pages in ESCWA countries.**

Country or territory	Share of Arabic Web Pages to Total Arabic Content in the ESCWA Region	Share of Web Pages in Arabic Over Total Web Pages
Syrian Arab Republic	2	94
Palestine	11	83
Saudi Arabia	37	67
Kuwait	3	51
Yemen	1	47
Bahrain	3	39
Qatar	2	34
Jordan	4	33
Oman	1	29
United Arab Emirates	18	22
Egypt	18	12
Lebanon	1	5
Iraq	0	0
Average ESCWA	8	28

Based on data from ESCWA(1), 2005.

while at the same time highlighting some notable paradoxes. For example, Syria has 94% of all its web pages in Arabic, while its share of Arabic web pages to total Arabic content is only 2%. Also, Saudi Arabia has the highest share of Arabic web pages to total Arabic content in ESCWA region. Saudi Arabia and Palestine have the highest share of web pages in Arabic (ESCWA1, 2005).

7.2 Toward a Knowledge Economy

Of the many definitions of the knowledge economy – this chapter borrows the World Bank view, namely that of "an economy that makes effective use of knowledge for its economic and social development. This includes tapping foreign knowledge as well as adapting and creating knowledge for its specific needs." In this context, the knowledge economy is based on four critical pillars as specified by the World Bank, namely (i) *Education and Training:* an educated and skilled population is needed to create, share and use knowledge. (ii) *Information Infrastructure*: a dynamic information infrastructure – ranging from radio to the Internet – is required to facilitate the effective communication, dissemination, and processing of information. (iii) *Economic Incentive and Institutional Regime*: a regulatory and economic environment that enables the free flow of knowledge, supports investment in ICT, and encourages entrepreneurship is central to the knowledge economy. (iv) *Innovation Systems*: a network of research centers, universities, think tanks, private enterprises and community groups is necessary to tap into the growing stock of global knowledge, assimilate and adapt it to local needs, and create new knowledge. These pillars imply the existence of modern telecommunication infrastructure as one of the basics of knowledge economy. Hence, the existence of a digital divide is contingent on the preconditions in place supporting transformations toward the knowledge economy.

7.2.1 The Wake-up Call?

In its stark review of the Arab region, the *Arab Human Development Report* (2003) sent shock waves across the world about its assessment of the region and most notably regarding the status of knowledge-related factors (UN, 2003). The *Report* highlighted three cardinal challenges facing the region: first, its growing knowledge gap, internally as well as in relation to the outside world; second, the cultural, economic, societal and political context influencing knowledge acquisition in the region at this critical junction in its history; and third, the need for a strategic vision that delineates the landmarks of a deep social reform process for establishing a knowledge-based society.

As indicated earlier, the entire ICT environment, readiness, and usage in all sectors in most countries are poor. Except for Gulf rich countries, most of the Arab countries suffer from a lack of an advanced ICT infrastructure and low PC and Internet penetration rates. In addition, all Arab countries have very low spending on research and development, and the educational systems in most of the countries still need considerable efforts. All of these factors are among the most in hindering expedient adoption of knowledge economy transformation strategies. The knowledge economy transformation is clearly championed by the UAE and Bahrain. Also, Jordan, Qatar, and some other Arab countries are addressing this issue very strongly. According to the World Bank ranking, the UAE is ranking first among Arab countries in terms of readiness to transform to Knowledge Economy (MRG, 2005). These differences are important as they highlight some emergent cleavages within the region whose implications are not yet fully understood.

7.2.2 Literacy, ICT, and Knowledge Access

There are many similarities in patterns of literacy, ICT and knowledge access. They are all important in building the knowledge economy. Knowledge access is as important for the development of today's knowledge capital driven era just as ICT access for informational capitalism era and as literacy for industrial capitalism era. Table 7.2 summarizes the differences and similarities between literacy, ICT, and knowledge access with respect to sources of information, which get expressed as content within or via that physical artifact, skill level sufficient to process and make use of that information, as well as it. Finally, the table also notes the different 'divides' that prevail, namely the literacy divide, the digital divide, and the knowledge divide (Warschauer, 2003).

Table 7.2 can thus be seen as 'mapping' of the knowledge-related features, with special relevance clearly to the Arab region. The very last 'row,' with its entries across each of the columns, signals one of the most controversial issues regionally as well as globally, namely the nature of the critical *divides*.

Fundamental to all of the foregoing – and to the matter of knowledge creation and diffusion in all regions and at all times – is basic literacy. Table 7.3 shows literacy rates around the world and signals that the Arab countries have low rates compared to developed countries. Therefore, while this chapter focuses on digital issues and challenges, it is clear that we cannot forget, nor can we put on the proverbial back burner, the basic deficits in literacy. Clearly, the rates of literacy must be increased if we are to anticipate a growth in the use of digital facilities in the Arab world or if we are to seek an increase the demand for ICT and knowledge access (UNESCO, 2006).

Table 7.2 **Literacy, ICT, and knowledge access.**

	Literacy	ICT Access	Knowledge Access
Communication stage	Writing, print	Computer-mediated communication	Internet and Intranet
Main economic era	Industrial capitalism	Informational capitalism	Knowledge capitalism
Physical artifacts	Books, magazines, newspapers, journals	Computer	e-Books, e-magazines, e-newspapers, e-journals
Organization of content	Novels, short stories, essays, articles, reports, poems, forms Reading	Websites, e-mail, and instant messages	Organizational memory, best practices, and lessons learned
Receptive skills	Reading	Reading and multimedia interpretation, searching, navigating	Understanding and accessing the needed knowledge
Productive skills	Writing	Writing and multimedia authoring and publishing	Knowledge creation and dissemination
Divides	A great literacy divide?	A digital divide?	A knowledge divide?

Based on data from Warschauer, 2003.

Table 7.3 **Literacy rates around the world 2000–2004.**

	Adult (%)			Youth (%)		
	Total	**Male**	**Female**	**Total**	**Male**	**Female**
World	82	87	77	87	91	84
Arab States	63	74	51	78	85	72
Central and Eastern Europe	97	99	96	99	99	99
Central Asia	99	100	99	100	100	100
East Asia and The Pacific	91	95	88	98	98	97
Latin America and The Caribbean	90	91	89	96	96	96
North America and Western Europe	99	99	98	100	100	100
South and West Asia	59	70	46	73	81	65
Sub-Saharan Africa	60	68	52	72	77	67

Based on data from UNESCO, 2006.

7.3 GSSD-Arabic

Even though the Arabic speaking countries represent 5% of the world population, Muslims around the world represent about 20% of world population. Being Muslim means that they have to learn some Arabic and many of them do read, speak, and write the language. The reason is that the Koran is in

Arabic. Today, most international organizations have multiple languages on their websites and Arabic is one of them. GSSD was one of the e-knowledge networking systems that took the leadership role to adopt the Arabic language as one of the major languages on its website in addition to English and Chinese.

Early on, GSSD also made a decision to focus on distributed and decentralized knowledge provision and to emphasize the contribution of local knowledge into global networks as well as the diffusion of global knowledge into local networks. The ultimate objective is to reduce the knowledge gaps that are created by language differences and most notably by English dominance on the Internet, in a world that is not English-speaking. Figure 7.1 shows the home page of GSSD-Arabic.

Figure 7.1 **GSSD-Arabic home page.**

7.3.1 GSSD-Arabic: Background

Despite the absence of convergence around the concept of *sustainable development*, it is generally understood in roughly the same ways in various parts of the world. Nonetheless, the fact remains that different societies may assign different linguistic expressions to the core concepts. At this point in time, the Arabic language has developed its own vocabulary related to various facets of sustainable development and a considerable portion of that vocabulary was developed by the scholars working on GSSD-Arabic.

In many ways, a central feature of this initiative, in its pre-computational or foundation phase, involved clarification and codification of concepts that have over the years become the core sustainability-vocabulary and a representation of its ontology. This pre-computational phase (an essentially conceptual exercise) was an essential prerequisite for building cross-language computational representation as well as all the functionalities of access, input, search, navigation and the like that are fundamental to the GSSD system.

7.3.2 Building GSSD-Arabic

This challenge consisted of a range of specific tasks that had to be completed such that the system's various functionalities that could be operated seamlessly. The most important of these are the following:

(1) Building the Arabic-language user interface and presenting the Arabic knowledge-base on the GSSD system, including appropriate letter-rendition, word formation, and sentence structures that are consistent with conventions of the Arabic language. As indicated earlier, in Part I, it is important to note that for many letters in the alphabet, individual letter looks different – and is rendered differentially – if it is located in the beginning of a word, the midst of word, or the end of a word. These conventions have to be respected in order to render an individual word accurately. Moreover, the sentence is presented from right to left and not, as is conventionally the case with the Latin-rooted languages, from left to write. Finally, selecting, and assuring the sustained use of the correct font transcends all of these issues and remains central to the entire effort – from its inception to its implementation.

(2) Building the Arabic language Convergence Glossary consistent with the Unicode conventions, in order to enable cross-language search and navigation operations.

(3) Constructing the Arabic language ontology for sustainability, by providing the condition for each concept and sub-concept for the fourteen domains of sustainable development and the four dimensions (see Chapter 1).

(4) Developing the Lotus Notes software for use with Arabic language applications, which required new solutions to problems emerging in the course of adapting the core software to Arabic.

(5) Translating from English to Arabic of all knowledge-content abstracts of the GSSD knowledge-base at the onset, as well as all relevant pages, including directives for user interface, menus, and related factors.

(6) Augmenting the GSSD knowledge-base, by locating and then submitting Arabic-language sites, as well as providing Arabic-to-English translation of select knowledge-content abstracts.
(7) Providing routine and consistent system management (including confirmation of replication and synchronization across mirror sites worldwide).
(8) Creating the relevant materials for posting on the “Reports” page of GSSD.

7.3.3 System Administration

It is worth noting the Lebanese team took the leadership role of GSSD-Arabic at early stages in thinking about the possibility of an Arabic language GSSD. Following some initial ‘testing’ at MIT, it became clear that a large-scale rethinking of design and implementation strategy was needed, and a comprehensive and redoing of what had already been put in place was required. Errors in applications and incompleteness in initial conditions in the Arabic language necessitated a near-complete overhaul of the system to that point.

Moreover, the knowledge-base had not yet been developed with any Arabic inputs regarding concept equivalence, nor had checks been undertaken on the few content translations that had been done. Early on, it became clear that different functions required different operational strategies. This means that the process of rendering static pages into Arabic was different than required for the dynamic pages, and different still from that required for the knowledge-base itself (that is, for the library of e-abstracts).

Before turning to details about these functions, it is worth mentioning the reason why a GSSD-Arabic mirror site was not initially built in Lebanon. In the late nineties, most Arabic countries, including Lebanon, did not have local Internet infrastructures. Internet connections were done through satellite through Europe and United States, or sea cables through Cyprus. Internet connection was very slow, very unreliable, and very costly. Despite recent advances, the legacy of these early conditions is powerful.

Today, Arab countries, especially in the Gulf region, are building the most advanced Internet backbones. This will increase the speed of the Internet and, therefore, it will be more practical to start thinking of building a mirror site in Lebanon or any other country in the region. At the same time, however, as we consider the future we still need to take into account the implications of the *Arab Human Development Report* as well as the nature of the evidence about ICT capacities and e-performance reviewed in Chapter 6.

7.3.4 Arabic-to-English Translation

When we joined the GSSD team and took the leadership role of Arabic section, our first mission was to start working on translation. Translation was done through e-mail by sending us documents related to the dynamic and static pages of GSSD. In essence we had to develop our own workflow process and interactions with MIT. (Later on we also had to consider the nature of communications with the GSSD-China team.)

When we started working on the translation, the Lebanese team never had any earlier experience with the Lotus system, nor had it benefited from any prior training on Lotus Notes and Domino. (And the Arabic language version of this software was not fully developed.) In fact, as pioneers in this domain, the team had to 'decipher' Lotus operations from inadequate documentation and to 'infer' operational solutions from less than adequate support services – long distance – via MIT team discussions with the Lotus system developers. Interestingly, at the time Lotus (early in its IBM integration) had not had an Arabic-language experience and the entire Global Workbench had not been 'debugged.' The early efforts to put in place a functional translation system as part of operating system was fundamentally flawed, to the extent that these had to be 'scrapped' and entirely redesigned.

Another type of challenge arose from the disconnect between concepts and Arabic-representation in relation to sustainable development terms. This was due in part of a relatively underdeveloped vocabulary of this domain at the time, and in part to the inconsistencies introduced in the absence of reliable vocabulary.[2]

It was at this point that both sides – in Lebanon and in Cambridge – realized the importance of the difference between 'static' and 'dynamic' pages was fully understood. No one in the GSSD-MIT team had signaled that there may be a difference between such pages. As such, a unique protocol had to be designed for both static and dynamic pages. At this point, the GSSD-MIT team allowed the AUB team to take over entirely. The AUB team had to address two challenges. The first was undoing the errors, as well as faulty designs and abortive implementation. The second was putting in place a new set of functionalities.[3]

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[2] For example, we received the whole document in MS-Word from GSSD administrator at MIT with some special format, with the request that it be translated in Arabic in the same format. In the absence of precedence – on either the MIT or the AUB side – the latter did had little clear understanding of how this information are entered in the system to begin with, nor was it given any particular hints from the MIT team.

[3] All of this was achieved with very limited assistance from the product developers, namely Lotus-IBM, since the GSSD initiative served as their global test-bed undertaken by 'real' users. Exceptions to this characterization are noted as relevant. See also Chapter 5 for added analysis of organizational challenges.

7.4 Charting New e-Spaces in the Arab Region

7.4.1 Challenges in the Development of GSSD-Arabic

Many of the challenges noted above are largely intellectual in nature, and required an intellectual response – such as rendering of concepts and meanings in coherent and internally consistent terms. At this point we turn to another set of challenges and problems encountered in the course of creating and implementing GSSD-Arabic. This set is technical and operational, rather than conceptual or intellectual. Interestingly, problems of the latter type pertained to product development for the Lotus software, and thus beyond our own scope of work since we were 'users' of this software in an application that we designed, developed, and implemented – and not originators of the software itself.

Many of the problems that we encountered were embedded in the computational products themselves, those of Lotus and IBM and presumed to have been resolved long before GSSD-Arabic was initiated. The fact that they were not, and that we had to resolve them ourselves, was certainly an unexpected exploration of uncharted terrain – one that we were not eager to pursue.

To be fair, however, Lotus-IBM had never before experimented with the concurrent application of two non-western languages (Arabic and Chinese) in an application that was conceived as a distributed e-networking system. We note some of these issues, by way of sharing with the others the development experience as transparently as possible and providing a backstage view of system development. In many ways, these are all features of an innovative process in the course of putting in place a distributed multilingual knowledge e-networking application.

More specifically, we address three issues: first is using Lotus Notes to provide translation functions; second is the development of Arabic Lotus Notes itself, most notably the accurate visual rendering of Arabic characters; and third are some aggregate effects pertaining to the hidden costs of e-collaboration in the knowledge networking domain. Each of these issues represents a distinct set of challenges. Each posed unprecedented problems that required the forging of novel solution. Once again, we note that this chapter is as much about problem-solving as it is about innovations-as-solutions.

7.4.2 Using Lotus Notes for Translation

As put forth in Part I of this book, the strategy of GSSD is to devise and utilize a common frame of reference and shared workflow system for the processing of knowledge and information, and, in this process, to build an e-system to decentralize knowledge provision, distribution, and sharing, and to accommodate the needs of various e-providers and users from different parts of the world through a customized and workflow process. In other words, the general method and the processes undertaken are in common – shared by all partners – but the individual task is and their implementation operations are localized. Recall that once synchronization and replication takes place, all mirror sites are identical.

In order to use the Lotus Notes software, an Arabic language version had to be installed first on a desktop computer in Lebanon at the American University of Beirut (AUB). This was the easy part. The next step was how to establish Internet connection with GSSD server at MIT. Recall that in an earlier chapter, we noted the difficulties associated with Internet access in the Arab region during past decade. In addition to 'normal' problems, there were security concerns. AUB has a firewall established around its network for protection. Assistance was requested from AUB Computer and Network Services (CNS). CNS technical assistants tried hard to establish connection with MIT server using socks. The connection failed because the CNS team had little knowledge about the Lotus Notes software. Both the name of the server and its IP address were tested unsuccessfully.

In order to solve the problem, a telephone conference call was established between GSSD technical director at MIT, a Lotus Notes technical advisor, and the GSSD-Arabic director in Beirut. One of the major problems with the connection was in selecting the wrong port, 1352 instead of 80. After the connection was established, it was easy to install the software on any desktop computer. The initial version of Lotus Notes that was used by GSSD-Arabic team at AUB was 5.0x. The connection to MIT server was important because all the GSSD-Arabic work is done online on the "GSSD-Arabic Content" database that exists on the GSSD server at MIT.

When the connection issue was solved, the next two major tasks were to start translating the abstracts in the "GSSD-Arabic Content" database, and to edit the translation of the dynamic and static pages that were initially uploaded into the system. We had no idea that these two tasks would open the door to new challenges with Lotus Notes software, to recognize that the system could not operate effectively for Arabic, and that some changes had to be made to make it more suitable for the Arabic language. The technical challenges that were faced with the software are discussed in more details in the next section.

Without any real documentation as yet on how to use the system, the GSSD-Arabic team struggled to try to figure out the correct menus in order to reach the abstracts for translation. In fact, it had to generate the very documentation that it actually required. There were many e-mail exchanges and telephone calls between MIT and AUB just to figure out how to use the system. Eventually, the efforts paid off.

7.4.3 Arabic Development of Lotus Notes

When we started using the early version of Lotus Notes 5.0x, problems with the software began to appear. Whenever we solved one problem another one popped up. This section discusses the major problems that were faced with the software and their fixes. These were idiosyncratic to our own case, but they are of a generic nature, as they are likely to be relevant to any non-western language.

7.4.4 Seeing the Arabic Characters

When the "GSSD-Arabic Content" database was opened, any item that was supposed to be an Arabic word appeared as dots ("……"). The reason for that was that "BiDi" was not enabled on the desktop computer. BiDi is a styled text editor that supports multiple languages, including English, Arabic, and Hebrew. The problem was corrected by going to the Control Panel Regional Settings and localized the Arabic language. In addition, one line, "EnableBiDiNotes=1," was added to the "notes.ini" file to enable the Arabic language in the software. In the following version of the software 5.03, only "EnableBiDiNotes=1" was needed. Finally, all the Arabic fonts were added to the system because early versions of the operating system, Windows 95 and 98, did not support Arabic fonts. One additional step was needed in case the Arabic font problem persisted: the "Enable Unicode Display" was selected from the File menu (Preferences and user Preferences). The later versions of the operating system, Windows 2000 and XP, solved the font problem and the new version of Lotus Notes 6.5 solved the "BiDi" one.

7.4.5 Practical Strategy

One of the most severe and recurrent problems arose when the first prototype was received from MIT, which was the computational rendering of some basic functions yielded Buttons that were not linked together and were ordered backward. Unlike English, Arabic reads right-to-left. The main page, as well as some subsequent pages of GSSD, included many action buttons that signal user access to the mechanisms required for enabling system functionalities. These problems only occurred with the Arabic language as noted earlier. The same was true for the search module which consisted of graphical search tools.

Given that the design and the drawings were completed at MIT using desktop computers that did not have drawing software that supports Arabic, the logistics were seriously challenging. We immediately recognized that making Arabic-enabled software more available would be an important step for closing the knowledge gap in the region, for enhancing knowledge about sustainable development, and for providing a voicing-venue for Arabic-speakers in the region and elsewhere that issue was not recognized as salient at the time.

In addition, the MIT operating systems were not Arabic-enabled.[4] In retrospect, all of this sounds simple, but at the time, the challenges were near-overwhelming. Indeed, there was no manual to consult and no technical help to recruit. The AUB team had to define and design an operational solution. Accordingly, we developed a computational procedure to eliminate the problem as shown in Figure 7.2, and thus display the Arabic language correctly in relation to itself, and to the Buttons.

The procedure devised by the AUB Team to generate correct and functional Arabic graphics was as follows:

(1) Copy and paste the graph of any key or shape, using graphic software, to an MS-Word Document.
(2) Write the text on top of the key using a text box, make it transparent, and bring it to the front so that the shape of both the key and text appear well. Use any font color and size to suit your need.
(3) In order to transform both the graph and the Arabic text to an image, some specific steps must be made in the correct order.[5]

These procedures were developed on a trial and error basis. Only through experimentation was it possible to converge on consistent results. Therefore we consider it important to share the results of such experiments, so to speak.

We are able to make graphics compatible with Arabic, and we can use graphical software that does not support the Arabic language. Over time, however, we hope that all software used by the GSSD-team in all locations will be able to support all of the operating languages. Until such time, the procedure now in place serves this function.

[4] This means that the systems cannot accommodate the idiosyncrasies of a script where the representation of an individual letter is physically different if it is located at the beginning, in the middle, or at the end of a word. This is not an issue in any of the western languages. But for languages like Arabic or that requires the Arabic alphabet representation, this is a fundamental feature of system operation.

[5] The steps are as follows: (1) Confirm that the location of the graphic in the MS-Word document is in the top left-hand side of the screen. Push "Print screen" of the MS-word document. (2) Open Microsoft Photo-editor and "Paste" the printed screen from the previous step. Use the Photo-editor to edit the image and save it. (3) Use cut-and-paste to move the image to the GSSD database, but make sure not to confuse the links with other pages.

7.5 Dynamic and Interactive e-Arabic

7.5.1 Translating Abstracts Online

The translation of the abstracts was done online as compared to the initial offline translation of dynamic and static pages. After fixing the Internet connection problem and accessing the "GSSD-Arabic Content" database, the next challenge was to access the abstracts to start the translation process of thousands of abstracts. The user interface was so confusing and without any training on the system, the abstracts were located after several telephone calls and many e-mails. At the same time, many problems with the abstract text editor occurred in addition to other ones that were mentioned in this chapter. Again in the absence of documentation and precedent, we had to proceed by trial and error, and, in this process, we literally had to develop the documentation that is (or would have been) required.

The text editor in the Abstract was a major challenge. Whenever Arabic text was typed, especially in an abstract with long strings, the system would crash and all entered information would be lost. The problem was communicated to MIT and then forwarded to Lotus Notes. The GSSD-Arabic team was put in direct contact with a programmer in Ireland who is familiar with the Arabic language. The problem was with the string length and it was fixed.[6]

7.5.2 Using the Arabic Text Editor in Dynamic and Static Pages

Editing the dynamic and static is now done on-line after local installation of the Lotus Notes. Besides the graphics problem that was discussed earlier, many problems occurred during the editing process. The two major problems were the Arabic text editor, and text and graphic links.

As indicated earlier, the Arabic language is read from right to left and the majority of the text that was loaded to the GSSD-Arabic database was aligned incorrectly, as shown in Figure 7.2 on the left side. In addition, the font selected by the system was a default font that is small and hard to read.

Also, the system did not allow the editor to make all the needed changes in the type and size of the fonts, and the alignment of the text. After several communications with Lotus Notes, all the fixes were done to 5.0x version and we received all the new updates. The new Lotus Notes version 6.5 had no problems.

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[6] Other text editing problems occurred in the translation process and were solved after several communications with MIT and Lotus Notes system programer, then located in the Lotus-IBM Dublin office.

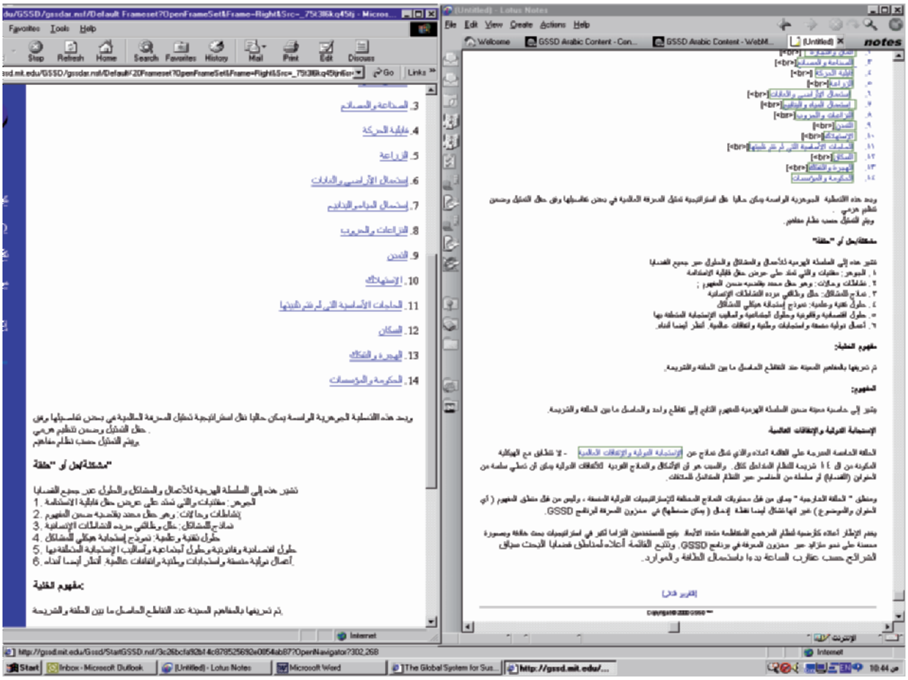

Figure 7.2 **Left-to-right Arabic text rather than right-to-left.**

Many of the links in the Arabic text in the static pages and graphics (especially in the search mode) were not correct. This is a very important point, since in the absence of correct links, different part of the GSSD system – and different pages – the equivalence across languages will not take place. Therefore, the process of correcting the links was not simple due to the fact that no training was provided on creating hypertext static pages with graphical links.

Finally, editing the dynamic pages was and still remains the hardest task to do because these pages are controlled by MIT, in order to retain consistency across sites during debugging phases – and the language barrier in terms of English versus Arabic conditions – makes it hard to communicate problems. Many of the fixes were done face to face during occasional travel of GSSD-Arabic team members to MIT. It is through this process that the customized workflow for Arabic language materials – referred to in an earlier chapter – was developed.

7.5.3 Arabic Search Engine

The search engine in GSSD, and its distinct forms of applications, is one of its major functions. Therefore, we had to make sure that it is working effectively when users are searching for knowledge materials pertaining to sustainability in the Arabic language. The search engine was correctly working after the continuous development of the GSSD portal and the Lotus Notes software. More testing is needed to make sure that the search engine is bug free.

7.6 International Collaboration

7.6.1 MIT Collaboration

Since MIT values student-staffed research initiatives – as part of the educational system – most of the MIT researchers working as part of the GSSD team are both graduate and undergraduate students. Therefore, turnover of staff was a problem because whenever a member becomes familiar with the system and with team members in Lebanon or China, then this individual leaves GSSD team after graduating from MIT.

In addition, no one except of the GSSD Director has knowledge of the Arabic language. For example, the GSSD main page, a dynamic page and has lots of graphics, had many spelling mistakes and it took more than three years to fix them. This was only done during the presence of the GSSD-Arabic team while at MIT because of their understanding of the Arabic language. In the past eight years, most of the communication was done through e-mails using "Print Screen" option on the keyboard to convey problems. This mode of common-communication became sufficiently well developed such that we could reduce the instances of miss or missed-communication.

7.6.2 The Lotus-IBM Connection

The other side of the operational collaboration required sustained communication with the Lotus product developers since ours was the first case of the Global Workbench in operation. We have obtained extensive collaboration with key developers on the Arabic language side, but these were always embedded in and connected to the MIT-Lotus collaboration. In this connection, it is useful to review Chapter 5 whose lead author is a former GSSD system administrator. That chapter highlights the challenges involves in collaboration between a research and educational institution, on the one hand, and a product-development global firm on the other. While the mutual advantages are many, realistically, however, it should come as no surprise that systematic delays in communication impeded rapid problem solving. In addition, given the developmental status of the entire initiative, it should come as a surprise that the GSSD-Arabic team had to solve its own problems rather than wait for the Lotus-IBM developers, with a range of other priorities, to generate the solutions.

7.7 Conclusion

Since its completion and launching, GSSD-Arabic evolved remarkably well from a user point of view. In retrospect, it is safe to say that the GSSD-Arabic team was a pioneer in more senses than one. More specifically, the team had to render operational the Lotus Notes and the Global Workbench itself to make the very tools and technologies that were designed to render the Arabic language actually operational. Arabic users can now browse the system-site to learn more about sustainability, its mapping in Arabic, and a platform for hosting Arabic language materials. They can search the web for all relevant information. To their surprise, users will discover that there is limited sustainability knowledge that exists in the Arab region and most of it must be imported from other regions.

At this writing, there are signs that things are changing. The first came with the publication of the *2003 Arab Human Development Report*, which gave a clear indication about the need for knowledge creation and dissemination. In addition, the previous chapter, ICT in the Arab World, showed the revolutionary progress of ICT development. Still, the Arab World has a long way to go, but it is on the right path. Of course there are many critical prerequisites that should be important to the successful creation of knowledge societies in the region. These are economic and political reforms. Clearly, the eradication of political corruption should be a priority because it will destroy any hope of economic prosperity in the future. In addition, Arab countries could learn from the Asia Tigers to complement each others and not compete between themselves because many resources will be wasted and many countries cannot afford that. This is hard to accomplish without reforms, and, most of all, without a clear vision about the future and the direction of the knowledge societies in the region.

Every country in the region is unique and has its own identity, culture, and heritage. Each country has to identify its role in the regional knowledge economy and work on fulfilling this role with the help and support of neighboring and/or regional countries.[7] We have to decide what knowledge will best drive the regional economies and what technology tools to develop

[7] For example, since its inception, Lebanon has been well known for tourism, education, banking, and healthcare. Lebanon can build on this by creating knowledge hubs in these areas that are related not only to Lebanon but also to all relevant countries in the region. A strong e-commerce activities and good marketing service can help reduce information cost in the long run. Lebanon can go into partnerships with countries that have similar interests.

further. Many individuals are calling for investments in high technology and especially in research and development without a clear vision. If we cannot learn from our past and present to build our future, then we will fail. Past experience should play an important role in the direction of our future knowledge economies. Afterward, we can decide what high technology investments and research and development are needed to support our vision of knowledge societies.

References

ESCWA1: Economic and Social Commission for Western Asia. (2005). *Digital Arabic content: opportunities, priorities, and strategies*.

ESCWA2: Economic and Social Commission for Western Asia. (2005). *Regional profile of the information society in Western Asia*.

Haghseta, F.S. (2003). *Information technology and sustainable development: understanding linkages in theory and practice*. MIT: M.S. Thesis.

MRG: MADAR Research Group. (2005). *The Arab knowledge economy newsletter*, 1(0).

UN: United Nations. (2003). *The Arab human development report*. (United Nations: New York)

UNESCO: United Nations Educational, Scientific, and Cultural Organization. (2006). *Literacy rate by region and gender*. Retrieved May, 2006 from http://www.uis.unesco.org/ev.php?ID=5187_201&ID2=DO_TOPIC.

Warschauer, M. (2003). *Technology and social inclusion: rethinking the digital divide*. (Cambridge, MA: MIT Press)

Chapter 8

GSSD-CHINA

Collaboration in Knowledge e-Networking

Shao Yubin and Huang Jing

Introduction

Sustainable development is one of the most important issues to the progression of human beings in the 21st century. Since the last century, human being have created huge physical fortunes and pushed civilization greatly forward. Meanwhile, many regional and global problems have emerged, such as the rapid increasing population, excessive consumption of natural resources, environmental pollution, and ecological destruction. These problems negatively influence economic development and people's living standards, further endangering the existence and development of human beings, impacting on the continuation of human civilization and the future of the earth.

GSSD in China is located in the Administrative Center for China's Agenda 21 (ACCA21), in the Government of China, Ministry of Science and Technology (MOST). ACCA21 was one of the first international collaborators in the development of GSSD, joining very early.[1] Indeed, establishing working e-relationships was an innovative strategy both for China-ACCA21 and for GSSD at MIT. This is a relationship of initial and strategic significance, and promoted the distribution of sustainable development information in China.

The purpose of this chapter is to highlight the features of GSSD-China, to review the evolution of the collaboration, and to summarize some developments to date on the domains of knowledge provision and knowledge sharing. Additionally, this is a review of experiences in facilitating global access to e-resources of ACCA21 (through English-based access of Chinese language websites) on one hand, and facilitating Chinese access to English language materials whose abstracts are rendered in English, on the other hand. For introduction purposes, Figure 8.1 shows the Chinese language,

[1] Other current members of the China team include Jia Li, Wang Lanying, Li Mei, Pei Zhiyong, and Lin Xin, all of ACCA21.

N. Choucri et al. (eds.), Mapping Sustainability: Knowledge e-Networking and the Value Chain, 143–150.

GSSD-China, in the China location. While this chapter focuses on GSSD-China, it is important to keep in mind that all GSSD sites in all locations are, at any point in time, intended to be exact mirrors or replicas of each other.

Figure 8.1 **GSSD-China homepage.**

8.1 ACCA21-China

The impetus for exploring collaborative activities took place under Dr. Huang Jing from ACCA21, while studying at the Department of Urban Studies and Planning as a visiting scholar (SPURS Program Fellow) at MIT in 1997. Several meetings with the Nazli Choucri, Director of GSSD at MIT led to a crystallization of common goals that jointly support the evolution of knowledge for policy in the transitions toward sustainable development. At that time, Agenda 21 had recently been formulated by the international community as a general set of directives for managing this transition to sustainable development, and each country was responsible for formulating and implementing its own strategies in the context of overall national goals.

With this shared understanding of the advantages of collaboration, a common work plan was developed and put in place. We will return to this point later on. First, however, we would like to introduce the nature of

ACCA21 and its distinctive features and responsibilities in the context of GSSD-China.

8.1.1 Overview

Established in 1994, ACCA21's mission is to promote the implementation of China's Agenda 21 program, and to encourage sustainable development in China. Formally ACCA21 is organized in several units, each with distinctive responsibilities internally as well as in relation to the overall objectives pertaining to sustainability. Aside from the administrative unit which governs ACCA21's activities, the other units include Policy and Strategy Research, Society and Regional Development, Information, Resources and Environment, Marine Planning, Global Environment, and Clean Technology Development.

Among the objectives of ACCA21, several specific items are of special relevance to GSSD in China. These pertain to the conduct of policy and strategy research in the area of sustainability development and providing policy support to government decision making, building a national information sharing network on sustainable development promoting information exchange and sharing, and enhancing public awareness of sustainable development through education and training programs. Also relevant are the ACCA21 objectives of coordinating and implementing research projects and pilot commercialization of research findings for key national research programs focusing on natural resources and the environment.

8.1.2 China Sustainable Development Information Network (SDNP)

An important e-resource and institutional capacity within ACCA21 is the China SDNP, developed in 1997, with inputs from the United Nations Development Program (UNDP). As a vast internal e-network, priorities related to the pursuit and promotion of sustainable development within China, SDNP now has counterparts in most of the countries of the world.

SDNP integrates data relevant to sustainable development. These data mainly consist of information about natural resources, ecology, and environmental disaster areas. SDNP is acknowledged and admired by various circles of Chinese society and possesses great authority and influence. Its users consist of scientific research institutions, universities, and the general public. As an important part of GSSD, GSSD-China has also become an important element of SDNP, and an important window for China to obtain worldwide knowledge and information of sustainable development. In this way, GSSD-China and SDNP bring out the best in each other, and put a huge impulse to the information sharing of sustainable development in China.

Organizationally, SDNP is centrally managed through one general network center, which is then connected with 17 distributed sub-centers via the Internet. With its establishment and functioning, the internal e-networks within China were effectively linked and their capabilities are mutually reinforced. This was, at the time, the first such large scale e-networking initiative ever established throughout China.

The General-Center for SDNP in China is located in ACCA21. Its holdings consist of 119 databases – accessible to the individual networks at no-cost – pertaining to population, resources, environment, social economy and natural disasters. Currently, the size of the general-center's holding amount to 20 GB. It also conducts information retrieval services and provides responses to data requests, search and retrieval, and other information-related queries – including downloading services as needed. Extending e-reach throughout in support of transitions toward sustainability, are 17 SDNP sub-centers. These sub-centers are shown in Figure 8.2 to illustrate the reach of China's SDNP and range of the information systems under its overall frame. Through these sub-centers, SDNP has engaged in a diverse set of projects.

Figure 8.2 **Sub-centers of the SDNP, China.**

8.2 GSSD-China

As indicated earlier, GSSD-China was one of the first global knowledge e-networking collaborators of MIT in the domain of sustainable development, and a founding member of the overall GSSD global network. A memorandum of understanding defined the responsibilities of the respective collaborators, and jointly we gradually developed an operational work plan and the mechanisms for establishing and maintaining replication and synchronization.

GSSD-China makes full use of the Lotus Domino software system, which supports double-byte simplified Chinese characters, in order to localize GSSD system functions, websites, and database resources into Chinese. Through the translation and Chinese localization of the GSSD-China knowledge database, homepage, and relevant websites, the English page layout and information on GSSD English website have been transformed into Chinese.

The compatible Chinese interface on GSSD-China can eliminate the language obstacle for Chinese consumers and enable them to browse and search information. Meanwhile, the functional units on mirror website have been localized in order to facilitate users to browse and search information about sustainability. In Figure 8.3, we show the GSSD-China version of the system overview image.

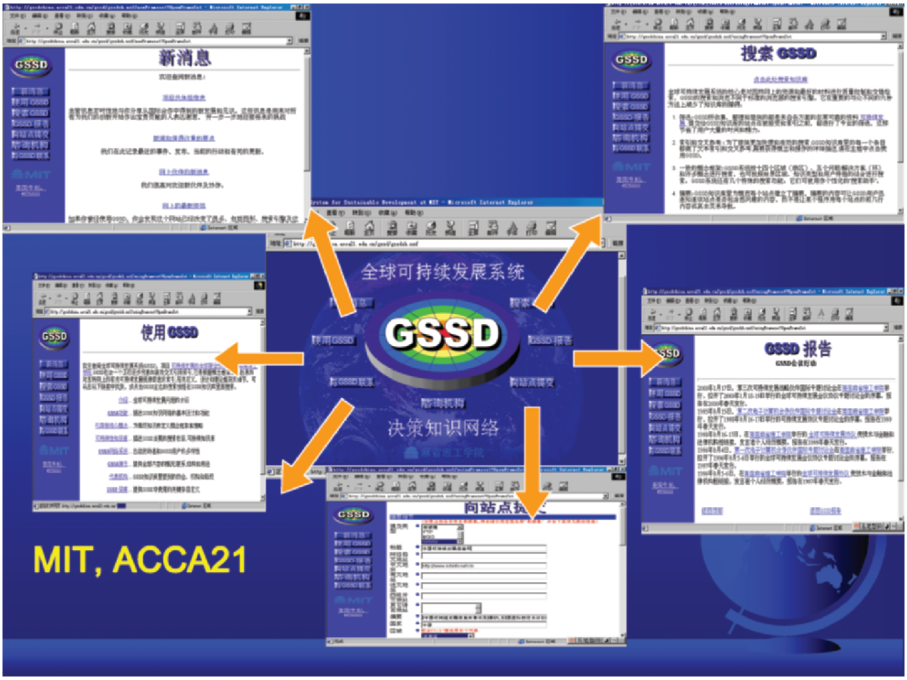

Figure 8.3 **GSSD-China overview.**

Parenthetically, we are pleased that the modality of display in Figure 8.3 was first introduced by the China-team and then adopted by other collaborators. In Part I, the GSSD home page is shown in that manner as a way of rapidly conveying some of the key functionalities of the system. This visualization was then also adopted as standard views in all mirror sites. Since the China team is responsible for expansion of the GSSD knowledge-base – as is every other collaborating member – the decisions that are made are reflected by necessity in the work plan of all other members whose knowledge materials are also subject to the routinized replication and synchronization.

For recognition purposes, Figure 8.4 shows several screenshots of the GSSD-China Search functions. Notice the similar structure to the main GSSD Search functions.

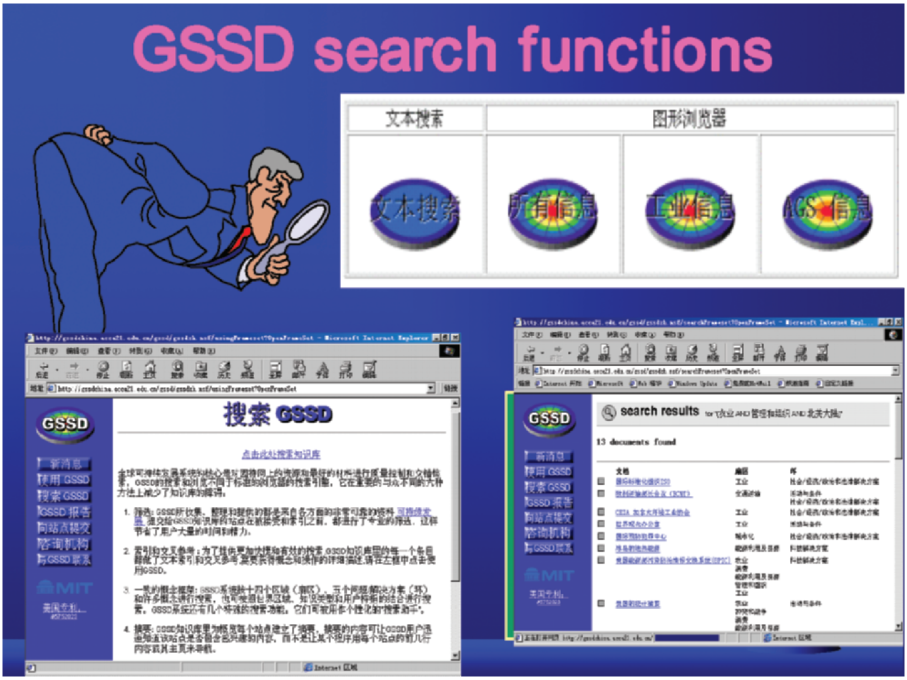

Figure 8.4 **Search functions in Chinese.**

Beyond sharing images, through the course of this collaboration to date, GSSD-China has completed a large scale Convergence and GSSD Glossary translation (2500+ items), as well as knowledge-content translations, including abstracts and Reports. In terms of content provision for the GSSD knowledge-base, over 6000 knowledge-content abstracts have been translated and rendered available for multilingual search and retrieval. These items (or documents) currently span nine of the fourteen domains of GSSD. This is an ongoing activity, since new materials are added and old ones become deleted.

The GSSD-China team has also published other key materials to the web, has continued to collect Chinese website materials for potential inclusion in the overall system, and has created the Chinese language website, including the various options for Search-GSSD. Constructing a Search-GSSD program in Chinese has been especially arduous as many sustainable development terms did not exist in Chinese before us. Fortunately, we have been able to create a Chinese searching tool for GSSD, keeping the structural integrity of GSSD intact.

8.3 Next Steps

The GSSD-China team has targeted several goals for improving the delivery of sustainable development.

First, while much work has been done on the knowledge-base in Chinese, there is still much more to do. Only nine of the fourteen slices of GSSD have had their abstracts translated to Chinese, leaving five more slices to translate.

Second, we need to provide Government of China ACCA21 materials connections to the GSSD-China site, via usage of the submit site functions.

Third, we need to review the current ACCA21 portfolio of activities and determine the priorities of relevant materials for inclusion into the GSSD-China knowledge-base.

Fourth, we need to control the dead-link 'clean-up' activities for the GSSD-China site, on the China side. Dead-links are links that are removed from their host sites. This can happen for a variety of reasons, and it is hard to determine when a link goes dead. As GSSD is essentially a library of links, such dead-links can be very detrimental. The collaborating partners of GSSD have been experimenting with different software to make sure that all links are active, and recently GSSD-MIT itself developed the software to reduce dead-links.

Fifth, currently we are in the process of framing the next phases of our collaboration on substantive concerns with GSSD-MIT.

To the extent possible, the system administrators of the mirror sites seek to render computational assurance as well as quality control and updating overall coverage. Currently, most of this is either automated or managed on a routinized basis.

8.4 Conclusion

An important feature of GSSD-China – and all of the other mirror sites in the system – is to ensure accurate content representation of key concepts, accurate translations of the static pages, and correct location of buttons signaling functions. Earlier, during the initial stages of development when all of the GSSD Glossary and conceptual features of sustainable development as a knowledge domain were being developed in Chinese – in real time around the world – establishing and retaining this cross-language consistency and accuracy constituted a major challenge. At this point, the workflow process is regularized, thus facilitating the update as well as the expansion of the knowledge-base.

By the same token, the GSSD-China team is responsible for insuring that any translation of China-submit sites into other languages (such as Arabic, for example) is accurate and does not misrepresent either formal content or intuitive intent.

It is important to stress that many of these issues are not distinctive to GSSD-China or to the Chinese language. All of the system languages were exposed to conceptual and linguistic uncertainties when dealing with new words, new ideas, and new ways of representing knowledge – in a domain that itself is undergoing considerable development and change.

This particular feature of the GSSD initiative worldwide represents knowledge-development in its most formal meaning, in the sense that the challenge for all of the collaborators was to ensure the provision of new understandings as accurately as possible in an area where the concepts themselves were in the process of being formalized and where no ‘dictionary’ had yet been recognized across the world as representing the multilingual equivalence of key concepts, ideas, and words pertaining to sustainable development.

Chapter 9

STRATEGIES FOR RE-ENGINEERING GLOBAL KNOWLEDGE e-NETWORKS

Amrith Raghavan

Introduction

The purpose of this chapter is to take stock of the performance of the Global System for Sustainable Development (GSSD) for the purposes of identifying central tendencies and providing some insights into directions for re-engineering. In this chapter, we provide an analysis at one point in time. Our purpose here is contextual, that is, to remind ourselves of the fundamentals of knowledge and of knowledge networking designed for this particular system as well as its targeted domain, namely sustainable development. We also provide a review of the current design of GSSD and its implementation, as well as its implications for the next generation of distributed knowledge e-networking

Put succinctly, the purpose of this chapter is to review and assess GSSD performance to date, to determine if the record is consistent with the intended objectives, and to highlight ways of improving or enhancing the overall undertaking. We begin this chapter with a discussion of methodology: how we shall measure the successes and shortcomings of GSSD. GSSD needs to be measured across two dimensions: its knowledge content and its user-traffic. In the second part of this chapter, we provide some initial results, closing with several recommendations for improving GSSD.

It is important to note that interactive knowledge e-networking in the context of distributed systems is of rather recent vintage. As a result, no robust track record has been generated against which we can examine the GSSD case. In addition, multi-lingual distributed e-systems are of even more recent vintage, thereby complicating the situation. The rules are not yet formally codified, nor are the methodology norms generally agreed upon. However, there are some common practices that we draw upon over the course of our inquiry.

N. Choucri et al. (eds.), Mapping Sustainability: Knowledge e-Networking and the Value Chain, 151–175.

9.1 Some Fundamentals

By way of placing the issues in context, we begin this chapter with some brief observations on the nature of knowledge and of knowledge-networking. Other chapters in this book have also dealt with knowledge and with networking – in many ways and with greater depth. Here, however, we highlight only those features that are directly relevant to the review.

9.1.1 Perspectives on Knowledge

Three perspectives of the ways in which *knowledge* has been viewed are especially relevant in this discussion. The first perspective treats *knowledge as an object* and assumes that knowledge can exist independent of human action and perception. Knowledge is conceived as some truth that can be codified and separated from the people that possess it. By adopting this perspective, the goal of knowledge management is then to convert the knowledge residing in the minds of people into structural assets owned by the firm and store it in the firm's knowledge management system (KMS).

The second perspective assumes that knowledge is *embedded in individuals*. Knowledge is inseparable from people, and knowledge resides only in the minds of individuals. Only people can know and only they can convert knowing into action. It is the act of thinking that can transform information into knowledge and create new knowledge. In addition, people seem to know a great deal more than they can articulate and this tacit component of knowledge has a personal quality which makes it hard to formalize and communicate. Thus this perspective focuses on the management of human resources. Since knowledge is viewed as difficult to codify, and loses its value once codified, the goal of a KMS in the second perspective should be to connect experts with knowledge seekers.

The third perspective considers *knowledge embedded in a community*, where knowledge is the social practice of knowing. In this perspective, learning, knowing, and innovating are closely related forms of human activity and knowledge is inexorably connected to practice. Each community develops its own language, its own shared narratives, and its own codes, making knowledge best understood within the context of its community. This view attempts to locate organizational knowledge and knowledge creation within distributed, multi-actor routines, rather than in the minds of individuals. The resulting focus in this third perspective is on processes that are geared towards enabling discussion, mutual engagement, and exchange between members of a community.

In the first two perspectives ('knowledge as object' and 'knowledge embedded in individuals'), knowledge is treated as a *private good*, where an individual owns the knowledge. Private goods are goods with high excludability and high rivalry. With private goods, it is clear who benefits and that person/organization can easily be charged for those benefits. In such cases, people exchange their knowledge through market mechanisms and receive commensurate benefits. Motivated by self-interest, they are less likely to exchange knowledge in the absence of returns.[1]

The 'knowledge embedded in community' perspective assumes knowledge is a *public good*. A public good is one where users collectively consume benefits and no one can be excluded from consuming the good or of reducing its essence. When confronted with a public good and no regulation, the economically rational action for the individual is to free-ride, or to consume the public good without contributing to its creation, maintenance, or development. We reconcile these perspectives by taking as assumptions the following: (i) knowledge is a public good that is privately produced, (ii) institutional and collaborative relations are the mechanisms through which individual generation of knowledge is embedded in *social interactions*, and (iii) knowledge outcomes assume the characteristics of public goods. We shall discuss the implications of treating knowledge as a public good and the theories of self-interest and collective action in the next section.

9.1.2 Knowledge Networks

At the most general level of analysis, knowledge networks can be characterized as comprising of actors, with relationships between actors categorized by their form, by their content, by their intensity, by the resources which may be used, and by their institutional properties, including structural, technological, and cultural dimensions.[2] It is useful to consider an overall context within which to place all key aspects of an e-networking initiative. Here we draw attention to the fact that some analysts consider a knowledge network as a unique hybrid form of organization between market and hierarchy because they contain elements of both forms (Thorelli, 1983). Please see Figure 9.1 for how we consider each element in turn using von Kragh's framework for characterizing knowledge networks as landscapes (Seufert et al., 1999).

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[1] These returns need not be tangible; reputation and status-directed obligation from the knowledge seeker may be garnered by sharing knowledge.

[2] Recall that the GSSD knowledge network is more formally designated to specify specific features pertains to the above, as noted in Chapter 2, and in other chapters of this book namely: (a) computer-assisted organized system of discrete actors, with knowledge producing capacity, (b) combined through the use of common organizing principles, (c) retaining their individual autonomy, such that (d) networking enhances the value of knowledge to the actors, and, accordingly, (e) knowledge is further expanded.

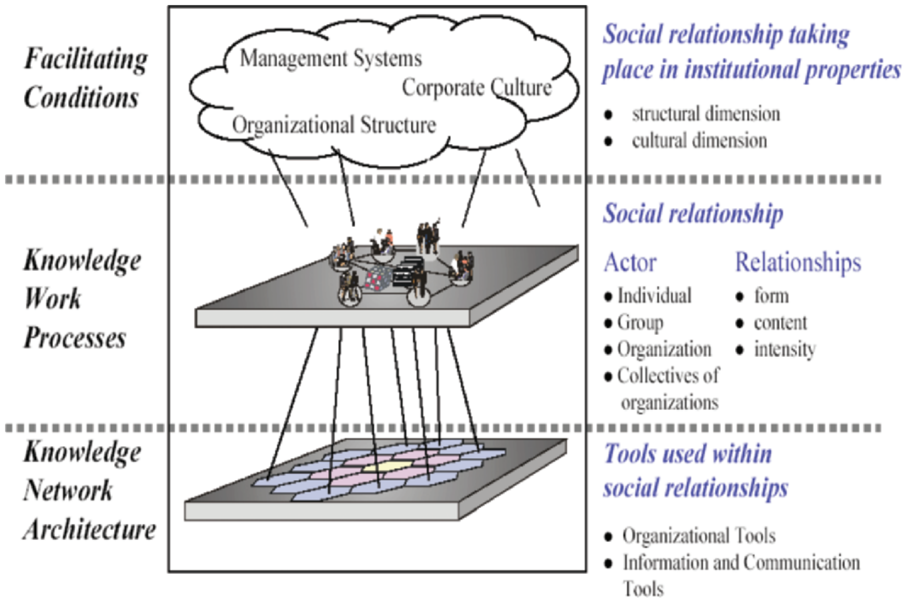

Figure 9.1 **Analysis framework for knowledge network. Source: Seufert et al. 1999.**

Across the left-hand side of Figure 9.1 are three layers: *Facilitating Conditions, Knowledge Work Processes,* and *Knowledge Network Architecture.* The first, *Facilitating Conditions*, refers to the network's internal structural and cultural dimensions in which knowledge work processes take place, thereby defining the environment for knowledge creation and transfer. This includes the organizational structure, the management systems, and the network culture. The structural dimension also includes the nature of relationships with various participants.

Knowledge Work Processes comprise social interaction and communication processes on an individual and at the group level. These processes can be conceptualized as an adaptation of Nonaka's (1991) four-stage knowledge spiral since the processes in the network act as a transformation process between explicit and tacit knowledge from *socialization* (the exchange of tacit knowledge between individuals in order to convey personal knowledge and experience) to *joint experience* (resulting in new shared implicit knowledge) to *externalization* (the actual exchange of knowledge between individuals and a group) to *combination* (where different fields of explicit knowledge are combined with each other to make new knowledge available on a network wide basis).

The third and final layer, the *Knowledge Network Architecture* refers to the tool-set used within social relationships. These tools include organizational tools, the roles of the knowledge actors, and the informational tools used to enable and improve knowledge work processes. This layer is also where the knowledge medium is set, how the network is configured to best supply knowledge, how the moderation mechanisms and quality control procedures are defined, and how the ontology is determined. Against this background, we now summarize some key elements of the GSSD e-network in order to yield some basic information to contextualize our analysis of system performance.

9.1.3 GSSD e-Network

The GSSD system is a large e-network which supplies knowledge pertaining to sustainability and sustainable development. A knowledge e-network is a *computer-assisted organized system of actors with knowledge producing capacity*. Common organizing principles define both the relationships of actors to one another as well as knowledge topics to one another, but the individual actors retain a high level of autonomy, such that networking enhances the value of knowledge to the actors and, accordingly, knowledge is further expanded.

As an intelligent document repository, the GSSD knowledge-base consists of thousands of *abstracts* which link to resources (websites) on sustainable development. Abstracts can be submitted by any user (without registration), and the submitted abstracts are reviewed, translated and published by the institutional partners GSSD works with.

Document repositories are usually unidirectional, impersonal, and often with little feedback.[3] Furthermore, the materials are treated as published books would be treated: with full respect of copyrights and complete acknowledgement of the authors' ownership. Document repositories have also been characterized as altruistic networks in the sociological literature as the motivations and incentives for people to contribute are not readily apparent (Desouza, 2002).

As discussed in Part I of this book, at the core of GSSD is its knowledge-base, consisting of a body of quality-controlled Internet resources on sustainability accompanied by abstracts of their content. These abstracts are organized within a consistent conceptual framework and translated into all supported GSSD languages (currently supported languages are English, Chinese and Arabic with soon to be included mirror sites for Japanese and French translations). The tags used for cross-referencing in the GSSD

[3] Note that the term document refers to any item that is entered into the knowledge-base, which may or may not be a document in traditional terms.

knowledge-base allow efficient retrieval of these abstracts by user specifications and facilitate an understanding of the linkages among issues and problems, strategies, and solutions. In this manner, GSSD serves to enhance integration of alternative views of sustainability.

Adopting a meta-networking strategy, GSSD provides networking facilities across stakeholder communities in order to help identify innovative approaches, enabling technologies, as well as new institutional, financial and regulatory mechanisms for meeting sustainability challenges that confront all countries. The GSSD collaborators are located in various institutions, including universities (The American University in Beirut), or in government agencies (Ministry of Science and Technology, Government of China). Collaborators assume the responsibility for abstract review and translation. The challenge within GSSD is to selectively aggregate content while maintaining a balance in the quality control process. This is very important because a lax selection process may lead to user searches yielding irrelevant results, and a strict quality control process may result in under-populated repositories that yield too few results.

Surrounding the core knowledge-base of GSSD and interactions with the institutional patterns is a set of processes and a preset workflow. The translation process deserves special mention here. Any abstract submitted within GSSD is automatically routed through an inbuilt workflow to a translation partner, who translates the abstract into his own language. Over time, this process results in a system where the content is available in all GSSD-supported languages. This process – along with the fact that GSSD is distributed over the Internet through a system of servers, or mirror sites allowing users worldwide to select both the server location that provides them with the fastest access (bandwidth) and the language they most prefer – greatly reduces some of the most difficult barriers to knowledge, especially in developing countries.

9.1.4 Evaluation of Knowledge Networks

At the most general level, the effectiveness of the network is defined as the ultimate value of a knowledge network to its users in terms of: (i) joint value creation, (ii) building capacity, and (iii) providing the information tools to influence policy processes. Effectiveness means doing the right thing as gauged by the constituency in question. Measuring the *effectiveness of the network* involves defining the overarching goals and the ultimate purpose of the knowledge network. Although most knowledge networks state their goals upfront, it is important that these goals are well defined, that they are clear, and that they are endorsed by its members.

As noted at the onset, in this chapter we use two different modes of operational analysis for gauging a network's success. The first is a *content analysis* approach, concerned with the relevance, usefulness, and the accessibility of the content within the network. The value of content is based upon the combination of its primary useable form, along with its application, accessibility, usage, usefulness, and uniqueness. Content analysis is targeted at understanding and matching content to user needs with the aim of facilitating collaboration and knowledge-sharing through greater content accessibility. In this approach, we inventory the knowledge resources available within the network, we identify the characteristics of content provision, and we seek to improve upon the organization of this content in the network by refining the set of rules and processes for contributing, collaborating on, and controlling content. One of the aims of the content approach is in refining the ontology for displaying content. Of course, in the GSSD case the detailed composition of the content may change, as new documents are submitted and old ones are deleted, but the overall framework is rendered consistent due to the ontology that has been developed to represent sustainable development as a knowledge domain.

The second approach focuses on the record of system usage and traffic of the network itself. One of the advantages of electronic knowledge networks is the ease with which data can be gathered about their usage. All websites generate log files that can be analyzed by a wide variety of software tools or outsourced services. The difficulty lies in deciding precisely what to analyze, and in determining the real significance of the data. Are *page impressions* a more accurate metric than *hits*, for example, or should we forget them both and concentrate on *conversion rates* or *repeat visits*? When applied to networks in any context, traffic analysis is used to examine the following features:

- *Size* of the online community using the knowledge system, and the size of the message base.
- *Growth* of the online community. This includes the number of new members voluntarily adding subscriptions versus the number of members who are defecting.
- *Activeness* of the online community, as determined by the percentage of contributors to subscribers.[4]
- *Relative activeness* of the online community, as measured by the number of total postings, the number of postings per contributor, the growth in postings, and increases in the thread length.

[4] This rate is always low. It is not uncommon to find that the bulk of the messages in successful networks come from a very small percentage of the members.

- *Relative number of sanction messages,* required keeping contributions on topic.[5]

Neither content nor traffic analysis yield any inferences regarding impacts on the constituency nor implications for actual behavior. At the same time, however, both content and traffic analysis provide useful tools to gauge the vitality and robustness of the network and need planned data collection mechanisms and organizational processes to make sure they are carried out on a periodic basis. These analysis tools provide an empirical view of the performance of the knowledge network. To assess the extent to which people's opinions, attitudes, and behaviors are changing these studies could be complemented by user surveys. Although surveys measure people's perceptions, these may or may not reflect empirical reality. However, people's perceptions will determine their behaviors with respect to knowledge collaboration and sharing.

9.2 The Analysis of GSSD Content

9.2.1 The Knowledge-Base Defined

What is the effectiveness of the ontology of the GSSD knowledge system? Effectiveness is defined here as the ability of the ontology to help the user find the content he or she desires. Our approach could also be viewed as a generalized method towards analyzing other similar knowledge or information classification systems such as the World Bank's Development Gateway's Topic Pages and the UNEP's Grid System on Sustainable Development. This approach also aids in developing dynamic ontologies or, more specifically, ontologies that continuously adapt based on the content that flows through them.[6]

9.2.2 Methodology and Results

In order to extract systematic observations on content, we exported the GSSD Lotus Notes Database and processed it to yield a text file. Each row of the file represented one abstract. Each abstract could reference one or more *slices* and one or more *rings*. Recall from the chapters in Part I that slices refer to the domains of sustainable development (such as Agriculture

[5] No sanctioning messages might indicate a dead community (no one cares any longer), while too many sanctioning messages might indicate a community having difficulty establishing the proper norms and expectations.

[6] The knowledge-base does not include news items, conferences, or any information that is time bound or whose value is not generic in some form.

or Industry) and the rings refer to the key dimensions (such as Activities and Conditions or Scientific and Technical Solutions).

For each pair wise combination of slices and rings, the number of abstracts referencing *both* was calculated. The results, illustrated in Table 9.1, and help us visualize the extent of interrelationships in the knowledge-base content. Table 9.1 should be read vertically (by columns). For example, the entry in Row C, Column D (6%), should be interpreted as follows: of all the 764 abstracts in the database that contain the slice Energy Use and Sources, 6% of them are also contained the in the slice Consumption. This example shows that the table is asymmetric – the entries for Row C, Column D are different from those of Row D, Column C. This difference is due to the fact that the figure of 13% represents the percentage of abstracts that contain Energy Use and Sources as a percentage of abstracts that contain the Consumption slice; and this figure is greater than the 6% figure noted above.

This asymmetry is a function of the composition of the knowledge-base during the period of this analysis. It shows the results of the knowledge provision practices. However, it is not possible to determine empirically whether this asymmetry is a function *only* of knowledge provision or, alternatively, it represents some underlying pattern or trend in the materials available on cyber venues. The purpose of Table 9.1 is only to highlight the composition of the knowledge-base during this specific period of investigation.

9.3 Implications for Re-Engineering the Ontology

For researchers trying to map a new domain, one measure of the effectiveness of their ontology could be the distribution of results in Table 9.1. A more equalized distribution would indicate a more effective classification, whereas one with *lumps* would indicate a high dependency across two slices.

Lumpiness could be due to a natural convergence between two domains (such as say energy and environment), but it sometimes requires that the slices be made more granular (divide ‘energy’ into ‘power generation’ and ‘energy sources’). Also, as the above example illustrating the difference between (C, D) and (D, C) indicates, one could gain insight into the directionality of the slices, with one slice being more important to another in a pair-wise relationship. Both granularity and directionality have important implications towards topic rationalization and therefore the users’ navigation experience.

Table 9.1 **Pair wise comparison of slices.**

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	Total Abstracts
A	7%	5%	9%	6%	11%	6%	7%	8%	5%	6%	7%	8%	7%	10%	904
B	3%	26%	3%	2%	3%	4%	1%	9%	2%	4%	3%	5%	3%	3%	453
C	7%	5%	5%	6%	7%	8%	6%	6%	5%	5%	5%	6%	8%	8%	764
D	11%	6%	13%	13%	11%	10%	24%	7%	25%	6%	10%	9%	8%	10%	1701
E	11%	6%	8%	6%	11%	7%	7%	8%	6%	6%	6%	8%	7%	11%	934
F	5%	6%	6%	4%	5%	4%	4%	7%	3%	6%	6%	8%	8%	6%	650
G	13%	6%	13%	23%	12%	11%	9%	7%	26%	6%	11%	8%	8%	12%	1689
H	3%	6%	2%	1%	3%	4%	1%	5%	1%	4%	3%	4%	4%	3%	341
I	8%	5%	9%	20%	8%	7%	20%	6%	7%	5%	8%	6%	6%	8%	1347
J	5%	6%	5%	3%	5%	7%	3%	8%	3%	26%	5%	9%	8%	4%	747
K	5%	5%	5%	4%	5%	7%	5%	6%	4%	4%	17%	7%	6%	5%	726
L	7%	7%	6%	4%	6%	9%	3%	9%	3%	9%	7%	6%	9%	6%	720
M	6%	5%	7%	3%	5%	8%	3%	8%	3%	7%	6%	8%	11%	6%	705
N	10%	6%	8%	5%	10%	8%	6%	7%	5%	5%	6%	7%	7%	7%	839

Agriculture	A	Migration and Dislocation	H
Conflicts and War	B	Mobility	I
Consumption	C	Population	J
Energy Uses and Sources	D	Trade and Finance	K
Forest and Land use	E	Urbanization	L
Governance and Institutions	F	Unmet Basic Needs	M
Industry	G	Water Use and Sources	N

The competitive advantage of GSSD relative to other peer meta-networks on sustainable development is its powerful ontology and classification system. Continuously updating the results of such an analysis into revisions of the ontology is needed if GSSD expects to maintain this advantage. The results of the content analysis are the first step in this direction. Examples of further content analysis could include:

- Formal cluster analysis to determine size of optimal clusters to characterize data. Cluster analysis is done on pair-wise comparisons of abstracts. The content analysis will have to consider more dimensions in its comparisons – as each abstract can reference more than one slice. Sophisticated graphical analysis tools for content affinity analysis need to be used for this purpose.
- Examining content characteristics across other features, like location/time etc. The content analysis described above ignores the characteristics of the user submitting the data. It would be useful to know whether developing countries' members of GSSD are contributing more than developed nations' members to certain domains, which countries lead in providing technical solutions/policy solutions, etc.

9.3.1 Traffic Analysis and Network Mapping

Turning now to the second method of system evaluation, we examine the web traffic patterns as well as user profile to the GSSD website, and we then undertake a very preliminary analysis of the relative position of GSSD with respect to other knowledge sources on sustainable development on the Internet.

9.3.2 Traffic Analysis

The empirical database that we used for these purposes consisted of the server log file data for a 410 day period from 1st Jan 2002 to 15th Feb 2003. These files were obtained and analyzed using a commercial log file analysis tool. The summary of results in Table 9.2, indicate that on an average day, GSSD received around 160 visitors a day. This figure could be viewed as large or as small depending on one's perspective. Given that GSSD avoids advertisement and it does not engage in any promotion, and given that the content is *intellectually heavy*, we consider this pattern to be healthy. In this regard it can be described as largely passive, relying on pull (through branding, reputation and a satisfying experience) rather marketing for its visitor base. Toward the end of this chapter, we shall refer to more recent traffic statistics in order to provide some balance of judgment.

Table 9.2 **GSSD traffic summary, 2002.**

Figure	Value	Description
First hit	12/31/2001 12:00:46 AM	Time of first hit
Last hit	02/15/2003 05:27:41 PM	Time of last hit
Hits	421032	Total number of objects accessed on web site
Page views	279209	Total number of page views
Visits	64659	Total number of visits (continuous page views)
Page views per visit	4.32	Average number of pages viewed per visit
Time per visit	0:02:51	Average duration of a visit
Visitors	13382	Total number of visitors
Visits per visitor	4.83	Average number of visits per visitor
One-time visitors	11040 (82%)	Visitors visiting only once
Time spent per repeat visitor	0:13:48	Average total visiting time per repeat visitor
Visits per day	156.94	Average number of visits per day

At the same time, however, Table 9.2 also points to a troubling finding: the number of one-time visitors is a very high (at 82%), which means that six out of seven visitors who visit GSSD never come back. What is interesting is that the number of visits per visitor is 4.8, which means that even with an 82% one-time visitor percentage, the number of visits by repeat visitors is so large that the average comes out to almost five visits per visitor. This proves the existence of two very different classes of users – browsing members who are usually one-time visitors, and repeat members – constituting 1/7 of the GSSD visitor base, who use the website heavily. An even more encouraging statistic is the amount of time repeat visitors spend on the site: a whopping 13 minutes, an impressive amount of time for any knowledge-base, particularly one that mainly provides links to other web pages.

A knowledge network needs a high percentage of repeat visitors whose sustained participation is necessary for a critical mass of members and resources to cumulate. A knowledge network also requires a steady participation of new members to compensate for natural attrition. The high browsing or repeat visitor ratio is worrying in terms of recruiting new members into the network, and GSSD as an organization has to recognize why this is happening. The reasons for this phenomenon could be marketing factors (attracting the wrong kind of audience in the first place), bad user experiences (not providing what the visitors are looking for or cumbersome navigation methods), or technological factors (a slow website).

It is possible to find some partial answers to the reasons why this is happening. An analysis of the most frequent exit pages (the pages last seen by the visitor before exiting the site) yields Figure 9.2.

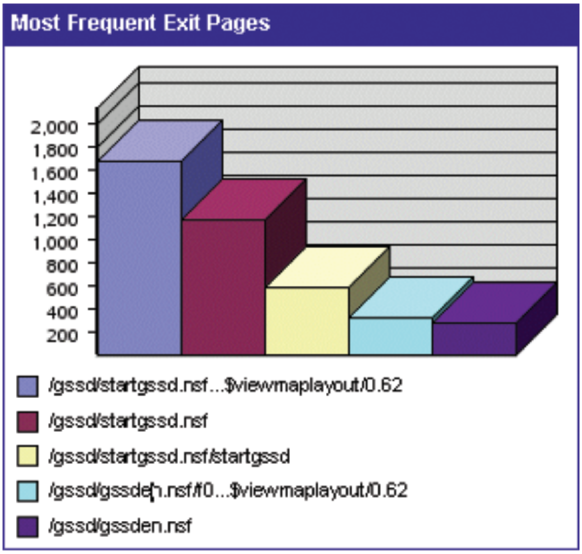

Figure 9.2 **Most frequent exit pages.**

The most frequent exit pages are all within the first two navigation levels of GSSD. This means that most visitors leave within the introduction page (where the visitor has to choose from amongst a list of languages and mirror site locations) or within the start page. The fact that most visitors exit from these pages indicates that the typical user who visits the GSSD website either faces confusion (over the choices), or frustration (over the multiple levels) to get access to the desired knowledge.

This problem is not serious for repeat visitors who are used to the interface, but this might be a significant deterrent to attracting new visitors to come back again. Clearly, GSSD will have to look at alternative design choices in its first two web pages to improve new user experience.

9.3.3 Network Mapping Analysis

Network Mapping Analysis may also shed more light on the types of people who are using GSSD. Hypothetically, the large incidence of one-time users could be the result of users who are looking for something non-GSSD related. The aim of this exercise is to find the relative position of GSSD vis-à-vis existing content domains on sustainable development existing on the Internet during the time of this analysis. This approach maps out the domain of knowledge on this topic on the web, providing a topology of similar content which could form the basis of collaboration and reverse linking, competitive analysis and benchmarking.

Specifically, we seek to find out the possible approach paths to the GSSD website (either by directly typing http://gssd.mit.edu, or by redirection from another website, or through a search engine). The log file data for redirection and direct entry into GSSD is not available, but a look at the search engine keywords used to come to the GSSD website gives us some insights. Table 9.3 and Figure 9.3 show the analysis on the keyword data for a period of two months (September–October 2003).

Table 9.3 **Most frequently used keywords to find GSSD – two month period.**

	Keywords	Visits
1	sustainable development	280 (4.9%)
2	MIT	118 (2.0%)
3	global system	94 (1.6%)
4	GSSD	94 (1.6%)
5	Substainable development	46 (0.8%)
6	global sustainable development	19 (0.3%)
7	Sustainable	19 (0.3%)
8	What is sustainable development	14 (0.2%)
9	global system for sustainable development	12 (0.2%)
10	GSSD MIT	11 (0.2%)

We see that during this two month period in 2000, users who came to GSSD do so by using either a combination of general keywords (sustainable development, sustainable, etc.), or very specific keywords (GSSD, MIT, etc.) Curiously, none of the popular keywords reference any of the content within GSSD. This is usually the largest and most important source of traffic for most knowledge networks as most knowledge network resources are indexed and made available to search engine robots. GSSD has only recently opened its database for public indexing. We expect to experience a substantial rise in user traffic.

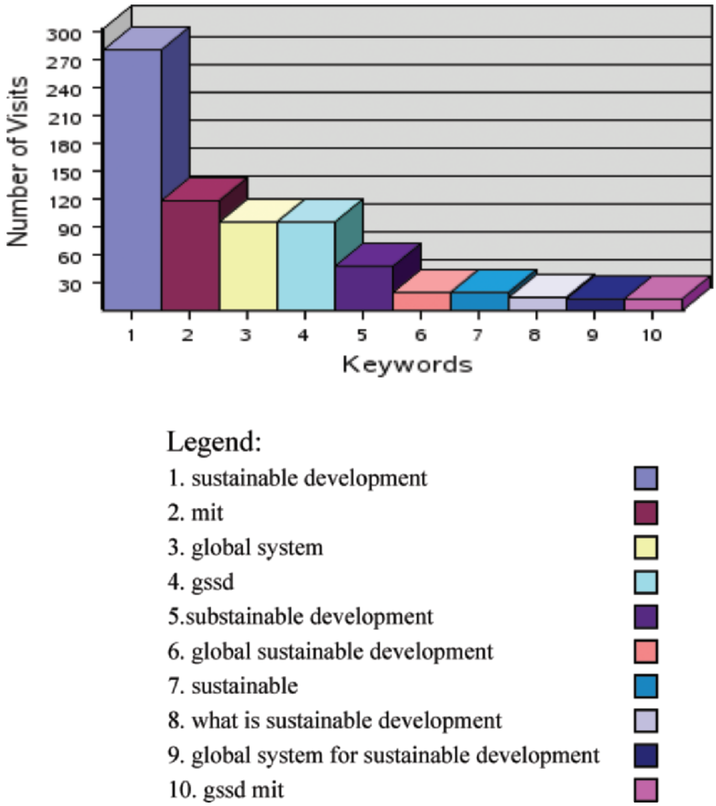

Figure 9.3 **Most frequently used keywords to find GSSD, two month period in 2000.**

In Figure 9.4, network mapping analysis is conducted by using a cartographic tool. The results delineate where GSSD stands with respect to other e-systems focused on providing sustainability resources over the Internet. The figure indicates where GSSD stands with respect to others on the search phrase 'global sustainable development.' Based on this map, one can see that while GSSD is geared towards users seeking 'resources' on sustainable development, the UNDP and the UN websites are for networking and for describing the challenges respectively. Amazon and Questia provide information on books related to sustainable development.

The results of the visibility analysis and the network mapping exercise can aid the network managers in planning corrective actions to draw more users to the website. Moreover, by examining the link to (the list of sites which link to the network the most), the network manager could identify co-promotional opportunities that could provide a steady source of traffic in a more sustainable way.

Figure 9.4 **GSSD's position in the sustainable development domain, two month period in 2000.**

9.4 Implications of Re-Engineering the GSSD e-Networks

9.4.1 Select Performance Issues

GSSD faces a problem of under-provision of knowledge resources due to a paucity of large-scale community participation. At the same time, however, GSSD does not actively encourage participation. Its partners and mirror sites are the major knowledge providers. In addition, the kind of resources submitted into GSSD are highly selective, the process of approval is even more rigorous, and the repeat GSSD user is much more discerning than users looking at other e-systems on sustainable development. The knowledge within GSSD is more akin to basic research and is augmented with selective and focused materials from policy sources. By contrast, other e-systems which focus on matters of sustainable development are more in the nature of managing applied research.

To explain, GSSD's core competence is the value added to the content through its powerful ontology. The users of GSSD draw upon the ontology to navigate and search for content, appreciating the multiple languages.

Moreover, GSSD is selective about the articles it includes into its knowledge-base. News reports and press releases – acceptable to the Development Gateway – are not allowed within the GSSD knowledge-base.

GSSD targets quality over quantity and moving to a community model of resource provision raises fears that the quality might be affected. However, we are still faced with the problem of continually populating the knowledge in a scalable manner. However, attracting a larger audience will not necessarily lead to a deterioration of the quality of content as the rigorous multi-stage approval process will still be used to weed out unworthy submissions. It must be recognized that GSSD only stands to gain irrespective of the quality of the users it attracts (as long as it does not turn off serious users). GSSD should clearly bait its users by attracting as large an audience as possible and hook them with its features – a comprehensive, intelligent, quality controlled knowledge-base.

Thus the key challenge for GSSD is to attract more visitors and to retain them. Attracting new visitors can be done by continuing to market the knowledge-base on search engines, by implementing link exchange programs, and by e-mail marketing. However, retaining visitors and making them visit again is a much harder task.

9.4.2 Strategies for Improving Performance

In order to improve performance, we need to increase the total number of members and we need to increase the total number of return users. We propose three potential strategic solutions, namely: (i) to build a feeling of community, (ii) to re-engineer the work process, and (iii) to re-engineer the partner incentives.

9.4.2.1 Community-Building

The lack of persistent identity in GSSD is striking. To combat this, community-building needs to be utilized. Communities are created when individuals build and maintain relationships within networks. Researchers have identified that interpersonal trust is a central characteristic of relationships that promotes effective knowledge creation and sharing in networks (Tsai and Ghoshal, 1998). However to create a feeling of trust, one needs to have a unique identity within the network. Currently GSSD does not recognize unique identities externally – it is not possible to find out who submitted a resource, nor is there a way to log on to the network and be recognized by the system. The first step towards building a community would involve a registration mechanism where users register their preferences and profile with the network with an option to disclose their profile to all other registered users.

The absence of mechanisms for social connections within GSSD is also a problem. Interactions are one way: between the user and the knowledge-base. New connections could be formed by allowing for comments on submitted resources or by launching new discussion groups. As currently conceived, the function of a discussion group is not incorporated within the GSSD mission.

Currently, the GSSD knowledge-base also does not systematically provide information on what has changed since the last visit. There should be a provision for displaying the most recent resources added, the number of resources in each of the domains and the number of new members added since last log on, in a prominent location. Such a development would make GSSD appear dynamic rather than static.

9.4.2.2 Re-Engineering the Work Process

The second set of solutions involves changing the organizational processes for improving participation. *Work processes* refer to the content submission policy, the content review process, and the process for translation and publishing. To a certain extent, it also refers to the user search and navigation process.

In order to improve the work process, the layout must be redesigned. The current layout of GSSD requires six mouse clicks before the user can get to the "Search GSSD" page, the principle navigation page of the site. This presents six opportunities for the user to leave the site. An analysis of the top exit pages have shown that most people leave the website after the first two pages. To combat early exit, the search feature should be made available in the first or second page. However, since these early clicks route users to theoretical and design related issues, bypassing these may hide some of the intellectual elements central to the overall mission.

Another way of changing the work process rests in changing the content-submission process. The current content submission process involves filling a form that has over 15 fields: a burdensome process for any but the most dedicated user. This form should be simplified by decreasing the number of fields. This would increase the burden on the internal reviewer.

9.4.2.3 Re-Engineering Partner Incentives

The third category of solutions involves re-engineering the incentives and motivations of the network's institutional partners and their representatives. Partners are motivated to collaborate with GSSD for a variety of reasons ranging from a genuine desire to participate in an initiative that provides a holistic view of knowledge on sustainable development, to a desire for peer recognition, to a desire to promote their own language or region (digital inclusion) to a desire to be affiliated to the GSSD-MIT brand name.

Of all the motivating factors, the most important ones are those where the actors genuinely believe in GSSD as a way of providing a new way for representing sustainable development and where the actors have internalized the values that GSSD stands for: an integrated perspective that cuts across domains, geography, and languages. As we have seen before, commitment by internalization is the preferred way of cultivating commitment behavior. In the context of GSSD, this ensures that the knowledge worker will try to maximize one's value added contributions and will not artificially inflate the quantity of contributions or skimp on the quality.

It is important to recognize that all of these are *soft* incentives and the temporal lag between the motivation and the actual deliverance of results could pose problems for ensuring sustained participation in the network. Soft incentives take time to deliver and need to be continuously reinforced to take effect. GSSD has been effective in rewarding genuinely committed partners by inviting partners to conferences within and outside MIT. However, more needs to be done. Other ways of engaging committed partners could be by initiating institutional joint projects on similar topics, providing access to sources of funding, offering increased networking options for partners where they interact with other MIT faculty/researchers, and by providing access to other scarce resources.

Thus far we have suggested that a community-oriented participation model, coupled with a strong institutional network backbone of partners can provide GSSD with a strong model. For this to happen, there needs to be a strong top management commitment, a long-term vision for the network where objectives are clearly stated, a clear list of timelines and resources needed, and a funding/sponsorship plan in place.

9.5 Key Features of GSSD-MIT

MIT's GSSD is viewed as a network mainly for researchers and policy analysts in the sustainable development community. GSSD is particularly focused on efficiently representing content and has differentiated itself through its ontology and its unique way of mapping the complex domain of sustainability. GSSD also has a well-defined workflow for routing of abstracts to content reviewers who approve all content submitted to GSSD. Content reviewers review respective language submissions and classify websites using the GSSD ontology. Content reviewers are pre-specified, and are not subject matter experts in any one domain. They are typically faculty, student research assistants, or temporary staff members.

Two distinctive features of the GSSD editorial policy bear mention in this context. One is that GSSD exercises a strict control of abstract submissions to the system as it was originally conceived as a knowledge-based system, not simply an information access device. To this end, GSSD does not allow submissions into its website that are: daily news items, popular magazines, etc.; statements of opinion or papers of opinion, *per se;* or unidentifiable institutional or individual sources.

The other unique feature of GSSD is that it is a system geared to replicating all content in all languages in all mirror sites. This high redundancy strategy (the idea being to let users access the mirror site closest to them, in any language) imposes a constraint on the architecture, and the system has to be geared for high redundancy without inconsistency.

Topic pages on the site are managed by guides (individuals and institutions) with demonstrated experience and expertise in the topic area, and are supported by advisors that help evaluate the page, and make contributions. Content suggested by users, like all content on GSSD, is reviewed prior to acceptance on the site. Like GSSD multiple languages are supported, however the content is not always available in every language. This eases the burden on synchronization of data amongst the different partner websites, who can now function as more or less autonomous content creation entities.

GSSD mirror sites have an arrangement where the partnering institutions maintain a server live to the web and integrated into the GSSD system that contains a replica of the entire GSSD database. Although this affords for easy and fast creation of local content, there is very little that can be done in terms of localization of the delivery of content. This is a drawback of the architecture of the system, where once the core application is developed; the regional deployment consists of simply translating the terms used in the application to each of the languages. This is managed at present using the Lotus Domino Global Workbench.

The relative merits of a centralized architecture of GSSD over a relatively decentralized architecture is that it enables better control and is thus ideally suited to an organizational model where individual mirror sites share the task of translating content from all other languages into their own. However, as a matter of policy and strategy, the current architecture does not enable a mirror site to develop its own customized welcome page and additional functionality without impacting the design of the system as whole. Since the GSSD mission is one of ‘exact replica’ or cloning such that there remains no difference between the MIT and other site location, the customization is, by definition, not an issue. Also, if strict access control measures are not employed, it is easy for any particular mirror site to tamper with the material of other mirror sites.

9.5.1 Performance Issues

The Domino server is not built for high traffic access. Given the loads under which GSSD operates (120 sessions, 10 concurrent sessions), the server has proved adequate, but the Domino server has known vulnerabilities at higher loads.

9.5.2 Lack of Development Experience

Availability of skilled technical resources is a key requirement to manage any technological system. It is difficult to find developers and administrators with Lotus/Domino experience. For GSSD, the problem is even more difficult considering that the main workers on the site are students. There are few skilled Lotus Notes programmers amongst the student community.

However, to move away from a proprietary, hierarchical system, one needs a multi-site relational database/content management system alternative that will still provide the benefits of easy content management, multi-lingual mirror site replication, and synchronization. Although multi-lingual and multi-site clustering solutions for relational databases exist currently – Oracle and MS SQL both provide solutions – they are not linked to content management systems. The alternative is to build a system from scratch with content submission, translation, publishing processes and the process of replication and synchronization across multiple languages using various scripting tools.

9.5.3 Re-Engineering Implications

So far, we have utilized an engineering systems methodology in our approach towards characterizing, measuring, and evaluating knowledge networks. Engineering systems are diverse, complex systems that include components from several engineering disciplines, as well as economics, sociology, psychology, and other sciences. An engineering systems methodology requires an inter-disciplinary approach to design, develop, implement, and sustain complex engineering systems.

Knowledge networks are perfect examples of engineering systems, and re-engineering knowledge networks typically involve proactive, systematic (and systems-based) approaches toward planning and design, management, measurement and evaluation to cultivate the conditions for sustained sharing and dissemination of knowledge resources.

As described earlier, knowledge network components are the actors, the relationships between actors, the resources which may be used by actors within their relationships, and the institutional properties, including structural and cultural dimensions such as control mechanisms, standard operating-procedures, norms and rules, communication patterns, etc.

Each of these components and the relationships amongst them contribute towards the viability of a knowledge network. For instance, a successful knowledge network requires both a supportive social atmosphere and an appropriate technical infrastructure to support that atmosphere. The technical infrastructure must mesh with the control and communications mechanisms.

In this section, we introduce an integrated framework that helps a network designer or planner layout the objectives and goals of the network. This framework consists of several components, and jointly they are integrated into a multi-stage network. The network as a whole consists of the following phases:

- Network Planning
- Network Design
- Implementation
- Network Evaluation
- Monitoring

See Figure 9.5 for a representation of these phases. Since each of the phases is distinctive, a description of each phase as well as the entire framework is in order.

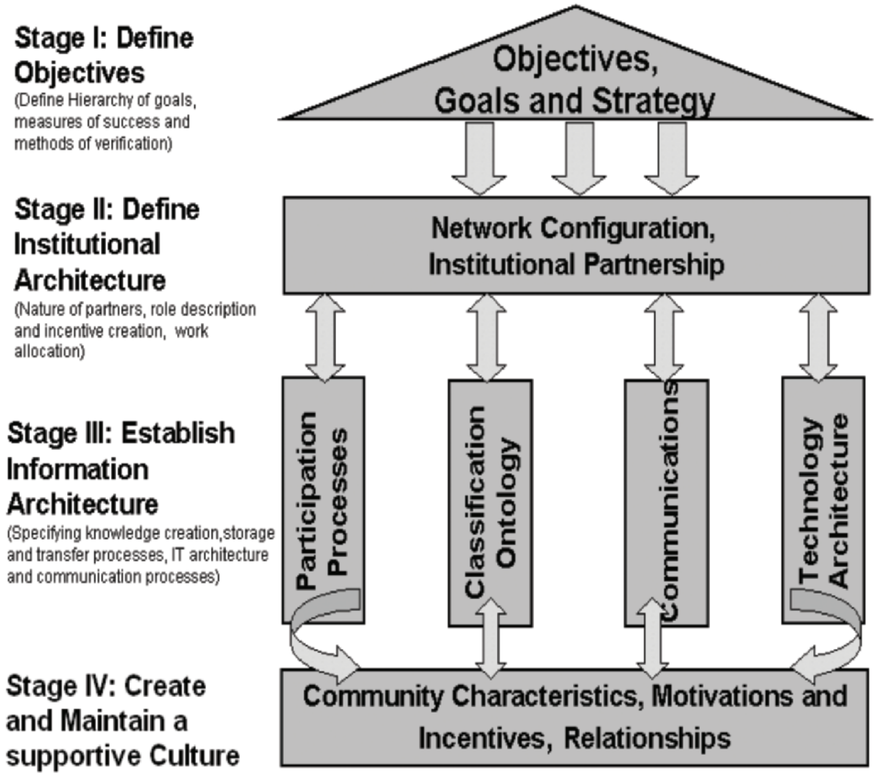

Figure 9.5 **An integrated framework for knowledge network assessment.**

The first phase in the framework consists of *Knowledge Network Planning* and involves establishing the goals and objectives of the network. In principle, it consists of identifying and prioritizing amongst various goals and creating a hierarchy of objectives that takes into account all stakeholder interests – including the needs and objectives of the sponsoring organization, the various institutional partners and the other individuals and groups that participate in the knowledge network. This stage also involves defining operational variables and the processes that reflect the network's ability to reach these goals. Once the hierarchy of goals is defined, the next phase is to choose an organizational and technological architecture most effective in realizing these goals.

The second phase consists of *Knowledge Network Design and Implementation* and incorporates Stages II, III and IV of the integrated assessment framework. Stage II involves laying out the organizational architecture that decides the number and type of partners, the level of control by the sponsoring organization, the degree of centralization, task assignment and alignment of incentives of partners, the amount of workload per partner and the network governance mechanism. Stage III is concerned with the planning of the information architecture and lays out the set of principles and standards that guide the high level design and selection, construction and implementation, support, and management of all processes of the organization and its communications infrastructure. Stage IV involves defining and maintaining a network culture (including amongst others the values, purposes, structural relationships, language, etiquette and history of the network) – and engineering trust, tolerance and rewards systems in place to reinforce the culture. This phase involves both planning and the actual implementation and often includes creating low-level designs, work schedules, performance targets and relevant incentives, rules of participation, moderation, and control.

The third phase focuses on *Knowledge Network Monitoring and Evaluation* and consists of an ongoing activity that involves setting up both the implementation of performance measurement processes and the decision rules to act on them. This phase specifies who has to monitor what and when, and what to do with the results. The organization develops and trains its personnel in the different methods of analysis (traffic analysis, content analysis and network mapping, surveys, etc.) and provides guidelines on how to interpret and act on the results.

It has to be noted here that knowledge networks as dynamics systems also exhibit features of adaptability and emergent behavior and do not always follow a plan–design–implement cycle. Very often processes, norms and relationships are created within a network that was not originally envisioned. The framework helps in deciding on which kind of emergent behavior needs to be encouraged and adopted and what needs to be censored or dropped.

The integrated structure outlined above uses an engineering systems approach to provide both a micro and a macroperspective that enables us to comprehend knowledge networks in its entirety. The multi-phase framework enables laying out the individual components while recognizing the interdependencies that exist among them. For example, the framework recognizes that networks are structural as well as cultural, and that the planning, design, and the evaluation phase will have to take into account the individual–organizational, the technological–institutional and the individual–technological interconnections that exist.

9.6 Next Generation Knowledge Networks

Knowledge e-networks are complex entities with many component systems and many inter-linkages between the systems. By looking at the various subsystems involved – individual, organizational, and technological – we take the knowledge network as an integrated whole. Although the approach adopted could be used for analyzing most configurations of knowledge networks and application domains, we are particularly interested in the characteristics of knowledge networks in the sustainable development domain. The interest in building and managing successful knowledge networks in development is particularly high among International Development Organizations (IDOs) who view these networks as an important part of their capacity development activities. Knowledge sharing at these IDOs has evolved over time, from an emphasis on capturing and organizing knowledge, to their current focus of adopting, adapting, and applying knowledge while connecting knowledge workers.

However, knowledge networks are continuously evolving and the next generation of knowledge networks is likely to be those that go beyond the sharing of knowledge to those that are able to translate knowledge into action. In the context of sustainable development, this would involve integrating knowledge principles and practices into the institutions and policy frameworks. Evidence of this phenomenon is already around us – from flourishing best practices networks to the shift towards Just in Time Knowledge – as knowledge-sharing practices are integrated into organizational work processes. The next generation knowledge network will be a more intelligent system, through the development of dynamic and adaptive ontologies for representing continuously changing knowledge domains, using data mining tools for analyzing linkages for improve cross-disciplinary understanding, and for other developments.

Technological improvements in the form of the next generation Internet, the semantic web and the growth of web services are likely to change the notion of knowledge storage and dissemination as we know of it today, allowing us to transform knowledge by combining, classifying, and analyzing it in new ways and with the emphasis shifting from connectivity to new levels of interactivity, would allow us to learn and create across disciplines, languages, and cultures. Essential in this regard is greater attention to the matter of language, to inter-cultural interpretation of common concepts and modes of communication, and to the overall science of the measurement of meaning.

References

Desouza, K. C. (2002). Socially altruistic electronic knowledge communities: avenue for research and preliminary insights. *Proceedings of the Fifth Annual Conference of the Southern Association for Information Systems*, Savannah, GA: March 1–2.

Kartoo. *Network Mapping Tool*. Retrieved fromwww.kartoo.com/.

Maugis, V. (2003). *Web-based content, behavior and context mapping and some comparisons with matrix-based analysis*. MIT: Working Paper.

Nonaka, I. (1991). The knowledge creating company. *Harvard Business Review*, 6, 96–104.

Seufert, A., von Krogh, G., and Back, A. (1999). Towards knowledge networking. *Journal of Knowledge Management*, 3(3), 180–190.

GSSD. Retrieved from http://gssd.mit.edu.

Thorelli, H. B. (1983). Networks: between markets and hierarchies. *Sloan Management Review*, 7, 37–51.

Tsai, W. and Ghoshal, S. (1998). Social capital and value creation: the role of intrafirm networks. *Academy of Management Journal*, 41, 464–476.

Chapter 10

THE VALUE OF KNOWLEDGE FOR EXTENDED ENTERPRISES

Shung Yar Lim

Introduction

Like the wave of the future, the 'knowledge movement' in commercial enterprises has been inexorably gaining in momentum and pervasiveness. The knowledge-based economy, knowledge management, knowledge networks, knowledge workers, knowledge markets, knowledge commodities, knowledge assets, knowledge stocks and flows, and knowledge infrastructures are recent conceptions that all carry the 'knowledge' tag. Indeed, the knowledge factor is very much at the heart of how organizations are run in the 21st century. The need for mechanisms to capture the value of knowledge points to the urgency of knowledge requirements today, and is made ever more intensive by rapid advancements in information and communications technology.

Simply put, the tolerance for error and slowness in decision-making in business can carry potentially tremendous penalties in an environment where the fickleness of consumer preferences and fluctuations in national economies make for increasingly volatile market environments. For enterprises that operate on a global scale, the multi-dimensional complexities that must be managed within ever-decreasing time horizons mean that the knowledge requirements by managers are ever-more demanding. Alliances of enterprises – value networks of independent enterprises that seek alliances to mutually leverage synergies and core competencies – are increasingly common and multifarious, increasing that level of complexity and raising the bar that must be overcome so that the right knowledge can be leveraged at the right time. One mechanism to solve such problems is that of knowledge networking.

This chapter addresses the use of knowledge networking strategies to meet the challenges of knowledge acquisition, creation and leverage on a global basis, focusing specifically extended business enterprises and multinational enterprise networks. Specifically, we focus on the importance of knowledge,

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the enterprises' own view or perspective on knowledge, the role of knowledge networks in global companies and the characteristic features of e-networking for extended enterprises – in that order.

Knowledge networking, a relatively recent term, is conceptually mature. Knowledge networking in its simplest form refers to the coming together of different people to achieve a common purpose. In order to achieve that common purpose, these different people collaborate and leverage the knowledge of each other. A successful knowledge networking strategy is one that leads to better knowledge creation and improved knowledge sharing. This chapter reviews the fundamentals of knowledge and knowledge networking in the context of global business.

10.1 Salience of Knowledge

Knowledge has always been an indispensable and critical component in effective management and business leadership. Philosophers and thinkers from Aristotle to Foucault have mused about the nature of knowledge, and indeed, few are unfamiliar with Francis Bacon's assertion that "knowledge is power." "Knowledge-creating companies" represent an example of the vanguard of intellectual input in the creation of knowledge management – a relatively young discipline of management practices thematically linked by their key emphasis on knowledge as a key driver of value creation (Nonaka and Takeuchi, 1995).

In retrospect, we now appreciate that the interest in knowledge and its management is founded on several distinct factors: (i) the experiences of networked knowledge-intensive enterprises that leverage the synergy between its employees to drive innovation, (ii) the development of business transformation strategies (as manifested in Total Quality Management and Business Process re-engineering initiatives in large corporations), (iii) the evolution of management information systems in enterprise modeling, expert systems, enterprise resource planning initiatives and relationship software, and (iv) the emergence of the learning organization which emphasizes the links between learning, knowledge and value-creation.

Knowledge in for-profit organizations is vital for two functions – that of being a fundamental resource for effective execution of its mission, and that of being a valuable asset for sale or exchange (Stewart, 1998; 2001). Knowledge is hence critical for the sustenance and strengthening of a business enterprise's viability. And in many ways, it has become the foundation for forging and retaining competitive advantage.

10.2 Knowledge in 21st Century Markets

The vision of a "knowledge-based economy" inhabited by "knowledge-intensive firms" and "knowledge workers" reflects the stark differences that separate the world economy today from that of a century ago. The knowledge revolution, the criticality of information and communications technology and the globalization of business offer a framework for capturing the value of knowledge in pursuing organizational objectives. In the past decade, there has been an especially strong shift to knowledge-based thinking.

These initiatives have had a considerable impact on existing schools of thought pertaining to strategy, innovation, organizational design, and information systems in business and industry. For example, 'knowledge-centric' thinking in business management has led to the theory that knowledge is the primary factor of production in the new economy, displacing capital in the industrial economy and land in the agricultural economy, in which non-tangible intellectual assets continue to displace physical and financial capital in relative importance.

In this context, developed nations have been shifting from a heavy reliance on traditional industries like textiles and steel to an economy built on knowledge-intensive industries. Such industries concentrate knowledge capital both in terms of the workers (deemed 'knowledge workers' for their skills, knowledge, and expertise) and the complex processes that require the former. As a result, these industries are responsible for producing most of the value in the final product, and this value is hence attributed to the knowledge capital that had been invested in creating the product or in delivering the service (Stewart, 1998, 2001).

Digitalization, the adoption of digital technology resulting in the enhancement of the capacity for transferring, storing and processing information, has driven innovations in networking practice and technology (Tapscott, 1997; Castells, 1999). Together, these developments have made the virtualization of work possible by eliminating the physical barriers of distance and time in organizing global business (Hagel and Singer, 1999). The increasing 'interconnectedness' of the globe is one factor that has resulted in market environments that are principally characterized by rapid change. The rapid pace of innovation and the efficiency of communications have compressed product life cycles at all stages while ramping up the urgency in time-to-market and research and development.

The explosion in the number of channels for information acquisition – as a result of the Internet and advancements in affordable means of high-speed of communication, and the rapidity of innovation in processes, product design, and ICT technologies – have outstripped innovation in the methods and techniques of managing knowledge in the enterprise. The obsession with meeting short-term targets, benchmarking and speed has obscured the need to innovate intellectually and to put new management concepts, systems and structures into practice.

10.3 The Value of Knowledge

The value of knowledge is a salient feature of the contemporary global system.[1] It is evident that knowledge has value in every function of the business enterprise that can be deemed core to the enterprise's operation. Knowledge is a key input to the identification and creation of new business opportunities, and the quality of decision-making is almost entirely premised on the presence of the required knowledge. Knowledge within the enterprise (the collective) as well as the employee (the individual) has an impact on productivity, efficiency, and effectiveness. These impacts are reflected in revenues and costs at every level, from decision-making to problem solving to innovation in processes, products and services. Paradoxically, however, despite the significance of knowledge to business enterprises, little attention has been paid explicitly to the creation and management of knowledge.

Just as flexibility and adaptability have been identified as strategic capabilities that modern enterprises cannot do without, knowledge is the necessary ingredient to achieve these and other strategic capabilities for enterprises. As such, knowledge is now widely regarded as a key tool for competitive advantage for all enterprises in the knowledge-based economy. This descriptor competition in multifarious countries in differing markets characterized by disparate cultures, politics and economics.

With good knowledge management, enterprise profitability increases along with the viability and market image of the enterprise, as the relationship between and among employees, partner enterprises, and customer are enhanced. The value of knowledge for the enterprise is shown in Table 10.1 in key areas in which a generic enterprise operates. Ultimately, knowledge is valuable to the enterprise to the extent that it is relevant and helpful in enhancing or expediting a business process that ultimately delivers real economic value to the enterprise.

For global enterprises, the diversity encountered in extending operations mean that the role of knowledge will be even greater as a result of the complexity of forming coherent aligned global and local strategies for managing activities in different environments in which different conditions prevail. These complexities arise from the presence of diversity in terms of the enterprise's

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[1] Of special relevance here is the Alliance for Global Sustainability (AGS) Project on the Value of Knowledge that provided the basis for several chapters in this book.

Table 10.1 **Enterprise knowledge domain and the value of knowledge.**

Enterprise Knowledge Domain	Characteristic Features in the Value of Knowledge
General Operations	Learning from mistakes of own and other companies, avoiding the costs incurred in 'reinventing the wheel' by knowing where the right information and/or knowledge can be obtained, faster problem-solving via ICTs that allow sharing of expertise and seeking of advice from other sections of the enterprise to minimize downtime, experience gained from operations is codified and stored to provide a repository of organizational memory that can advise and guide future operations, process innovations reduce administrative costs.
Products and Services, Research and Developmen	Shortened development times, increased rate of innovation, avoiding 'reinventing the wheel' reduces the costs incurred due to redundancies while refining product quality, mechanisms that permit free flow of ideas via discussion forums etc. allow refinement of ideas that can improve process efficiency and end-product quality.
Customers	Intimate knowledge of customers allows development of products that are more oriented to the needs of customers, improved customer services and hence increased customer satisfaction in the near-term and loyalty in the long-term.
New Business Opportunities	Acquisition and synthesis of new and existing knowledge in databases and people aid in a more timely and accurate analysis of new business ventures that can reduce potential losses and identify the most profitable opportunities, while allowing a better understanding of the risks involved.
Human Resources	Recruiting, assigning and motivating the right people to the right tasks results in higher quality work, lower costs due to errors, and greater efficiency in completing the task. Retaining talent within the organization ensures that the keepers of the uncodifiable component of organizational memory remains with the organization and can hence be tapped at a later stage.

operations and operating environments. This diversity represents both a strategic challenge as well as a strategic opportunity. The challenge arises from the need to manage the additional dimensions of complexity associated with maintaining semantic equivalence across cultures, varying time zones, differing regulatory regimes and political environments, and cultural distinctions. For the most part, the strategic opportunity that diversity offers arises from local differences that demand at least some local innovation to adapt products designed in the headquarters of the enterprise to the preferences of the local market. The knowledge that is created in the design and manufacturing of a product for local markets can be indirectly transplanted to other markets.

10.4 Sources of Value

The value of knowledge to enterprises and multinational corporations results from the convergence of three factors: globalization, emergent responses, and complexity of competition. The first factor, *globalization,* is that international competition has increased as a result of an increasing number of substitutes in most product markets, and production and service capabilities that were hitherto available only in industrial nations are now frequently located in developing countries. Knowing how to be effective in operations, marketing, and product/service innovation is therefore critical.

The second involves *emergent responses* to changes in supply and demand in the market: Knowledge about customers will be crucial: enterprises need to be both better and faster than competition in delivering products and services. To harness the value of innovations (product, operational or otherwise) by suppliers, enterprises themselves must know how to integrate suppliers into their own business model.

The third factor is the *complexity of competition*. There is the possibility of innovation by competitors themselves. Competing organizations are constantly innovating in terms of products, services, and business processes. As new technologies emerge, enterprises face competition both from existing rivals and from entrants who are unburdened by legacy systems and can hence leverage new technology and practices for competitive advantage. Knowing how to innovate and implement change at all levels is therefore necessary. Then there is the matter of operational effectiveness. The enterprise must perform both efficiently and effectively, to remove bottlenecks in operations. Hence, knowing where to look for the bottlenecks must be coupled with how to solve them. Since speed is the key with the emergence of the 'real-time' economy there is also a need to know how to resolve bottlenecks quickly. In addition there is competition for talent, embodied in knowledge workers. Among corporations and enterprises, there are analogous movements of expertise driven by the attraction of better opportunities and incentives.

10.5 Knowledge from the Enterprise Perspepctive

Knowledge as a term defies any one single specific definition and indeed there are varieties of views about the fundamental features of knowledge as offered by philosophy, sociology and organizational-behavioral studies.

10.5.1 Knowledge in for-Profit Entities

In the business context, the categorization of knowledge provided by Charles Savage is especially relevant (1996). He frames knowledge as a set of six fundamental components that have powerful synergism when occurring in concert. Savage's components are:

- *Know-who* – Identifying the right people for a task;
- *Know-what* – An understanding of the knowledge needed, and where to look for it, for a task;
- *Know-how* – In terms of skills, processes, and procedures;
- *Know-why* – Understanding of the underpinnings and context for the task and its relevance for the enterprise as a whole;
- *Know-when* – A sense of timeliness – when to act; and
- *Know-where* – A sense of place – where to act.

The best way to capture the value of knowledge is to make sure that all six elements are in place concurrently – in any particular situation of interest. Three key perspectives of knowledge can be derived from the Savage components namely: (i) knowledge vs. information, (ii) knowledge-as-a-process vs. knowledge-as-a-commodity, and (iii) 'explicit knowledge vs. tacit knowledge. All three perspectives address knowledge in conceptual terms as well as in practical applications.

10.5.1.1 Knowledge vs. Information

Information is the medium through which knowledge can be transmitted, but the two have fundamental differences that there have been frequently overlooked by enterprises engaged in knowledge management initiatives (Wiig, 2000). Information is distinct from knowledge in that it includes facts and data with context while knowledge is the meaning of the information (Amidon, 1997).[2] In essence, knowledge methodologies in the form of mental models, scripts, and schemata, must provide the capability to work with novel situations by synthesizing disparate concepts and predefined methods. Hence, Savage's

[2] More precisely, the operational definition of information is that it consists of facts and other data organized to characterize a particular situation, condition, challenge or opportunity. Knowledge is instead found in humans or inanimate agents as truths and beliefs, perspectives, concepts, judgments and expectations, methodologies and know-how. Reality dictates that knowledge is not comprised, however, of clearly specified guides to deal with routine situations, since few situations are repeated and details and contexts are often, and critically, different. Practically speaking, a person who possesses knowledge in a certain field therefore must therefore have the understanding that permits him or her to envisage possible different ways of handling different situations and to anticipate their implications and effects.

analysis of knowledge describes the practical applications of knowledge with not so much concern for what knowledge is, as opposed to what it does for the enterprise.

The conversion of information into knowledge is a complex process that reflects the fundamental differences between the two concepts – new information and insights are internalized by the establishment of links with prior knowledge and these links vary from firmly characterized relationships to vague associations, hence resulting in the creation of new knowledge. The latter is hence a synthesis of prior knowledge and new information resulting in updated and modified mental models that permit reasoning, decision-making and action. Karl Wiig (1995) observes that while information and rudimentary knowledge can be codifiable in a form external to the human, understanding, based on knowledge in determining what a specific situation means and how to handle it, is more difficult to codify and hence primarily people-based.

Enterprises in the past equated information with knowledge, simply because without the former, the latter was ineffective and sub-optimal in effect Enterprise managers have made the assumption that given a repository of enterprise information, employees would be able to find the right information, and hence gain the right knowledge to make the right decisions. This logic follows a linear line of thought that assumes information can directly map into knowledge by providing more detail, and ignores the complex cognitive processes in the human mind that bridge the discontinuity between information and knowledge. Information is therefore a necessary requisite of – but not sufficient for – the formation of knowledge.

The failure of information systems – the vehicle of information processing and storage – to cure the enterprise's knowledge requirements as manifested in costly deployment with in-apparent returns, flawed decision-making and process sub-optimizations, is not an indictment on the uselessness of an enterprise-architecture. The backlash against information systems is not so much against the effectiveness of information systems in doing what they are truly supposed to do, but against the hype and inflated expectations that surrounded their deployment. Management information systems process information, and provide decision-support via the provision of information and processed data.

The codification of knowledge has been of great concern to managers who intended to make knowledge mobile. The codifiability of knowledge spans the continuum from 'codified knowledge' – a more sophisticated and elaborate physical codification of knowledge that attempts to directly communicate insights and know-how – to 'uncodifiable' knowledge, which is knowledge that defies easy codification.

10.5.1.2 Explicit and Tacit Knowledge

Delving deeper into the nature of knowledge, one can distinguish between two types of knowledge – explicit and tacit. In an organization, knowledge is found in the form of corporate policies, market analyses, products, organizational processes, technologies, and the skills, know-how and expertise of employees. A model for knowledge creation and acquisition, called SECI (Socialization, Externalization, Combination, and Internalization), was developed by Nonaka and Takeuchi (1995) to describe the ways in which knowledge is generated, transferred, and re-created in organizations at three levels of abstraction or social aggregation. This model distinguishes between two types of knowledge – explicit and tacit – where: (1) explicit knowledge is formal and systematic – can be codified in the form of documents and reports, and has been referred to as 'migratory' knowledge because it can be easily shared and transferred, and (2) tacit knowledge is personal knowledge that is difficult to transmit or capture in codified form – it encompasses skills, ways of working, rules-of-thumbs, mindsets, values, and beliefs that is difficult to change or communicate.

Tacit knowledge, however, must be made explicit, more so for the enterprise so that it can be easily transferred and leveraged. A SECI knowledge cycle includes (i) the identification of tacit knowledge, (ii) making the tact knowledge explicit so that it can be formalized, captured, and leveraged, and (iii) allowing the explicit knowledge to be individually processed, absorbed and contextually applied by employees in a process that makes it tacit again.

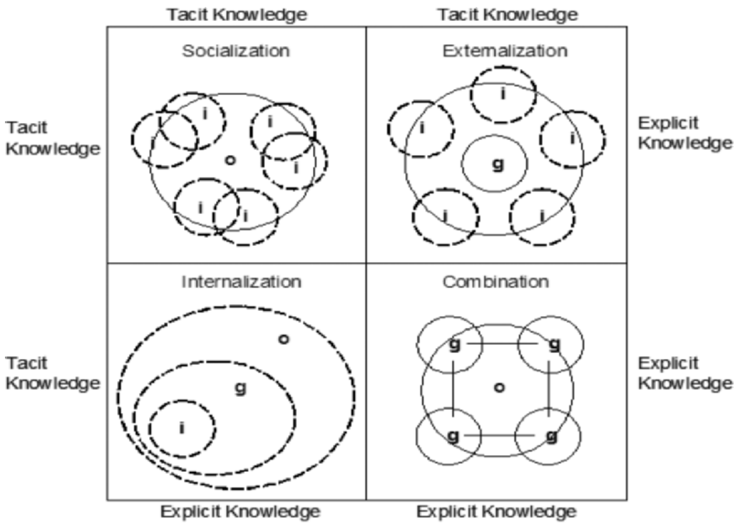
The SECI model examines the interaction dynamics and interplay between these knowledge types at three levels of social aggregation – individual, group, and organizational – and describes a sequence of four processes of knowledge creation. Defined by Nonaka and Takeuchi (1995), these consist of the following:

Socialization: Sharing of tacit knowledge between individuals through joint activities like brainstorming, discussions and debate.

Externalization: Expression of tacit knowledge in publicly comprehensible forms, i.e. when knowledge is applied or when goals and frameworks are set.

Combination: Conversion of diverse sets of explicit knowledge into more complex, better integrated sets of explicit knowledge: communication, dissemination, and systematization of explicit knowledge.

Internalization: Conversion of externalized knowledge into tacit knowledge on an individual or organizational scale; the embodiment of explicit knowledge into actions, practices, processes, and strategic initiatives.



Legend	
i: individual g: group o: organization	Full lines refer to formal links Dashed lines refer to informal link

Figure 10.1 **SECI processes. Source: Nonaka and Takeuchi, 1995.**

The overlap of units between the inside and the outside of the organization reflects the key influence of factors from the external environment that affect the knowledge process within the organization. In this connection, Nonaka and Takeuchi (1995) identify the *knowledge spiral*, which they define as a process of organizational knowledge creation that ideally culminates in the internalization of knowledge on an organizational scale. More than that, however, the SECI processes presented in Figure 10.1 illustrate knowledge acquisition, diffusion and sharing, creation, and re-use – all of which are processes in the enterprise knowledge life-cycle that will be discussed further in this chapter.

10.5.1.3 Knowledge-as-a-Process vs. Knowledge-as-a-Commodity

The tacit–explicit nature and SECI processes provide a lens to scrutinize the nature of knowledge and the processes by which explicit forms are converted into tacit forms. Here, enterprise perspectives of knowledge are identified that are conceptual offshoots of tacit and explicit knowledge, and these are respectively: knowledge-as-a-process and knowledge-as-a-commodity. This distinction is now common in the area of knowledge management, and its relevance has been largely internalized as part of the common understanding, in theory as well as in practice. Both views of knowledge begin by analyzing the nature of knowledge and then deriving its applications. Generally, the modern enterprise usually encompasses both types in managing knowledge. On balance, however, the process approach lends itself more easily to tacit knowledge while the commodity approach would do so more easily for explicit knowledge.

Knowledge as a process is also known as the 'collaboration' or 'personalization' approach. *Knowledge as a process* emphasizes ways to promote, motivate, nurture, and guide the process of knowledge creation by individuals working alone or in groups, in order to leverage the knowledge in the community. A process-oriented view of knowledge recognizes that knowledge is often unique to individuals and irreplaceable and as such, mechanisms such as incentive systems and greater flexibility in the allocation of responsibilities are used to ensure that creativity is not stifled and that talent is retained and used in the most optimal way. The focus is therefore on collaboration support technologies that can assist the social communication processes between individuals that is necessary for knowledge creation to take place. Hence, knowledge is deemed to be closely tied to the user or the creator and knowledge is shared effectively only via person-to-person contact (physical or virtual). IT-based tools are then developed not to store knowledge, but to facilitate communications, and examples of these include e-mail, video conferencing, workflow management systems, and group-decision support systems.

Knowledge as a commodity is also known as the 'content-centered' or the 'codification' approach, treats knowledge as an object that is separated from its creators and users – a thing that can be located, manipulated and hence, captured, measured and managed as one would with tangible artifact. Indeed, the focus of such a perspective is on products that contain or represent knowledge, and such products are typically concerned with managing documents and databases in the processes of their creation, storage and re-use in computer-based corporate memories. Further examples are best-practice databases and lessons-learned archives, case-bases that record in detail older business-case experiences, and knowledge taxonomies. The goal is to store documents with explicit knowledge in them (memos, reports, articles, etc.) in a repository where mechanisms are put in place to allow users to access them and hence reuse existing knowledge in creating new knowledge that is specific to the user's context.

10.6 Knowledge within the Enterprise

Knowledge in an enterprise is that which is found within its own bounds (as embedded in people, processes, and organizational memories), as well as knowledge about the external environment (in terms of understanding market fluctuations, regulatory changes and technological innovation and the like). Within the enterprise, knowledge has been called *intellectual capital*, while knowledge that pertains to events and entities external to the enterprise is called *competitive intelligence.* Most generally, intellectual capital consists of three components – human capital, structural capital, and relationships capital. The first two refer to the human talent and the technological infrastructure of the firm, while the third is concerned with knowledge about the customer, and knowledge about other enterprises that are allied to the firm – for example, suppliers, buyers, and service providers. By contrast, competitive intelligence refers to knowledge on the environment outside of the enterprise and on competitors to the enterprise and is therefore closely associated with relationships capital.

10.6.1 Intellectual Capital (IC)

In enterprise parlance, intellectual capital usually refers to the knowledge assets of the enterprise and the value network to which the enterprise belongs. Intellectual capital is found in the organization's patents, process methodologies, employees' skills and experience, technologies, and information about customers and suppliers. Intellectual capital is explicit as well as tacit: the former can be codified or captured, and the latter, which is contained in the heads of employees, defies easy documentation. Therefore intellectual capital is created only when intelligence is given coherent form, whether in a database, report or process methodology document, and encapsulated in a form that can de described, shared, and exploited. The more tacit form of intellectual capital is understood to be 'soft' knowledge, and consists of the expertise (a semi-permanent body of knowledge) of personnel with respect to executing a certain task, as well as to the tools that can augment this expertise by acquiring facts, data and information, and that deliver expertise to employees who needs it in a timely and accessible fashion. In sum, intellectual capital spans the knowledge assets of the enterprise and its allies, and is hence internally focused and introspective in its perspective.

In an enterprise context, intellectual capital is generally viewed as the synthesis of three components – human capital, structural capital, and relationship capital. This is a well recognized view of overall intellectual capital, but there remains considerable disagreement regarding the particular mix or relative salience of each factor. *Human capital* refers to the skills, talents and capabilities of employees. Human capital is also the source of innovation in terms of organizational design, product design, technologies, and organizational culture. *Structural capital* refers to the key enabling infrastructure like information systems, intelligence-gathering units, and research and development laboratories that allow sharing and leveraging of knowledge. Techniques and technologies that can be identified as easily transplantable, customizable, and reusable, and the ICT infrastructure that facilitate knowledge transfers are therefore the twin pillars of structural capital. *Relationship capital*, also known as *customer capital*, is the value of the knowledge embedded in managing the relationships between the enterprise and other entities with which it conducts business, and recognizes the emerging salience of strategic partnerships between suppliers, buyers, customers and service providers in the value chain of a product or service.

At the interface between the enterprise and the customer is the point at which intellectual capital is ultimately converted into monetary form, and the effectiveness of this conversion mechanism is determined by the enterprise's knowledge of the customer – preferences, habits and spending patterns as manifest in complaint letters, renewal rates, cross-selling, and referrals – and how it leverages this knowledge of the customer in terms of branding, marketing, and advertising.

10.6.2 Competitive Intelligence (CI)

Competitive intelligence comprises knowledge of competitors and rivals that critically determines successful decision-making in an enterprise. It is therefore externally focused and concerns the enterprise's competitors, some of which may be allied to the enterprise in other related markets. CI thus spans knowledge about competitors that is formally derived from analyzing and understanding information on competitors, market trends and other industry-related materials collected from sources that include media like radio/television interviews/analyses, published journals, newspapers and annual reports, and employee contributions from the routine conduct of their jobs and customer inputs. This glut of information is scrutinized from the disparate sources and meaningful material is extracted (via increasingly sophisticated technologies that assist the human reviewer) for further analysis. The output analyses that reviewers put together will give insights into the intentions of competitors, governments and other organizations that can impact the enterprise's bottom-line and operations.

The deployment of competitive intelligence allows management to anticipate (as opposed to merely reacting to): (i) changes in the market and industry for the enterprise's products and services, (ii) initiatives and actions taken by competitors, and (iii) changes in political power and government regulations that will affect an enterprise's strategy and activities. In general, enterprises face challenges in two aspects: in acquiring competitive intelligence and in utilizing it.

The second set of key challenges pertains to *utilization* of competitive intelligence. Generally, enterprises leverage competitive intelligence in the major domains of activity. These include discovering potential newcomers into the market; learning from the successes and failures of competitors and their strategic intentions; learning about the state of technological advancements in the industry and how they can be applied to its own context; identifying potential strategic partners and acquisition targets; learning and understanding the implications of innovations in product design and manufacturing processes; and recognizing and adapting to changes in the political or regulatory climate of the nations in which they operate.

Overall, the acquisition of competitive intelligence for the extended enterprise is considerably more difficult than for the domestic enterprise. The latter needs to gather competitive intelligence on the political, economic, regulatory, and social developments of a single nation as well as on local competitors, but the former must do so for the myriad countries in which it is active. Gathering competitive intelligence therefore becomes a task for intelligence units within the enterprise. Beyond gathering intelligence, clearly the challenges of effective utilization are critical. To utilize knowledge effectively, an enterprise must leverage intellectual capital as well as competitive capital – in other words, it must leverage its access to all *intelligence.*

10.6.3 Leveraging Intelligence for the Enterprises: IC + CI

While knowledge can be seen as a combination of IC that is internal to the enterprise or to the value web of allied enterprises, and CI that pertains to its competitors, an enterprise leverages this knowledge to generate tangible value via the knowledge life-cycle that consists of two main processes: first is the creation of new knowledge via innovation in management practices, product development and process improvements, and second is the management of current enterprise knowledge in its six fundamental components identified by Savage (1996). Figure 10.2 shows key dynamics associated with knowledge creation and knowledge management.

Both processes highlighted in Figure 10.2, encompass the SECI processes as proposed by Nonaka and Takeuchi (1995) from Figure 10.1. Indeed, the SECI knowledge cycle addresses processes that do take place within the enterprise but an added feature is needed to tie the creation and management of enterprise knowledge to the fulfillment of the enterprise's strategic goals. This feature performs something of connectivity function, and it best provided by the formulation and implementation of the knowledge life-cycle that involve the SECI processes *at every stage.*

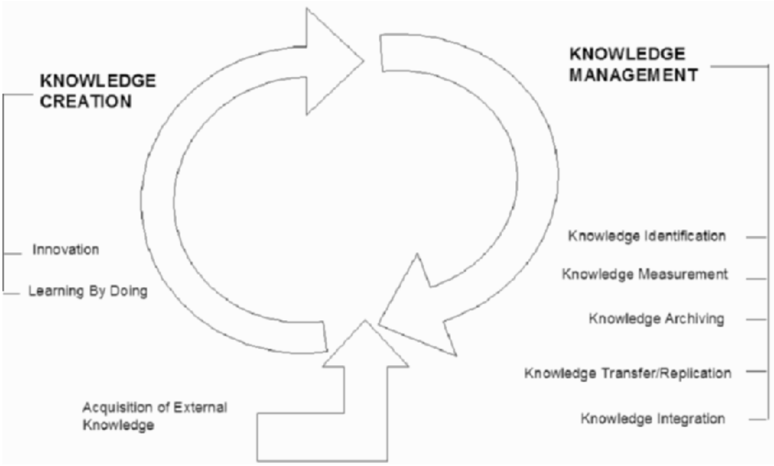


Figure 10.2 **The knowledge life-cycle processes.**

Clearly, the goal of leveraging knowledge is to create value for the enterprise. It is to ensure that the people in the enterprise – the decision-maker, the designer, the customer-services personnel, etc. – can access the right knowledge in the fastest possible time. This means that linkages must be formed for people to access people with expertise, information in a database, and tools and software that can support decision-making with analysis of data and information.

10.7 Knowledge Networks in Enterprises

In retrospect, advances in information technology during the last decade of the 20th century can best be characterized by two notable trends. First is the continual and rapid improvement in functionality and performance of ICT (for example, the prescience of Moore's Law on the doubling of a microchip's capabilities in memory size, processing speed and other performance attributes every 18 months). Second is the increasingly tight interconnectedness and interdependence of business enterprises, organizations, governments and individuals resulting from the increasing pervasiveness of communications and computer networks, the most universal of which being the Internet. This is the context within which we need to consider the role of knowledge networking in extended enterprises.

The emerging salience of the 'knowledge network' has its roots in innovation networks, information networks, and other associated networked organizational variants that encompassed networking processes in which knowledge was acquired, shared and created by members. As its title suggests, the knowledge network consists of ‘knowledge’ and ‘network.’ The first of these terms has been addressed earlier and requires no added descriptors. In the business context, the term network refers to an organizational form, one that is associated with the characteristics of flexibility and adaptability, both of which are increasingly recognized as features that are very appropriate for the volatile market environment of today, where dynamic market conditions demand high-speed responsiveness.

The knowledge network hence possesses fundamental features of the network organization, in terms of its structural and cultural configurations, and is shaped by the organization’s purposes of leveraging knowledge to achieve competitive advantage. As an example of knowledge networks, the clusters of interdependent high-tech industries in regions like Silicon Valley and Route 128 in the USA and Hsin-chu in Taiwan, with links to universities and research institutions have led by example in terms of what collaboration and synergy between ‘knowledge workers’ (the innovators, academia, and professionals) and business (the entrepreneurs and MNEs) can produce. Fittingly, ‘knowledge network’ has been a name that has been ascribed to a multiplicity of technology-based organizational forms that connect knowledge-creating entities in to leverage the value of synergistic knowledge sharing.

In an earlier chapter of this book, the term ‘knowledge network’ was defined from the perspective of the of not-for-profit knowledge producing entities. In this chapter, we focus on knowledge networks that cross the boundaries of language, culture, distance, and regulatory regimes in the course of pursuing for-profit activities. In commercial contexts, three sets of elements jointly define the knowledge network, namely strategy, people, and technology. While strategy defines a direction and a framework for action to achieve organizational objectives, the people and technology factors, and the interfacing between them, are determinants of the efficiency and effectiveness of the knowledge network. (It may well be that these same features are relevant to the not-for-profit knowledge networks, however, addressing this issue is beyond the scope of this chapter.)

From a related perspective, people-centric networks fit well into management cultures that belong to the “knowledge-as-a-process,” competence-driven school of thought, while technology-centric networks fit nicely into management cultures that adhere to the “knowledge-as-a-commodity,” infrastructure-driven school of thought. An enterprise that adopts only one of these models of knowledge network will be not able to both successfully compete globally at the same time levering global opportunities. In this chapter and the next two chapter, we will be arguing that that for a knowledge networking strategy to be successful globally, both elements – people and technology – must be holistically synthesized and integrated in a coherent strategy, and that coherence is essential in order to facilitate enterprise-wide innovation and learning processes.

10.8 Knowledge Networks for Decision Making

As observed earlier, the quality of decision-making and 'knowledge work' – non-repetitive, novel tasks that require know-how and knowledge – depends on the quality of knowledge embodied in the decision-maker, and more generally, it depends on the extent to which decision-making is co-located with the requisite knowledge. This sort of co-location can be achieved either by devolving decision-making authority to the source of knowledge, or by concentrating knowledge at the source of decision-making. The latter crucially depends on the mobility of knowledge and the degree of error in decision-making that is tolerated.

Market tolerance of flawed decision-making is shrinking with increased competition from rivals both global and local, the lowering of barriers-to-entry to many markets, and the increasing adoption of free-market policies in most countries of the world that had hitherto maintained close markets. Market volatility, as well as pressures for the enterprise to be flexible and adaptable, point to the increasing salience of distributed decision-making. In relatively stable market environments like those of the industrial era, centralized decision-making traded off speed, responsiveness, and creativity for efficiency, quick response, unvaried products, and an unambiguous command-and-control mechanism.

Today's markets demand both efficiency as well as creativity in products and services, on top of responsiveness to a market in which customer preferences – market demand is rapidly changing and market leadership is hinged on providing better and better products/services in the absence of high barriers-to-entry. A mechanism is hence needed to coordinate distributed decision-making as a result of the need to devolve decision-making to the sources of knowledge, while centralizing codifiable knowledge since it is not always possible or practicable to completely devolve decision-making powers throughout a large organization due to coordination problems or to concentrate responsibilities on the best qualified.

In order to provide a structure that facilitates decision-making, an organizational structure that facilitates the free-flow of knowledge in its forms – tacit and explicit – needs to be built. This mechanism needs to: (i) connect people with other knowledgeable people, (ii) connect people to information, (iii) enable the SECI processes as well as the conversion of information into knowledge, and (iv) provide a vehicle to mobilize knowledge so that knowledge sharing and organizational learning can enhanced. The knowledge network provides the integrated mechanisms that enable all of these functionalities to take place.

10.8.1 Structural Imperatives of Networks

The knowledge network is a structure born of an environment marked by increasing market volatility and its demands on the enterprise – demands for rapid responsiveness, increasing costs of innovation, flexibility in shifting the scope and scale of production, and adaptability in implementing new technologies. It is the result of increasing recognition that knowledge, embedded in humans, processes and products are critical determinants of an enterprise's abilities to compete in market conditions that punish inefficiency and flawed decisions. In the past, a network of inter-dependent agents as an enterprise organizational structure was rendered unfeasible by high coordination costs and the efficiencies associated with hierarchy and control amidst market conditions that changed slowly in the near-term. Indeed, the necessary mechanisms for coordinating multiple tasks and projects, and that could permit high-speed and cost-feasible communications in a network of inter-dependent agents were absent, hence precluding the formation of large-scale networks.

With the dramatic advances in information and communication technologies over the past three decades, the situation has changed substantially. Tight centralized control has been rendered impractical and too costly as a result of the myriad temporally-varying complexities engendered by a rapidly changing market environment, while the emergence of affordable information infrastructure has rendered communications, computers and enterprise information infrastructures de rigueur enterprise coordination mechanisms. Cisco, which largely adopts a network organizational structure, has proven the feasibility of a network organization on a global scale (Castells, 1999).

Choucri et al. (1999) define the knowledge e-network by synthesizing elements of people, technology and structure, as: "The knowledge network is a computer-assisted organized system of discrete actors, with (a) knowledge producing capacity, (b) combined via common operating principles, (c) relating their individual autonomy, such that (d) networking enhances the value of knowledge to the actors, and (e) knowledge is further expanded." Nothing in this expressed view refers to the uses of knowledge or to the purposes for which new knowledge and increased value will be deployed. Nor does this definition imply any particular organizational or institutional arrangements. For all enterprises – national or international, limited or extended – the organizational features of a network are important in shaping, even defining, its potentials and performance.

10.8.1.1 The Basic Network Features

In a structural sense, the network structure consists of nodes that are interconnected by links, where nodes can consist of individuals, groups, or organizations, which serve as hubs of activity or organizational processes, while links refer to the various connecting and coordinating mechanisms that provide paths for communications, team-working and knowledge flows, tangible or otherwise (Skyrme, 1999).

Organizationally, the knowledge network is characterized by specialized knowledge assets under the joint control of its members – in the network, knowledge assets in the form of intellectual capital and competitive intelligence are shared in the form of collaboration (possibly cross-departmental) between network agents, information from knowledge-bases and personal interactions is made readily accessible to authorized agents, and informal virtual communities of practice can form within the enterprise from these networks. Also, the network is governed by flexible coordination mechanisms – the boundaries within the enterprise are flexibly defined with the formation of temporary teams to handle specific projects, and this means that associative ties between agents are often dynamic. Decision-making is largely decentralized and locally defined, such that executive management will provide the goals and a broad strategic framework while empowering network agents with decision-making capabilities within clearly defined bounds.

When viewed through the *interaction lens*, linkages within the knowledge network have a social component in addition to commercial contract – relations that bind together a group of individuals, teams or organizations in collaboration to achieve some collective purpose. Trust, commitment and loyalty have been touted as key elements of an enterprise human resource policy, and act as the glue that will retain talent within the organization. Indeed, the nature of team formation-and-dissolution in a network whose linkage configurations are intentionally dynamic mean that individual loyalty to the enterprise must be cultivated by the right people policies and incentive systems. The case of the multi-enterprise knowledge network introduces additional complexity and will be discussed later, since it represents a case in which loyalty to the node – which, in this case, is the enterprise – supersedes loyalty to the network as a whole, and as such, introduces a host of challenges that must be met with policy responses.

Technologically, the knowledge network refers to an organization in which individuals or teams are connected together by a network of computers that acts both as a coordination mechanism of enterprise activities, or as gateways of shared access to a common database of virtual resources on a corporate intranet and/or on the Internet. Communications backbones like broadband access and management information systems are front-runners of today's knowledge management systems that offer virtual collaborative capabilities to eliminate physical barriers to collaboration.

10.8.1.2 Some Extensions

Having failed at living up to the fog of hype that proclaimed management information systems (MIS) as a silver bullet to solve the enterprise's needs, the true value-added of MIS has too often been missed – MIS applications, today best known as enterprise integration (EI) systems, automate repetitive financial reporting and accounting processes, while organizing information and data into data-warehouses from which they can be extracted for analysis in strategic planning. Today, EI applications assist in decision-support in a wide range of areas from supply chain management to customer relationships management. While EI provides a computationally effective toolbox for optimizing routine enterprise processes, knowledge management systems (KMS) provide virtual environments that permit real-time multi-party, multi-directional communications and virtual collaboration via instant messaging, chat forums and message boards that are also enhanced by modeling and analytic software packages that can mine data and information for un-obvious patterns that could be of potential value to the enterprise.

In sum, the knowledge networking process that occurs within the knowledge network itself builds on the collaboration between people and the connections between computers, and reflects the joint control and shared ownership of knowledge assets through collaboration and dynamic partnerships within the network.

10.8.2 Network-Elements

The essence of the knowledge network is built around a triad of elements – strategy, people, and technology.

10.8.2.1 Strategy

The *strategy* of a knowledge network describes the organization's vision, mission, and plan to leverage knowledge from the synergies of collaboration between network agents in the pursuit of organizational goals. This framework for action considers people policy and technology management in seeking to drive innovation and learning in the enterprise and must ensure that both elements are harmoniously aligned. It involves promoting a culture of ICT-supported knowledge-sharing between physically distant agents, while installing incompatible software systems that prevent electronic data-sharing, is one example of non-aligned strategy, or in many cases, a non-existent strategy for optimizing the interactions between technology and people.

The barriers that prevent the formulation of coherent strategy are largely people-based. These include the fear of change, the fear of losing organizational control, an inability to communicate the underlying value proposition supporting knowledge networking processes in the enterprise, mismatches and disconnects between the perceptions of executive managers and line managers. In addition, the lack of buy-in from managers tasked to coordinate knowledge networking initiatives, the misunderstanding of the scale of change required, the misconception and subsequent sub-optimization of the collaboration process, and the resultant demoralization of employees are all factors that cause knowledge networking to fail from the planning stage to the execution stage.

10.8.2.2 People

People – the knowledge workers in the organization – are the *raison d'etre* of the knowledge network, and form the basis of organizational competence. The barriers that prevent the formulation of coherent strategy are largely people-based – the fear of change, the fear of losing organizational control, an inability to communicate the underlying value proposition supporting knowledge networking processes in the enterprise, mismatches and disconnects between the perceptions of executive managers and line managers, the lack of buy-in from managers tasked to coordinate knowledge networking initiatives, the misunderstanding of the scale of change required, the misconception and subsequent sub-optimization of the collaboration process, and the resultant demoralization of employees are all factors that cause knowledge networking to fail from the planning stage to the execution stage.

10.8.2.3 Technology

Technology – in the form of ICT infrastructure and the information systems within the enterprise – provides the infrastructure for knowledge networking. While the adage goes that power without control is nothing, the global enterprise requires technology for knowledge networking to take place on a global scale. Technological issues like harmonization of protocols and standards, systems scalability and upgradeability, and enterprise-wide compatibility are considerations that must be resolved at the planning stage to avoid the immense costs suffered by firms that stumbled in implementing large-scale enterprise resource planning projects in the late nineties.

This broad accounting of networking factors provides the context for focusing on operations of knowledge networks in extended enterprises globally, those for-profit entities that cross boundaries, span jurisdictions, and engage in complex products and processes, generating added value through the deployment of material as well as virtual means.

10.8.3 Knowledge Networks in Expanding Enterprises

Conceptually, knowledge networks are subsets of the enterprise. When the enterprise is small, as in the case of the start-up operation, the enterprise can itself be the knowledge network, within which enterprise employees form teams to handle different projects. As the enterprise grows in size, enterprise functions are increasingly specialized into business units that handle areas like finance, human resource, product development, research and development, and manufacturing. Knowledge-intensive functions of the enterprise – strategic planning, research and development, or human-resource, for example – are commonly the sources of the enterprise's competitive advantages, and it is in these areas that knowledge networking will be most effective. Knowledge networks within each of these business units can be coordinated by an organizational meta-network structure that loosely coordinates the activities of the business units as a whole.

In terms of the enterprises that knowledge networking can describe, scale is a possible axis of variance – knowledge networks can describe the organization of entities within an organization, the organizational design of the whole enterprise itself, or the organizational structure of an alliance of enterprises. Single enterprises may be an entire knowledge network unto itself – as are many small and medium enterprises – with dynamic network associations of assets and human resource (knowledge-workers) that form in order to perform certain knowledge-intensive projects that require different areas of expertise. The meta-network model, where the entire organization is a network of networks of knowledge workers working on disparate projects, has a central governance node that performs administrative duties and financial accounting activities, and which acts as a coordinating, 'leader' node.

10.8.4 Characteristic Parameters of Knowledge Networks

There are several ways of characterizing the knowledge network – by function, node-size, linkage strength, centralization of authority, and boundary-crossing complexity. Knowledge functions center mainly on knowledge sharing and access, and knowledge creation. The knowledge life-cycle noted earlier comprises two principle elements of 'knowledge management' – in this context, referring to knowledge sharing and access – and 'knowledge creation' – the creation of new knowledge via collaborative research and development between agents seeking to leverage the synergies of cooperation. The former gives rise to 'knowledge sharing' networks and involves shared access to archived information that is separately supplied by network members, and open channels through which advice may be sought from other members of the network. The latter gives rise to 'knowledge creation' networks that are more active in the use of knowledge resources – it is concerned with innovation and the application of knowledge arising from synergistic collaboration between members – and new knowledge that is created in this innovation process is fed back into the knowledge creation process.

Some knowledge networks are naturally involved in both the provision of access to shared knowledge as well as providing the organizational mechanisms for collaborative innovation initiatives. 'Knowledge creation' networks result in the creation of new knowledge though the main objective for such organizations is to apply the knowledge of network members in pursuing goals that are coincident with the organization's mission, and knowledge creation is a by-product of this process. The talent of the members of the network, and the policies that encourage and constrain creativity affects the quality of knowledge created and hence applied by these networks.

Examples of knowledge creation networks are found in the cross-company, non-business-affiliated communities of practice founded by professionals working in the similar trade, non-profit organizations like IISD (International Institute of Sustainable Development) and TiE (the Indus Entrepreneurs – a club of Indian entrepreneurs that hosts networking events to facilitate joint-ventures and collaboration). Knowledge sharing networks are operated around the technologies of databases and policies of knowledge sharing. Network member entities pool their stock of codifiable and explicit knowledge into an archive that is accessible by other members and that is updated frequently. Examples of knowledge sharing networks include the sustainable development gateway built and maintained by Indian organizations engaged in sustainable development and online reference sites on specific interests.[3] Hybrid networks that execute both functions naturally exist, though with varying degrees of efficiency and success. Examples of such hybrid networks that combine both core knowledge processes are Skandia and Cisco.

10.8.4.1 Node-Size

This feature refers to the scale and scope of networking between individuals, teams, departments/divisions, and enterprises. The size of nodes in the knowledge network depends on several parameters, the most important of which is the size of the enterprise in which the knowledge network is contained. Hence when the enterprise is viewed as a knowledge network – a startup conceivably will have the smallest node size where each node consist of individuals, while the largest MNEs have nodes the size of whole divisions and within each node, sub-networks with sub-nodes the sizes of teams or sub-divisions.

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[3] For an example, visit www.china.eastview.com, which bills itself as "the knowledge infrastructure" of China.

MNEs therefore can be considered to be knowledge meta-networks operating on a global network consisting of knowledge networks of varying node sizes, with each node consisting of smaller networks and smaller nodes, where node size decreases with network size to the point where a node consists of an individual. Hence there is a continuum in node size and network complexity (number of links and nodes) from the smallest node size of the individual (in the start-up) to medium node sizes of teams and departments in small-and-medium enterprises to very large node sizes of divisions and departments in MNEs and large corporations.

10.8.4.2 Linkage Strength

This factor refers to the pattern and constitution of linkages and nodes are dynamic and evolve to adapt to events and projects, hence links strengthen and weaken while density of connections change. Linkages tend to be strong when they are established over time and augmented by tradition and history. Such that ties gradually obtain a greater social component – with factors like reputation, trust, and loyalty that reinforce the bond.

If linkages are weak change dynamically, then the ties that bind network actors together are purely commercial and too short-term for trust and loyalty to develop. Within the network organization, because of the project-driven nature of work, team compositions are in constant flux – these are very apparent in consultancies, in which teams form and dissolve as dictated by the projects' need for specific expertise and experience. Hence while link dynamicity provides organizational flexibility and efficiency – permitting the deployment of the most suitable person for the task – the trade-off could count against the establishment of trust in the relationship.

10.8.4.3 Authority Strategy

The conventional view is that centralization minimizes coordination costs and delays, while permitting greater coherence in execution of activities that concern network sustenance and expansion. Accordingly, so the argument proceeds, global optimization, across the entire network, is more easily accomplished when authority is more centralized, than in a decentralized network where there exists the danger that local optimization may not be coincident with policies that allow for a more beneficial global optimization. At the same time, however, some skepticism is in order.

Increasingly, we recognize that decentralization reduces the bottlenecks in decision-making processes – since the central 'leader' node need not be consulted for every operation or decision – and hence decentralization reduces delays and associated costs, allowing enhanced responsiveness and flexibility of the network. In permitting greater freedom to individual nodes, decentralization encourages creativity and innovation, and allows opportunistic responses to environmental changes by individual nodes. The downside would be that, as a result of less coordination from the center, decentralized decisions might be inconsistent with the overall strategy of the network, hence the danger of local optimization taking precedence over global optimization. It is fair to say that, in the last analysis, the relative efficiencies of centralization vs. decentralization may be enterprise and/or context specific.

10.8.4.4 Boundary-Crossing Complexity

This delineating factor refers to global enterprises and the additional dimensions of complexity that must be considered when activities are spread across multiple disparate environments. A knowledge network can also be viewed in terms of the boundaries that it crosses. The larger the spread of the knowledge network, the greater the complexity of governing the network and the need for ensuring network effectiveness as well as the coherence required to transcend operational differences between each node.

10.8.4.5 Cross-Jurisdiction Spread

The matter of jurisdiction is a fundamental feature of the global economy. The complexities of jurisdictions – intra-state (national), inter-state (national), regional (international), and trans-regional (international) – can often pose powerful challenges for enterprise networking. Political and regulatory changes are most apparent when one considers the boundaries across which the knowledge network operates. Local knowledge networks operate intra-state, with activities and network membership confined to a single homogeneous set of regulations and political considerations. Inter-state or regional knowledge networks deal with a more complex mix of regulatory and political considerations while trans-regional or international networks have to deal with a large set of differing political and regulatory considerations.

10.8.4.6 Cross-Cultural Spread

While everyone agrees that culture matters, there remains little consensus as to how, when, or why. Differences in intra-region, inter-regional, global (trans-cultural) can often be accompanied by powerful similarities, even synergies. However, as the geographic spread of the knowledge network increases across states and regions, there will invariably also be differences, of varying intensity, in culture (for example, China vs. the US, Southern US vs. Northeastern US). Factors like exchange rate differences and language differences must also be considered in managing virtual collaborative ventures to ensure semantic equivalence under different contexts.

10.9 Knowledge Networks for Extended Enterprises

Extended enterprises – operating across boundaries of time, distance, language (semantics as well as syntax), culture, and regulatory environments – recognize that dominating global markets is founded on the need to achieve both global efficiency and local responsiveness, which in turn are driven by the organizational capability to develop, acquire and leverage knowledge on a worldwide basis. In globalizing, an enterprise needs to make decisions in addressing six issues (Govindarajan and Gupta, 2001): product choice, choice of strategic markets,[4] mode of entry,[5] transplanting organizational culture, achieving dominance in the local market,[6] and speed of global expansion. All six require knowledge inputs to inform decision-making, and all are vital in ensuring the viability and success of the global enterprise.

The record to date shows us that hierarchical organizational structures performed well in an earlier era of bulk-processing industrial economy under conditions of market stability when a bureaucracy of enterprise planners could adequately respond to an environment marked by low complexity, a low rate of technological obsolescence and low demand uncertainty. If, or rather when, operational complexity in worldwide enterprise activities increases, technologies become rapidly obsolescent and markets are characterized by volatility, then hierarchically organized enterprises that were strong in corporate command-and-control were too slow in responding – as IBM who found heavy cost in the 1980s, relative to more flexible and adaptive competitors like Digital Equipment – the need to experiment with flatter hierarchies and more 'organic' organizational structures emerged As a result, at three modes of organizational responses emerged among the many new efforts and pioneering institutional initiatives.

10.9.1 Modals Forms of Extended Enterprise Networks

Over time, the adoption of some features of the basic network organization, led extended enterprises to develop and adopt hybrid network structures.

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[4] The strategic importance of a market is determined by the current and future market size as well as the learning opportunities offered by that market. Indicators of the former two factors are the size of the country's economy as well as the country's GDP, and indeed also, the wealth of its citizens and their predilections with respect to the product or service. Learning opportunities are determined in turn by the level of sophistication and exactitude of the customer base.

[5] Mode of entry refers to two factors: the reliance on exports versus local production in the target market as expressed in a continuum of forms, and the extent of ownership control over activities that are performed locally in the target market.

[6] Dominating the local market requires both the winning of customers as well as beating off competition from competitors established in the host country.

Table 10.2 **Multinational enterprise networks.**

Organizational Characteristics	**Modal I – Local Specificity**	**Modal II – Global Efficiency**	**Modal III – Internationalized**
Node Description	High level of decentralization with decision power. HQ and subsidiary nodes share assets and responsibilities. Subsidiaries have high degree of independence from HQ.	Low level of decentralization. Assets, decision power, and responsibility are highly centralized at HQ. Subsidiaries implement plans developed at HQ with no flexibility to develop local strategies.	Medium level of decentralization. HQ delegates decision power to subsidiaries which adapt products and marketing to local conditions, but are dependent on HQ for overall strategy and innovation.
Network Linkages	HQ-Subsidiary linkages are not formalized. Formal governance tools (like simple financial controls and reporting mechanisms) are supplementary.	Very strong linkages result in tight control of strategies and operations. Highly developed channels of communications, reinforce command-and-control by HQ.	HQ-Subsidiary linkages are very formal. Enterprise planning and management facilitate command-and-control by HQ.
Learning and Innovation	The high degree of decentralization retains learning and innovation within each unit.	Innovation and learning are highly centralized in HQ, and subsidiaries are considered mechanisms to execute HQ's plans.	Innovation and overall strategies directed by HQ and diffused to subsidiaries.
Strategic Capabilities	High level of sensitivity and responsiveness to local differences.	Highly coordinated global strategies that capture global scale efficiencies.	Well-developed mechanisms and infrastructure for worldwide knowledge sharing.
Challenges	High degree of decentralization and subsidiary-autonomy creates independent 'fiefdoms.' Silos around subsidiaries impede knowledge networking. Subsidiary loyalty restricts exchange of ideas and advice, leading to strategic misalignment, inefficiencies, and opportunity costs.	High degree of centralization of decision reduces sensitivity to local conditions and create sub-optimal performance. Competetiveness in local markets is threatened by rivals with better adaptive mechanisms.	High level of formal relations between HQ and subsidiaries lead to sub-optimal worker perfromance. Control of innovation at HQ. Lack of attention to local conditions lead to potential loss of ideas and wasted opportunitie to mobilize the global talent base.

These consisted of mixed network-hierarchy organizational forms that attempted to reconcile command-and-control efficiency with responsiveness, flexibility and adaptability. These network forms are distinguished by the configuration and characteristics of the nodes and linkages within the network, and the strategies and policies that direct and guide enterprise operations. In a survey of twenty one multinational enterprises, Bartlett and Ghoshal (1989) identified three modal forms. These are presented in Table 10.2 as three modal forms, which jointly can be seen precursors for a fourth which is especially relevant to any discourse about knowledge networks for extended enterprises.

The fourth modality, defined by Bartlett and Ghoshal (1989), consists of an emergent form that could integrate the strategic capabilities of the three while resolving the fundamental challenges that faced each. They have dubbed this emergent model the trans-national network MNE. This organizational form is characterized by inter-dependent and specialized regional subsidiary business units capable of aligning targeted local initiatives with global strategies. To do so, knowledge creation and sharing are effected via inter-subsidiary unit collaboration in knowledge-intensive work, and via worldwide technology-and-human-policy enabled knowledge sharing mechanisms.

There are other characteristics in addition to inter-dependence, collaboration and knowledge diffusion. The transnational network organization is also recognized for its flexibility, decentralization and synergistic opportunities, and these characteristics both augment, and are augmented by, knowledge sharing and knowledge creation processes.

The main challenges that the network structure had to resolve were those of coordination, communications, culture, misalignment of collective interest in favor of individual self-interest. Because the network organizational paradigm encompassed thinking that had multiple dimensions – strategic, social and enterprise processes – the shift is not exclusively confined to just formal organizational structure. The organizational changes that were occurring also impacted the core decision-making systems and management processes – the administrative systems, communications channels and inter-personal or inter-divisional relationships. In other words, they were all-pervasive.

10.9.2 Network Value Chain for Extended Enterprises

Value network concepts are not new, and have evolved into different variants, but are united in their emphasis on the external economies of the firm and its interactions with other entities, as opposed to the traditional focus on the internal structure of the corporation. The value network perspective hence describes how value networks are concerned with aim to realize external economies of scale and of scope by relying on fragmented rather than on vertically integrated forms of industry organization.

Most generally, a value network refers to added value accrued through connections among enterprises – irrespective of the specific nature of the connection or the participating entities. Though applicable to both the private and public sector, the focus of discussion here will be on value networks of private sector organizations, or group of organizations, that engage in both tangible and intangible value exchanges.

In the value network, unlike the traditional variant where boundaries between allied enterprises were clear, well-defined and cross-boundary interaction was minimized, the boundaries between the enterprise and its suppliers, service providers, and buyers are becoming increasingly blurred as companies shed non-core competencies by outsourcing them to other specialist companies and focusing intensely on their own core competencies. Functions that were formerly executed in-house within a single player in the value chain would now be performed by electronically networked multiple companies behaving as a single enterprise – the virtual extended corporation (VEC), with inter-enterprise value exchanges taking place within this network of enterprises. In this context, "value exchanges" describe the interactions and transactions between enterprises, and can be intangible or tangible.[7]

10.9.2.1 Virtual Extended Corporations (VECs)

The formation of VECs has resulted in increasing integration of allied enterprises to enable coordination of the necessarily precise and timely execution of business processes. Indeed, for a VEC to be viable and successful, a considerable amount of information must be integrated across the enterprises' value chain in real time. The VEC is thus seen as a network of companies that are inter-dependent and engaged in the pursuit of common commercial objectives in the production and/or delivery of goods and services within a value chain. Both the technological infrastructure and human-related policies like enterprise cultures and norms must be ready for such networking.

Indeed, these elements must be ready for the implementation of knowledge networking practices. More than just a flow of data in the form of

[7] Tangible value exchanges refer to exchanges of products or services and financial transactions, and include tangible knowledge products and services like reports, documents and consulting. Intangible value exchanges refer to knowledge transfers that can result from tangible exchanges of knowledge products and services – as manifested in know-how, strategic planning information, joint product or process developments etc. – and benefits like informal benefits that arise from the formation of more intimate relationships between enterprises and their personnel.

customer details and inventory figures, the network is a necessary common platform on which to support the crucial innovation and knowledge management processes that must take place across enterprises in order for the VEC to be able to compete in an ever-changing market. Where e-commerce was about trading – buying and selling – over the Internet, e-business encompasses the full range of business interactions between enterprises – from supply chain management to customer relationship management, to enterprise resource planning and e-commerce – and has enhanced the effectiveness and indeed, the necessity, of the VEC network.

10.9.2.2 Cross-Value Chain Networks

The evolution of such cross-enterprise networks have given way to cross-industry-segment networks – VECs have pointed to the formation of an even broader, but often no less tightly connected, network of allied VECs that operate across value chains. As in the VEC, enterprises within the value network are electronically integrated in a common system that enables real-time cross-enterprise flows of information, transactions and processes. The differences between the VEC and the value network are those of scale – value networks cover a larger industry segment encompassing more value chains than the VEC – and scope – value networks are more complex in terms of their end-products and services than VECs. The key drivers shaping the formation of VECs and value networks are shown in Table 10.3.

Table 10.3 **Drivers of trans-enterprise knowledge networking in value networks.**

Key Drivers	General Network Advantages
Market volatility requiring faster time-to-market and greater flexibility and responsiveness Greater cost efficiencies in producing products of high complexity Innovation as increasingly important to competitiveness Expansion into different markets; creation of new markets	Reduced costs through economies of scale from resource-sharing; broadening of product portfolio and greater product customization, leveraging of core competencies; flexibility in resource allocations throughout network, access to specific expertise and a more diverse pool of technical resources, access to more channels into different markets; spreading out of risk for investment

Most generally, the objectives of the enterprise and the value network of which it is a member, the internal tensions of cooperation to advance common interests and competition to secure individual advantage that does not necessarily benefit the collective, and the asymmetries in relationships between enterprise partners, add new dimensions of complexity to the formulation of a coherent knowledge networking strategies for a value network. The parameters of power and interdependence, and the degree of their asymmetry across the network members, can be used to analyze the internal power structure of the value network.

10.10 Conclusion

This chapter focused on the value of knowledge in for-profit entities, with specific reference of extended enterprises operating on global scale and scope. Partly a review of dominant themes shaping this domain of activity, partly reviewing key elements and characteristic features, and partly as foundation for framing new modes of knowledge networking for increasingly competitive, diverse, and extended enterprises. While knowledge is a privately produced public good, the fact remains that its value for business lies in the implications of its implementation. Some knowledge-creation, deployment, diffusion and sharing features are generic, in that they are essential for non-profit as well as for-profit entities. Others are distinctive, and key, to the operations of extended enterprises, whose motivations are framed by the 'bottom-line' and the latter defined in monetary terms.

10.10.1 Structures and Functions

From each of the divergent characteristics of knowledge networks addressed in this chapter, some shared elements are apparent. Of the most significant common elements in all knowledge networks pertains to the roles of human agents, technology, and the interplay between these. In the following chapters we will focus on two different models of knowledge networks that have been observed in organizations to date, and then put forth the design elements for two emergent modalities. These include the conventional, or past-to-present, models consist of human-centric (Type I) and IT-centric (Type II). The emergent modalities consist of partially-integrated (Type III) and Fully-Integrated (Type IV).

Each of these models is predicated on different structural configurations within the more general 'network' pattern, and each is characterized by different processes and operational codes. Addressing each of these modalities, we will seek in the following chapter to show their structural, behavioral and knowledge requisites and, in so doing, provide a framework-based comparative analysis across all types.

10.10.2 Toward Emergent Value Networks

This chapter is essentially foundational in that it highlights the value of knowledge and of e-networking in for-profit contexts. Extending this analysis, the following chapter seeks to demonstrate the adaptation of GSSD, which was initially designed for, and implemented in, a not-for-profit context – can be valuably adapted, and extended considerably for knowledge e-networking technology and strategy to the realities and imperatives of for-profit extended enterprise. The following chapter will demonstrate – via proposed designs and a brief case study of conceptual implementation in a real MNE – how the basic GSSD framework is one whose structure and operation in a research context can be adapted to enhance the value propositions of global business.

References

Amidon, D. M. (1997). *Innovation strategy for the knowledge economy: the Ken awakening*. (Newton, MA: Butterworth-Heinneman)

Bartlett, C. A. and Ghoshal, S. (1989). *Managing across borders*. (Cambridge, MA: Harvard Business School Press)

Castells, M. (1999). *The information age: economy, society, and culture. Vol. III: end of millennium*. (New York: Oxford University Press)

Choucri, N., McHugh, G. and Millman, S. R. L. (1999). Defining knowledge networking. GSSD-MIT Working Papers Series.

Drucker, P. (November 1, 1999). The next society. *The Economist*.

Govindarajan, V. and Gupta, A. K. (2001). *The quest for global dominance*. (San Francisco, CA: Jossey-Bass Publishers).

Hagel, III, J. and Singer, M. (Mar–April 1999). Unbundling the corporation. *Harvard Business Review*.

Nonaka, I. and Takeuchi, H. (1995). *The knowledge-creating company: how Japanese companies create the dynamics of innovation*. (New York: Oxford University Press)

Quinn, J. B. (1999). Strategic outsourcing: leveraging knowledge capabilities. *Sloan Management Review* 40(4):9–21.

Reich, R. (1992). *The work of nations: preparing ourselves for twenty-first century capitalism*. (New York: Vintage Books)

Savage, C. (1996). *Fifth generation management*. (Newton, MA: Butterworth-Heinneman)

Skyrme, D. (1999). *Knowledge networking*. (Newton, MA: Butterworth-Heinneman)

Stewart, T. (1998). *Intellectual capital: the new wealth of organizations*. (New York: Bantam Books)

Stewart, T. (2001). *The wealth of knowledge: intellectual capital and the twenty-first century organization*. (New York: Doubleday)

Tapscott, D. (1997). *The digital economy: promise and peril in the age of networked intelligence*. (New York: McGraw-Hill)

Wiig, K. M. (1995). *Knowledge management methods: practical approaches to managing knowledge*. (Burlington, MA: Schema Press)

Wiig, K. M. (2000). *Knowledge management: an emerging discipline rooted in a long history*. (Newton, MA: Butterworth-Heinneman)

Chapter 11

GSSD-ENTERPRISE FOR MULTINATIONAL CORPORATIONS

Shung Yar Lim

Introduction

The focus of this chapter is largely on knowledge-linkages between subsidiaries and central management in large and mature multinational enterprises that are themselves meta-networks of smaller knowledge networks in subsidiary nodes. Examples of such extended enterprises include Sony, 3M, and Siemens, among the most obvious. Our purpose is to show how the conceptual and architectural design for the knowledge e-networking system presented in Part I of this book, namely the Global System for Sustainable Development (GSSD), may be adapted, customized, and implemented to serve as a value-enhancing knowledge network for extended enterprises. We will show how many of the key features of GSSD can provide critical support services as human knowledge-networking in the nodal business units within the network.

More precisely, in this chapter we systematically derive the features for a fully developed frame system and knowledge architecture for a GSSD-Enterprise initiative such that it serves as the knowledge networking technology system of the enterprise. Such a system must be built upon a communications backbone infrastructure and must provide an integrative architecture for the enterprise's communication and knowledge management systems. We will label this new version of GSSD-Basic as GSSD-E, referring to GSSD-Enterprises, and we will show that it can serve as an integrated infrastructure, on which knowledge networking capabilities can be built, linkages between subsidiaries and the headquarters (HQ) – which are vital for control and coordination by HQ as well as for allowing the extended enterprise to strategically leverage knowledge within the organization.

This chapter proceeds as follows: first we begin with the organizational and institutional fundamentals for global business enterprises, characterizing

N. Choucri et al. (eds.), Mapping Sustainability: Knowledge e-Networking and the Value Chain, 209–228.

the most essential features relevant to the design of GSSD-E. Second, we focus on the core elements of the frame system, which we refer to as the architecture that is fundamental to the construction GSSD-Enterprise. On this basis, third, we will then present three different modal types of GSSD-E – each characterized by distinctive features that could very well operate on a stand-alone basis. We will refer to these as Types I, II, and III. In a sense, these modal types can be seen as *pure forms*, or frame system archetypes, for GSSD-E. Only when their critical features are fully integrated into a robust architecture can the disparate features of the modal types yield a system whose whole is greater than the sum of its individual parts, and, by extension, which performance is greater than any singular set of improvements alone.

The logic for this sequence is as follows: at issue here are not only the attributes of knowledge networking e-systems, but more important, as these are embedded in, and are designed to be of service to, a multinational enterprise. Thus, the nature of the entity itself requires certain networking properties or functionalities. The underlying hypothesis is that networking requirements would have to change and remain consistent with changes in and modify-cation as well as further extensions of enterprise activities – in temporal, spatial, or functional terms.

11.1 Global Business Structures

The institution of the multinational enterprise (MNE) as an engine of global innovation and technological transfer is a subject that has been well explored. Less explored, however, are the conceptual models which represent the mechanisms through which MNEs can achieve knowledge transfers to facilitate knowledge creation and re-use. In order to begin a design of a GSSD-E system it is first necessary to view key features of an MNE as an organization, of which two organizational principles are especially fundamental to the operations of the entity. Namely, the *Product Structure* – Product A, B, C, … *n* (where *n* is the number of the products in whose market the enterprise is involved); and the *Geographic Structure* – Area A, B, C, … *n* (where *n* is the number of places in which the enterprise has operations).

The content of information and knowledge flows – between the HQ, the subsidiary, and between subsidiaries – is necessarily complex and essential to the operations of the global firm. At the most basic level, these encompass flows from advice-givers (from internal or outsourced planning or consulting units), from customers, from suppliers, and from other internal knowledge sources.

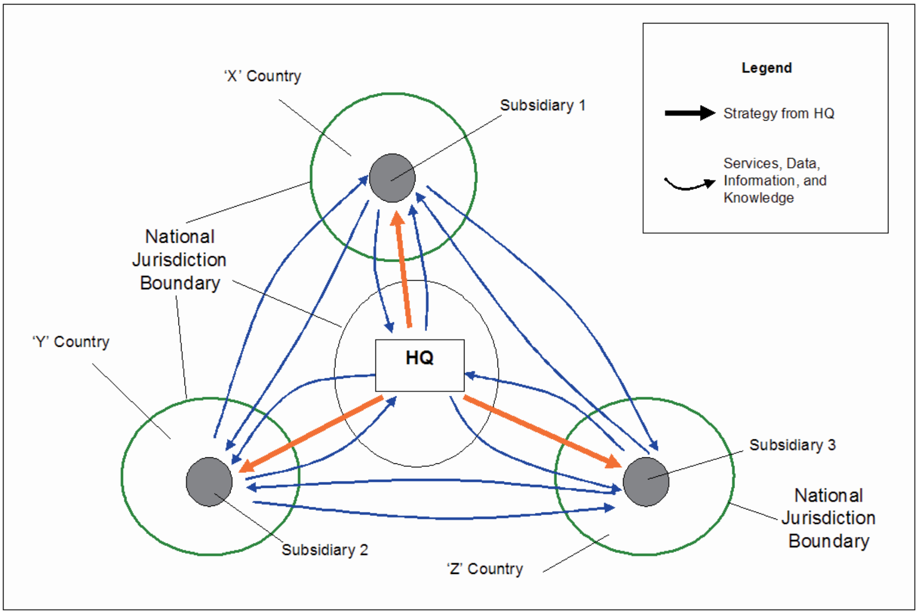

Figure 11.1 **Knowledge flows in MNE with HQ and operations in three countries.**

Figure 11.1 illustrates a general model for knowledge flows within an MNE, in which the MNE has one HQ unit in the home country with operations in three other countries. Other scenarios of various permutations and numbers are conceivable – for example, one HQ unit and several subsidiaries within the home country with operations in several countries, each of which having several subsidiaries. The barriers and constraints to these flows depicted in Figure 11.1 were once predominantly physical in nature, namely distance and time zones. Now they have become largely intangible in nature, and often pertain to differences in national or state regulations, technological standards, and context-sensitive socio-cultural factors (Feese-Zolotnitski, 2002). Among the most salient of such factors are:

- *Privacy* – Accessibility of databases and information sources within the MNE, as well as monitoring of communications. Privacy also pertains to security issues.
- *Security* – Authentication measures, encryption and security clearance levels for access to information that is classified according to different levels of confidentiality.
- *Taxation/Licensing Fees* – Leveraged on internal non-material products, an example of which are software licenses.

- *Intellectual Property Protection* – Issues related to technological innovation and stability of the property rights regime in protecting the innovator.
- *Semantic Differences in Language* – Context and meaning may be inadequately captured in translating from one language to another.
- *Knowledge-Sharing Culture* – Willingness to share knowledge among coworkers and to offer help and training.

Most of these factors are generic across business, and are especially dominant in commercial entities. At the same time, however, there may well be some important equivalencies in non-business, institutional and organizational contexts with respect to knowledge management and sharing.

11.1.1 Challenges by Analogy

As indicated in Part I of this book, the first application of the GSSD system focused on the broad domain of *sustainable development*. To avoid confusion, this chapter uses the term GSSD-Basic to refer to the sustainable development application. The knowledge architecture is sufficiently robust to retain its value irrespective of the content that populates the frame system and its parameters. By way of supporting this assertion, we show in Table 11.1 a comparison of knowledge challenges for GSSD-Basic (focusing on sustainable development) and the needs of GSSD-Enterprise (addressing the needs of global business).

In terms of creating a frame system and mapping domains of relevance, both GSSD-Basic and GSSD-Enterprise share common objectives – despite the fundamental differences that are to be expected with respect to knowledge content. At the operational level, both systems need to enhance the accessibility of knowledge about enterprise activities, competitive and market intelligence, and innovations in processes, technologies and perspectives to knowledge workers and decision-makers who are devising or executing organizational strategies. Both systems also enable knowledge sharing through dedicated and customized search engines and spidering algorithms, quality-controlled knowledge mining tools, multilingual capacities, and decision-support modeling software. Both systems also provide virtual environments which facilitate collaboration between different nodes within the network and which can transcend boundaries of distance, culture, and language.

Table 11.1 **Knowledge challenges for sustainable development and for global business.**

	Sustainable Development	**Global Business**	**Sustainable Global Businesses**
Linkage Challenge	Understanding connections between environmental factors and social activities, between forms of knowledge and types of solutions	Understanding connections between strategy and the role of knowledge in the MNE, between the forms of knowledge and types of solutions	Understanding connections between enterprise activities and impacts on society and environment between forms of knowledge and types of solutions
Policy Challenge/ Strategy Challenge	Definition of appropriate concepts and approaches to decisions about management towards sustainability and management for safeguarding the global environment.	Definition of appropriate strategies and frameworks for decision towards enhancing competitiveness and increasing core competencies in a global market in line with MNE vision.	Definition of appropriate concepts and approaches to decisions about enterprise management towards sustainability and managing the global environment in aligning enterprise objectives with environmental concerns
Institutional Challenge/ Organizational Challenge	Identification of appropriate approaches, methods, and procedures for international responses to environmental alterations due to human activities and attendant social dislocations	Identification of appropriate organizational design methods, culture-shaping policies, and human-technology policies for global organizational responses to competition and dominating global markets	Identification of appropriate organizational and process-design methods. Human-technology policies for global and local organizational responses to the environmental impacts of enterprise activities, and the cost feasibility of environmental initiatives

To achieve these objectives, GSSD-E must encompass: (i) a coherent strategy for integrating and organizing worldwide enterprise knowledge in multidimensional and multisectoral terms, (ii) in which knowledge is represented via a plurality of interrelated concepts and interrelationships organized in taxonomic form and adhering to a GSSD Glossary of shared terminology, (iii) the knowledge acquisition process, at the individual user's level of abstraction, is augmented by functionalities that include navigation mechanisms and collaborative arenas, (iv) in which a set of multilingual functions will enable non-English speaking users access with equal usability to the same functionalities as English-speaking users. These fundamental features of GSSD-Basic remain central to the GSSD-E initiative.

11.1.2 Essential System Features

Accordingly we single out here the specific features of GSSD-Basic that need to be adapted for GSSD-E. These include:

- *Gateway character with analytical features* – interface to repository for distributed knowledge provision, submission, and input.
- *Knowledge-base with cross-indexing* – an organized repository of links to sources of codified knowledge, information, and data.
- *Subject-specific* – the original application, on sustainable development involves specification in multiple sectors via multiple lenses (problems, solutions, issues). It lends itself to a knowledge-base design with regards to one subject domain of relevance (for example, product type).
- *Content-relevant* – content priorities are always specified by the system designer (to meet user needs). Including abstracts as well as links to reports, articles and databases, and the like.
- *Multinational and Multidisciplinary* – involving participating network members in different locations.
- *Information* – within the knowledge-base resides in servers located at participating network members in various countries.
- *Mirror sites* – which are established in the locations of network members to enhance speed of access and minimize risks related to dependence on a single centralized site for the knowledge-base.
- *Multilingual aspects* – which are addressed by translation at the site of the network member that is providing content for the knowledge repository.
- *Semantic consistency* – which is maintained by means of a commonly-established terminology.
- Users can identify *classes of content* that is most relevant to their needs and either link to, peruse, or download the latter into their computers.

As noted previously, knowledge networking technology consists of an information communication technologies (ICT) backbone infrastructure, an enterprise integration framework, and a knowledge management system. Each element can be subdivided into multiple components. Given that the GSSD-Basic framework is directly relevant to the knowledge management system features of an overall, many of its features relevant to extended enterprises constitute the foundations for the new GSSD-Enterprise. At issue are elements of architecture that are built upon the fundamental design features highlighted above.

11.2 Strategy for e-Networking Architecture

The guiding strategy for implementing the networking system for corporate entities consists of two steps. The first is to define GSSD meta-layer which will provide the framing of all subsequent steps. The second is to identify specific modal Types that can be derived from, and remain consistent with, the GSSD meta-layer. This second step introduces flexibility in order to provide a best-fit between enterprise needs and requirements, on the one hand, and system functionalities on the other. Keep in mind that some extended enterprises require specific, but singular functions; others may need more extensive or differentiated services.

11.2.1 GSSD Meta-Layer

The purpose of the meta-layer interface is to capture and implement the key ideas of Figure 11.1. By using two parameters namely, *geographic area* and *product/service sector* as anchors for modeling the MNE, the central frame for the knowledge architecture is thus put in place. The product/service sector parameter relates to an industry or a sector within the industry at the highest level of aggregation. For example, 3M operates in multiple industrial sectors including architecture and construction, automotive, aerospace and marine, electronics, healthcare and others; Sony operates in the entertainment (computer, movies, and music), electronics, insurance and other industries.

The meta-layer of GSSD-E provides a portal – an e-entry point – consisting of a matrix within which the user can locate the product-country/region intersection that contains the knowledge or information content that is most relevant to his or her requirements.

In Figure 11.2, we show an image-structure that is consistent with the GSSD-Basic design, adapted to the conceptual categories of international business. Recall that in Part I the GSSD-Basic framework was utilized for mapping the domains and dimensions of sustainable development. The same logic is followed here, with appropriate adjustments of content.

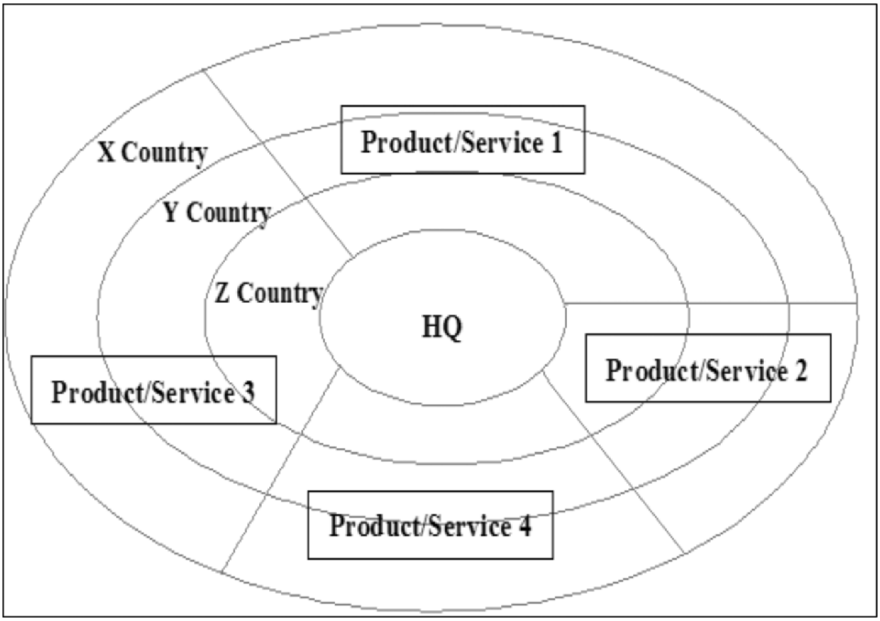

Figure 11.2 **GSSD-Enterprise meta layer – geographic regions and product services.**

The components consist of the following two elements: (1) *Rings*, which refer to geographical area, in terms of countries/regions of operations, as well as the geographic location of an enterprise's HQ; and (2) *Slices*, which refer to specific product-service sectors and industries. Many MNEs are geographically-diversified across international borders, and many are also industrially-diversified.

Extending this basic structure to design more specific applications derived from the GSSD architecture can readily follow from the architecture of the GSSD-E meta-layer in Figure 11.2. Since the meta-layer serves as a portal – via which users can narrow search preferences by increasing the level of specificity – targeted access is assured by selecting a ring-slice intersection of geographic-area and product/service-sector. The user can thus locate the content that is germane to the intersection selected, and retrieve knowledge about particular business activities that have been harmonized and integrated worldwide by the enterprise in question.

11.2.2 Variations of Modal Types

Extending the meta-layer for the GSSD-Enterprise further, Figure 11.3 shows the development of three alternative system designs, all derived from the GSSD-E meta-layer depicted in Figure 11.2. The first is *Type I GSSD-E*, which consists of a basic knowledge-base centered on a single product/ service-area intersection. This system entails minimal changes to GSSD-Basic. The second is Type *II GSSD-E*, which is an interface portal for the knowledge management systems of the enterprise. In this case, GSSD-E becomes a gateway to collaborative software, analytical tools and cyber-libraries for all e-functionalities of the enterprise. Finally the third, *Type III GSSD-E*, consists of a common interface to enterprise integration tools (like some of the most common tools at present, notably Resource Enterprise Planning, Supply Chain Management, and related types of software).

Each has specific focal points with attendant advantages and disadvantages. Each brings some assets to the overall initiative, but each must be expected to be bounded by some limitations as well. Figure 11.3 integrates Types I, III, and III.

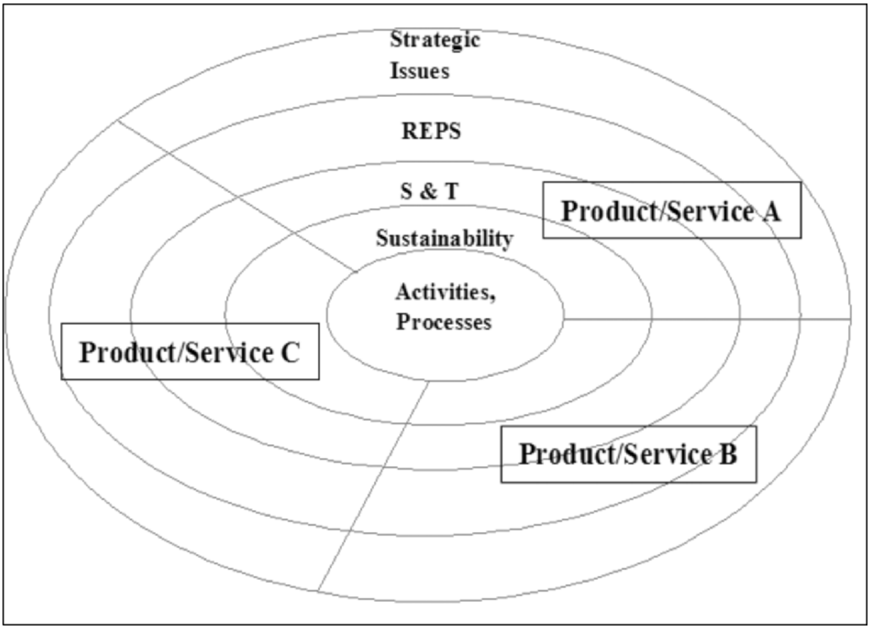

Figure 11.3 **GSSD-E knowledge-base conceptual design – Types I, II, and III.**

With this logic in place, the user will encounter features of system usability and ease-of-use, degree of integrity and timeliness in delivery of content, and extent of system compatibility with other enterprise applications. Given these practical requirements, the following four criteria would be of special concern: first, the usability of human–computer interaction (HCI) functionalities – HCI studies is a relatively new branch of information systems engineering that is concerned with the usability of computer-based applications. In this case, HCI design concepts should be used to guide the design of the knowledge-base to ensure that the system is learnable and usable in the shortest time possible. Surveys and monitoring of usage are techniques commonly used to assess the usability of the system, and HCI intimately affects the *action ability* of information. Second, the *quality of information* that is uploaded into the knowledge-base must be monitored both for its integrity and timeliness, since broadcasting the inaccurate information, or information that is obsolete, can have potentially disastrous effects. Third is the *standardization of data formatting* and *technological compatibility* – harmonization of software protocols and technological systems to ensure that seamless information and data exchanges are possible. Fourth is the *standardization of terminology*, which must be maintained in translation across differences in language and exchange rates. Context mediation technologies must be leveraged to maintain consistency of meaning.

Given that each of the three model types presented in this chapter are characterized by distinctive features, they deserve individual attention in their own right. This consideration is especially important, as further along we will draw on many of these features in order to develop a fully integrated architecture for an emergent fully integrated GSSD-Enterprise. As we show later in this chapter, the functional capabilities of the integrated system, are greater than the sum of the individual parts. At this point, however, we focus only on the fundamentals, issues essential to robust foundations for an enhanced enterprise system.

11.2.3 Focus on Knowledge-Base: Type I GSSD-E

The design for Type I GSSD-E directly adapts GSSD-Basic for use as a knowledge-base. This knowledge-base serves as an enterprise knowledge map, and could be used to facilitate employee self-help in accessing organizational and external related knowledge, or as a mechanism for transferring and diffusing local knowledge from one node within the extended enterprise network to the entire organization, or as storage of organizational knowledge as part of organizational learning. Housed as mirror sites at various nodes on the enterprise's intranet, the knowledge-base is jointly built and maintained by the different nodes within the network, such that nodes are interdependent on each other as knowledge sources. This will be especially crucial within the transnational network structure of an enterprise in which nodal units in the multinational enterprise network are highly specialized and interdependent on each other for knowledge inputs that are critical for timely and accurate decision-making.

For Type I GSSD-E, which relies largely on the effectiveness of its content, the knowledge-base would be managed with non-interactive functions and the content would focus largely on codified knowledge. As noted earlier, such content includes information and databases, mostly qualitative with some quantitative content depending upon the goals of the enterprise.

The methods by which content is added to the knowledge-base is similar to the way in which content is added to GSSD-Basic, as previously introduced in Part I of this book.[1] Here, nominations are made by employees, and these nominations will be assessed by researchers according to a common set of criteria. Accepted contributions are then used to form abstracts in the various languages of countries in which the MNE has subsidiaries, together with a link to the new addition and classified within

11.2.4 Focus on Knowledge Management Systems (KMS): Type II GSSD-E

The Type II GSSD-E KMS combines the knowledge sharing objectives of the Type I knowledge-base with venues of joint knowledge creation and application. The latter activities refer to the virtual team-working functionalities that facilitate: (i) real-time communication across physical boundaries, (ii) virtual teaming and joint problem solving, and (iii) learning from employees in other divisions. Knowledge management systems supplement such virtual meeting places with enhanced analytic tools for intelligent searches in intranets, information-to-knowledge facilitating technologies, and interactive e-learning resources as well as simulation and modeling packages. Unlike Type I GSSD-E, however, which has only non-interactive content in the knowledge-base; the Type II GSSD-E has both interactive as well as non-interactive content.

Between GSSD-Enterprise and GSSD-Basic, there are some significant differences in the domains and dimensions represented in the knowledge architecture.

11.2.5 Focus on Enterprise Integration (EI): Type III GSSD-E

Type III GSSD-E EI encompasses all of the enterprise integration tools that form the enterprise's management information infrastructure. Type III comprises software for various services, like enterprise resource planning tools like transaction processing software, customer relationship management and human resource management applications. Type III provides the deployment and accessibility to such decision-support EI tools on a global level, such that strategic planning and decision-making can take place in HQ or in subsidiaries with knowledge inputs from all nodes within the MNE network.

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[1] In GSSD-Basic, content is added through submissions, which are then reviewed by GSSD-specific content supervisors.

The differences among these three Types become more apparent as we consider their respective requirements pertaining to content provision, ontology applications, and overall knowledge-system design. While sharing some common elements, the distinctive features are particularly relevant for purposes of structure and architecture as well as implementation and operation, all of which are contingent on attendant knowledge, ontology, and system design.

This third Type of GSSD-E is one that seeks to reflect overall enterprise integration in structure and operations. Accordingly, it would comprise EI software that encompasses, among other interactive components, applications like Customer-Relations Management (CRM) software, Supply Chain Management (SCM) software, Human Resource Management (HRM) software, Financial Process Management software, and Product Life-Cycle Management software. It would also retain the requisite non-interactive knowledge components, like data, reports, bulletins and the like.

Increasingly, specialized information technology consultancies like Accenture and IBM are offering solutions that integrate EI applications onto a common platform of standards and protocols. GSSD-E complements such development by acting as a framework that leverages such integrated software packages as the main mechanisms for operational global knowledge networking.

11.2.6 Knowledge-Representation and System Design

Part I of this book – devoted to the conceptual foundations, design, and architecture of GSSD-Basic as well as on operations in a distributed global context – began with a clear specification of the knowledge domain. *Mapping Sustainability* yielded the ontology of the knowledge domain which, in turn, provided the fundamental inputs for computerization of the knowledge organization and management system of GSSD. These functions dictated the requirements for knowledge submission including content selection, indexing, and cross-referencing, as well as the functions required for web-based knowledge location, retrieval, access, and sharing. The generic features of the system were identified and their characteristics were delineated accordingly.

Then in Part II, some of the challenges encountered in multilingual and cross-cultural design were addressed. Against this background, we provided the foundations for making the transition from GSSD-Basic to GSSD-Enterprise. In essence, the multilayer logic employed by GSSD-Basic also includes the common platform-features upon which GSSD-Enterprise can be built.

In this context, the emergent properties of GSSD-Enterprise – formulated in terms of three distinct Types – have been introduced not only to the underlying principles, but also to highlight the potentials for customizing the design elements in order to meet the most important demands of operations for a specific extended enterprise.

11.3 New System Based on Integrating the Three Types

Focusing on the knowledge needs of extended enterprises – those multinational corporations whose reach extended beyond territorial boundaries and whose operations may be dispersed across jurisdictions – this chapter derives the most fundamental requisites for e-networking predicated on the logic of GSSD meta-layer. The meta-layer consists of a generic representation of knowledge derived from GSSD-Basic.

The key contribution of this chapter is the specification of attributes of knowledge networking e-systems in ways that are consistent with the goals of any particular extended enterprises. In other words, while there are generic features essential for effective operations of e-knowledge systems, these must be customized to the particular requirements of the corporate entity in question. In other words, the architecture of a corporate knowledge e-networking system must be embedded in, and are designed to be of service to, the needs of a multinational enterprise. The nature of the corporate entity itself requires if not dictates, certain networking properties or functionalities.

The underlying proposition in this chapter is that the e-networking requirements must remain consistent with the needs of the enterprise. If and when conditions change, as needs and requirements are modified, then the e-networking functionalities must be adapted accordingly. At any point in time, the e-system must remain consistent with changes in further extensions of enterprise activities – in temporal, special or functional terms. By way of illustrating this proposition, we derived three types of a GSSD-Enterprise system, each predicated on the GSSD meta-layer. Each of the model Types has important features relevant to an integrated GSSD-E system. When fully integrated, the design and operation for the e-system of an extended enterprise can be specified as follows:

GSSD-Enterprise =

- Integrated Knowledge-Bases +
- Knowledge Management Systems +
- Enterprise Integration

This integration and its application is the subject of the following section. The challenge is to render this integration coherent and internally consistent, while at the same time retaining the initial mission and architecture of GSSD-Basic on the one hand, and enhancing rather than sacrificing attention to the critical requirements for effectiveness of extended enterprises. Finally, an essential requisite for all of such initiatives is based on the reality that matters of network security are fundamental for effective knowledge-sharing among value chain partners.

The overall system design for GSSD-E, Type IV, is presented in Figure 11.4. This figure integrates the three Types into a cohesive whole so that the user can select among the functionalities and/or use one in combination with another.[2]

11.4 Application of GSSD-Enterprise: The Sony Case

The environmental management organization of Sony Incorporated is an ideal MNE for utilizing GSSD-Enterprise to demonstrate that the GSSD framework extends beyond sustainability. Sony's wide-reaching business operations are divided into five functional units: network companies, group companies, computers, games, and music. Environmental management must be coordinated across each business unit and in every geographical region. The GSSD-E meta-level matrix of product/service sectors versus geographic areas can hence fit this categorization appropriately, while a knowledge-base design will be germane to the environmental dimensions of Sony's operations.

11.4.1 Corporate Context and Environmental Strategy

Sony has developed an environmental strategy, summarized in Table 11.2. Led by a vision that is supported by four enabling pillars – commitment, technology, business models, and education – Sony has developed clear activities and supporting systems to achieve its environmental aims, and they have developed assessment measures that draw on clearly defined data sources.
Environmental management at Sony is clearly knowledge-driven, and knowledge networking mechanisms will be effective in helping Sony headquarters and its worldwide subsidiaries strategize and align their activities towards these strategies. These subsidiaries, or Environmental Conservation Committees, execute the environmental goals of corporate HQ as adapted to the various regions and locales. In Figure 11.5, the location of Sony's five Environmental Conservation Committees is presented, as reported in 2003.[3] These are located in Japan, China, Asia, Europe, and the Americas. The headquarters is located in Japan.

[2] If and when this design moves to the operational stage, then specific tests will be undertaken in order to determine the internal consistency among the type-based components and to identify and then correct for any design or computational redundancies.

[3] Sony's publicly available materials suggest that they launched their "globally integrated environmental management system" in 2004 and completed the shift in 2006. See Sony's Global Environmental Activities for more details.

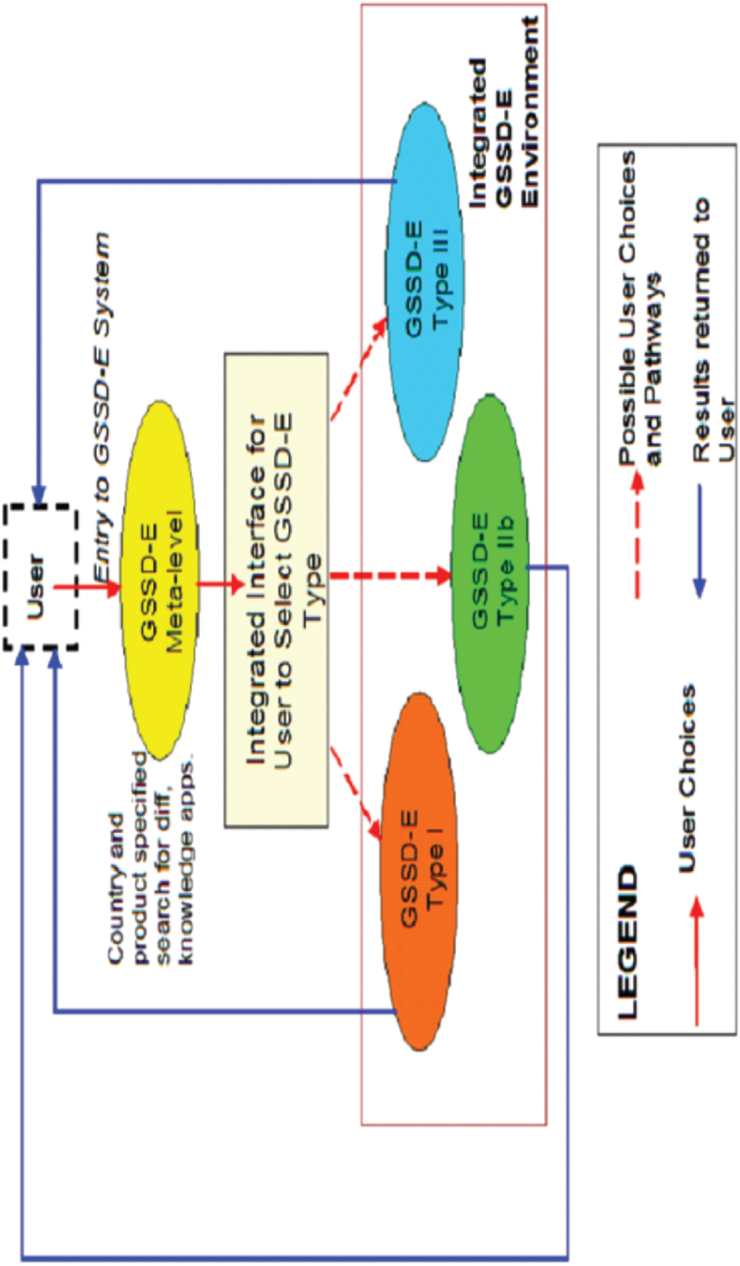

Figure 11.4 **GSSD-E integrated architecture.**

Table 11.2 **Sony environmental strategy components.**

Environmental Vision	Commitment, Technology, Business Models, and Education
Action (Activities)	Green Procurement and Purchasing, Energy Conservation, Resource Conservation and Waste Management, Chemical Substances, Facility Design and Construction, Product Planning and Design, Environmentally Conscious Products, Distribution, Sales and Services, Product Recycling, and Environmental Activities in Various Business Operations
Supporting Systems (Environmental Management Systems)	Environmental Technology Development, Environmental Education and Support Programs, Environmental Business Models, Environmental Communication, Risk Management System and Environmental Auditing, Occupational Health and Safety and Disaster Prevention, and Community Relations Activities
Data	Environmental Accounting, Energy, Water, Chemical Substances, Waste, and Products

Based on information from Sony website:
http://www. sony.net/SonyInfo/Environment/environment/index.html

11.4.2 GSSD-Enterprise for the Sony Environmental Management Sector

The parameters considered in adapting GSSD-E for Sony's environmental management sector are differentiated according to core product sectors as follows:

- Computer Entertainment – Games console and software business
- Music – Music software business
- Pictures – Movie/TV programming business
- Group Companies – Including many businesses, especially a life-insurance business
- Network Companies – Including business units in Home, Mobile, Semiconductor, Core Technology, Broadband Solutions, Digital Telecommunications, and Display sectors

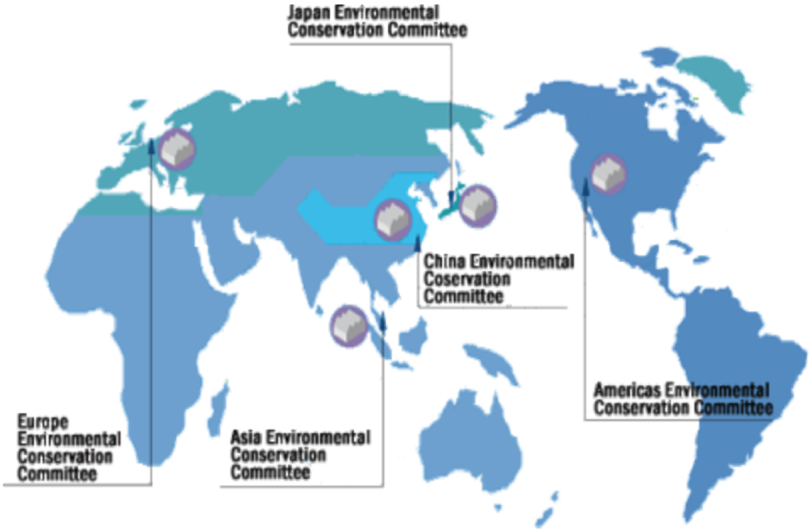

Figure 11.5 **Sony's five environmental conservation committees. Source: Sony website.**

Generally, there are environmental offices at each of these business units. Using the template developed earlier – and consistent with GSSD-Basic – the second feature of design implementation, the meta-layer may act as a gateway to the implementation of specific features for the GSSD-Sony Enterprise), namely those pertaining to a *knowledge-base* and to overall knowledge *management.*

The meta-layer consists of rings (namely the Regional Environmental Conservation Committees – Asia, China, Europe, Japan, and the Americas) and slices (notably Network Companies, Group Companies, Sony Music, Sony Pictures, and Sony Computer Entertainment). This meta-layer is displayed in Figure 11.6.

A closer look at the composition of each of the slices in Figure 11.6 another, lower-level structure based on GSSD. For instance, under the slice of *Network Companies*, there is a corresponding set of slices, and rings as presented below:

Slices: Network company sectors such as home, mobile, semiconductor, core technology, broadband solutions, digital telecommunications, and display business units.

Rings: Environmental Data, Sustainability Action Issues, Sustainability Support Systems, Regional Regulatory/Economic/Political/Social (REPS) Issues and Environmental Strategies.

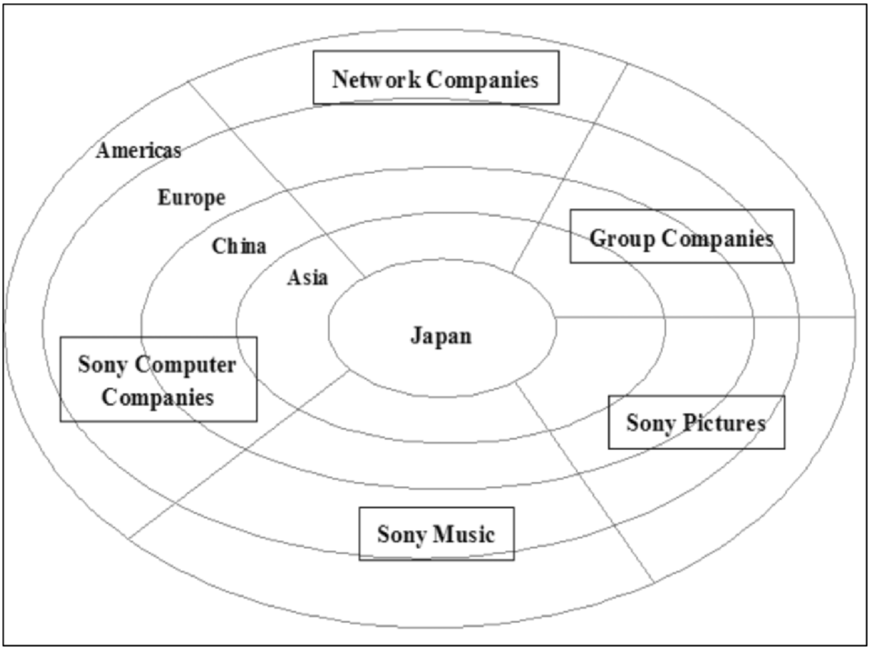

Figure 11.6 **Meta-level GSSD-E adapted for Sony.**

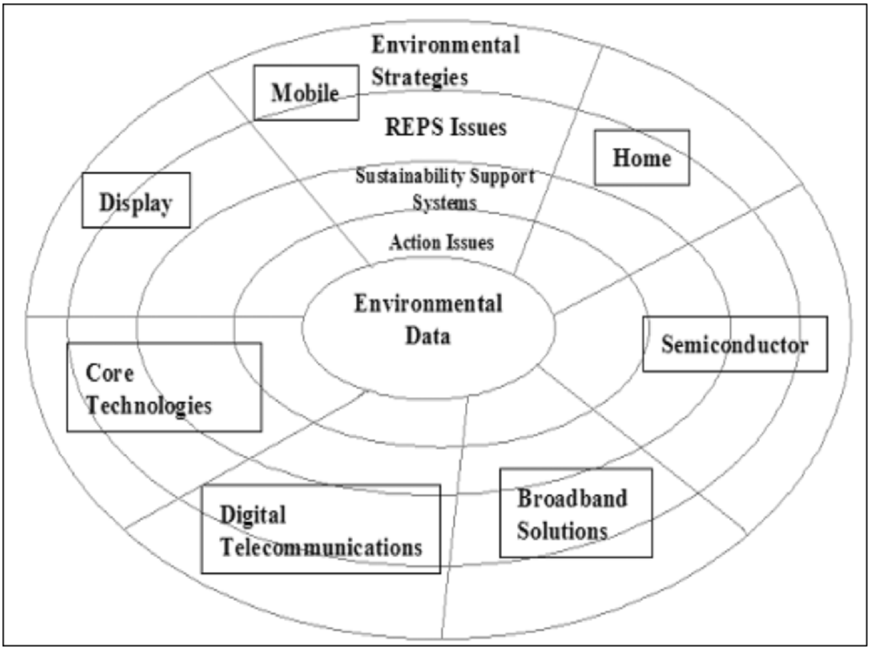

Figure 11.7 **GSSD-E model for environmental management in Sony's network companies.**

This extended structure is shown Figure 11.7. Like GSSD-Basic, within each of these Rings and Slices are sub-Rings and sub-Slices, respectively. These are where specific initiatives and conditions would be captured. For instance, in the Sustainability Support Systems Ring, issues such as Environmental Technology Development, Environmental Education and Support Programs, Environmental Business Models, Environmental Communication, Risk Management System and Environmental Auditing, Occupational Health and Safety and Disaster Prevention, and Community Relations Activities are all captured.

11.5 Conclusion

The imperative for firms to globalize, combined with the market dynamics arising from enterprise innovations and the demand for increasingly sophisticated products and services, have accentuated the need for rapid decision-making. Such rapid decision-making is absolutely contingent on knowledge. Hence, empowering 'knowledge-workers' with decision-making authority while mobilizing knowledge to ensure organizational learning and facilitate innovation is necessary. Such changes require mechanisms that are presently inadequate.

If knowledge sharing among value chain partners is to be effective, then the knowledge-base design must be a core enterprise asset. It can be shared among multiple enterprises in multinational value networks that include MNEs, its suppliers, down-stream customers (businesses), and service providers like distributors and retailers. The key issues of knowledge sharing in this context pertain to the security of the system, and the latter is again contingent on robust technology and people policies.

This chapter contributes to shaping an overall vision for the global knowledge networking strategy for global businesses, as a foundation on which more enterprise-specific developments could be deployed. This global knowledge networking system was derived from the GSSD ontology to establish a global knowledge-base in sustainable development. The proposed analog of a GSSD ontology for enterprises, known as GSSD-E, was expressed in a series of three possible designs, with an integrated platform for all the technology strategy components as part of the integrated knowledge network.

In considering alternative design-types for GSSD-E, such technology-based security systems must be implemented for this purpose. Clearly, while human networking policies are preventative in nature, technological solutions are required as safeguards to deter and minimize the risks arising from cheating. The enterprises that will contribute to the common knowledge-base can view content as governed by a security classification as deemed fit by the MNE and possibly its partner enterprises.

Accordingly, we proposed a general task framework that could schedule the roll-out of the technology strategy in its entirety, as well as specific design and operational features that are relevant to an individual multinational enterprise. In this connection, we presented a case-study involving just the initial design stage for an example MNE: the environmental department at Sony was examined. Using GSSD concepts to develop a pilot GSSD-E model will be the next step in determining the knowledge demands of the enterprise.

Further refinement of the knowledge-base design will be required, and this will be possible only with the availability of more information about Sony and its enterprise organizational structures, its alliances, and other enterprise information. Completing such an application to its operational implementation will require a much more thorough investigation, survey and audit of Sony's enterprise activities, organizational structure and planning processes in order to construct a more precise and useful knowledge-base, and the designs above show that a GSSD-type knowledge system can be deployed to provide an integrative mechanism for creating a knowledge networking technology infrastructure. The next challenge will involve addressing the experiences of people actually using the infrastructure in ways that are optimal for innovation and organizational learning, and these will be governed in some sense by the organization's knowledge networking people policy, the other crucial competence in mobilizing competence in leveraging the proposed infrastructure.

References

Feese-Zolotnitski, M. (2002). Multinational enterprises, *Modern Communication Technologies and National Economic Policies*: Third Berlin Internet Economics Workshop.

Sony Global. *Environmental Activities*. (2006). Retrieved October 12, from http://www.sony.net/SonyInfo/Environment/environment/index.html.

PART THREE

Chapter 12

VISUALIZATION

Exploring Growth and Development in the Global System

Carlos I. Ortiz

Introduction

The purpose of this chapter is to highlight select features of current visualization technologies that are especially relevant to our understanding of globalization and the global system. If by visualization we mean "a method for seeing the unobservable," then information visualization has yet to acquire the status of mainstream methodology within the social sciences (Orford et al., 1976: 300). As yet, visualization has not enjoyed a strong, central, and coordinated research program to put forth visualization in mainstream scholarship – other than geography scholarship with a slow diffusion process often taking place from the "harder sciences" to the "softer sciences" (Orford et al., 1976: 300).

In his landmark text on the subject, *The Visual Display of Quantitative Information*, Edward Tufte puts forth the notion of *graphical excellence* referring to well-designed presentation of interesting data (1983). Graphical excellence spans issues of *substance, statistics,* and *design*, while giving the viewer the greatest number of ideas in the shortest amount of time with the least ink in the smallest space. It is nearly always multivariate, and excellence requires telling the truth about the data (Tufte, 1983: 51). This points to the importance of overcoming *perceptual impairment* since "graphics *reveal* data" (Tufte, 1983: 14). Tufte cites William Playfair, an eminent English political economist and a forerunner in the use of graphical designs, summarizes the ability for visual representation of information to facilitate the process between hypothesis generation and verification by overcoming perceptual impairment as follows:

> Information, that is imperfectly acquired, is generally as imperfectly retained; and a man who has carefully investigated a printed table, finds, when done, that he has only a very faint and partial idea of what he has

N. Choucri et al. (eds.), Mapping Sustainability: Knowledge e-Networking and the Value Chain, 231–260.

> read; and that like a figure imprinted on sand, is soon totally erased and defaced. The amount of mercantile transactions of money, and of profit or loss, are capable of being as easily represented in drawing, as any part of space, or as the face of a country; though, till now, it has not been attempted. Upon that principle these Charts [graphics] were made; and while they give a simple and distinct idea, they are as near perfect accuracy as is any way useful. On inspecting any one of these Charts attentively, a sufficiently distinct impression will be made, to remain unimpaired for a considerable time, and the idea which does remain will be simple and complete, at once including the duration and the amount (Tufte, 1983: 32).

At the same time, however, visual methods themselves are not without criticism. For instance, Tufte (1983) writes, that "for many people the first word that comes to mind when they think about statistical charts is 'lie,' 'the obvious to the ignorant,' or 'to protect the helpless dullards from crass graphical deception.'"[1] Although Tufte has outlined a methodological program for properly creating and usefully employing graphics in the natural and social sciences, he does not formally explain how the visual method is a distinct and valuable step in a general research design. In this chapter we argue that the visual method is an intermediate link between deductive theory and inductive analysis that generates feedback between qualitative reasoning and quantitative inference in scientific research.

12.1 Geographic Information Systems

One avenue of information visualization technology of increasing interest to understanding international relations is *Geographic Information Systems* (GIS).[2] By manipulating and retrieving spatially-referenced multivariate data, and linking the data to computer-generated maps, GIS allows the analyst to produce a variety of visual renditions and techniques through maps, while

[1] Professor Stephen M. Meyer of the Political Science Department at MIT once replied to this author on the subject of information visualization: "I wish I had something useful to say on the subject, but I don't. I use data visualization techniques when and where I think it helps the reader understand patterns in the data. That is, I use maps when maps help; I use graphs when graphs help; etc. The problem is most people cannot read graphs or maps." This opinion on information visualization is shared by many scholars and researchers in international relations, let alone political science, and his statement has provided a much needed critical outlook to this author in identifying the need for visualization in international relations.

[2] According to the Environmental Systems Research Institute (ESRI), the leading developer of Geographic Information Systems (www.esri.com), GIS is "an organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information."

including a multitude of exploratory and quantitative tools for analyzing the data displayed on a given map. The traditional discipline of geography has embraced GIS technology throughout its present research program, and applied geography-GIS research has established its presence in environmental studies, earth and atmospheric sciences, urban studies and planning, and only more recently political science.[3]

12.1.1 GIS Applications

In the study of world politics, for example, Starr employs GIS and its accompanying spatial analysis tools both to operationalize and compute opportunity and willingness of geopolitical interaction (i.e. territorial trade, migration, or conflict), as well as to perform spatial statistical analysis of geographically referenced geopolitical data in order to quantify the effects of borders and distances in international structures and behaviors (2002). In the context of Lateral Pressure Theory in empirical international relations, Choucri has recently addressed the role of visualization for "exploring alternative representations of the global reality," and has undertaken initial applications of GIS technology for visual exploration of geopolitical datasets within geospatially-referenced structures. In a novel integration of GIS and AI (Artificial Intelligence) simulation, Koch uses GIS tools to provide a spatial computational engine and a framework for embedding simulated agents in a social networking space in order to analyze the influence of space upon agent-to-agent capabilities of interaction (Koch, 2005). Stephen Mathews, director of the Geographic Information Analysis Core of the Population Research Institute – which provides a larger collection (and monitoring thereof) of GIS implementation in political science – observes:

> There is evidence of an increased use of spatial analysis techniques within the social sciences generally, and for political science in particular. In part, the increased use of spatial methods arises from the increased mapping, visualization and spatial analysis functionality of GIS software. However, this trend is also driven by the increased availability of geospatial data on a variety of socioeconomic and environmental domains relevant to political scientists as well as the ability to couple advanced spatial statistical software with GIS software … (Mathews, 2002)

In sum, as Tufte suggests, the GIS visualization and the resulting geographics will help the researcher overcome the *perceptual impairment* of

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[3] For a sample of journals related geographic work in the mentioned disciplines: *Annals of the Association of American Geographers*, *Climatic Change*, *Computers*, *Environment and Urban Systems*, *Economic Geography*, *GeoInformatica*, *The Journal of Urban Planning and Development*, *The Journal of Environmental Planning and Management*, *Geopolitics*, and *Political Geography*.

complex datasets by conveying "a thousand words [or data-points] through a single picture," a formidable task for comparative case narratives or a statistical table of results (Tufte, 1983).[4]

12.1.2 Basic Research Design

The social sciences usually deal with complex sociopolitical phenomena.[5] As a general statement, we can consider the overall "scheme" for research design in the social sciences to consist of two stages: the logical stage of theoretical framing and modeling on one hand, and the analytical stage of small versus large-N empirical methods on the other hand. Clearly, this is something of an oversimplification given the range of variations around this general representation. However, it does accurately reflect central tendencies in the social sciences. Hypotheses are framed and then accepted, rejected, or partially supported, and the results are assessed in order to decide how to improve or modify the underlying theory being tested. This general process is presented in Figure 12.1.

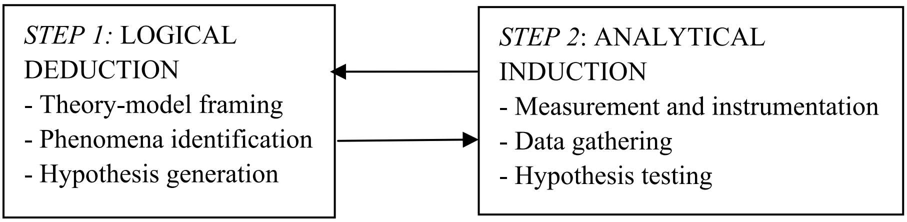

Figure 12.1 **Diagram of basic scientific research design.**

The view depicted in Figure 12.1 ignores the role of the human interface in making the transition from deductive logic to inductive analysis, and back again. But the human interface is an important feature of this process. Clearly, human cognition does not seamlessly and automatically translate ideas in the world of deductive reasoning to experiences and observations. Instead, the researcher enables interaction between reasoning and observation through a perceptual interface. This iterative process is not neutral with respect to the role of human, to their perceptions, and to their operational understanding of the underlying meanings. Information visualization becomes especially important in this context.

[4] For an excellent example of perceptual impairment, consider the problem of data exploration faced by climatologist Ralph Kahn of the Jet Propulsion Laboratory in Ball (2002).

[5] For a critique of large-N analysis in assessing complex causal processes, see Almond, with Genco (1977). Tufte also asserts this point in *The Visual Display of Quantitative Information.*

12.1.3 Topological Representation

Formally, the visual interface allows the researcher to comprehend logic and analysis via some intervening medium of perception. It attaches meaning to deductive and inductive results by *presenting* the results in a manner in which the researcher and observer can understand. To this end, this chapter argues that the addition of a third intermediate stage – *information visualization* – to the aforementioned scientific method provides a significant bridge between logical deduction, on the one hand, and analytical induction on the other. Logical propositions, proposed phenomena, and generated hypotheses are depicted in a visual medium by simulating predicted observations. Measurement, data gathered, and empirical inferences are also depicted in a visual medium in order to enable comparisons with simulated predictions. We refer to the formal relationship between logical deduction, the intervening stage, and analytical induction as one of *topological representation.* The rest of the chapter proceeds as follows:

First, we articulate a theory that prescribes sets of objects and their Cartesian product where all observable objects can possibly belong to and can be possibly related to each other (the scope of interest in a study). Logical propositions and generated hypotheses thereof then predict a subset of the Cartesian product (a relationship) in which the generated hypotheses expect objects under consideration to be organized.

Second, using visual representation then enables us to map the logical propositions of sets and relations to equivalent topological spaces, where relevant aspects of objects and their relations are represented by spatial features. For instance, a logical relation can correspond to a geometric surface inside a space, conveying information about how objects relate to each other (in terms of quantifiable equations) with geometric information (such as orientation, distance, curvature, area, volume, or connectivity).

Third, we then engage in applied analysis that takes the proposed logical relations and compares them to observed data, by comparing the analytical properties of the predictions to the analogous properties of the observations. For example, interval properties (i.e. increasing or decreasing, or concavity, maxima or minima) or functional parameters (i.e. linear, polynomial, or exponential coefficients) are assessed, and a likelihood of the success of a prediction is estimated (i.e. computing the square of the OLS Pearson product-moment coefficient along with the α-level of significance, or applying Mill's methods of experimental inquiry).

Fourth, through visual representation, observed data can also be spatially illustrated (in addition to predicted observations), and the topological features displayed using collected data can be used to reevaluate the theoretical predictions. Figure 12.2 shows key elements of scientific research design augmented by topographical representation. Figure 12.2 makes the functionalities of topographical representation explicit rather than implicit, and places the deployment of visual capabilities within the process of scientific inquiry itself.

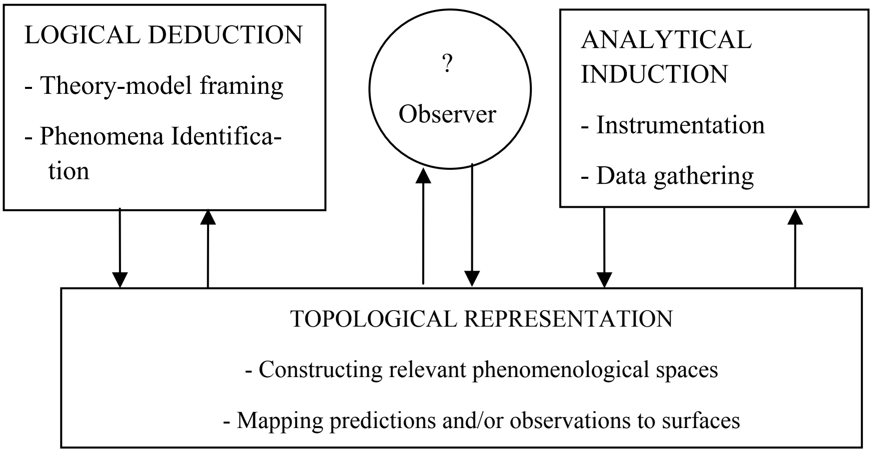

***Figure 12.2* Enhanced methodological design for general scientific inquiry.**

12.2 Visualization in Geopolitics: Case Studies

Of the many issue areas in international relations and world politics, few are as pervasive and compelling as issues pertaining to environment and development. Many scholars and policy makers argue that a balance is required between environmental conservation, economic development, and institutional performance and adaptability in order achieve "sustainable development."[6] In this context, we present a set of case investigations of data visualization in world politics, drawing on the theory of Lateral Pressure, and we illustrate how various topographical views provide different inferences and insights about the global system as a whole as well as its constituent parts.[7]

[6] Many definitions of sustainable development exist. The operating definition for this chapter comes from the 1987 Brundtland Report, where sustainable development is defined as "economic, technological, and political development which allows the needs of the present generation to be met without compromising the ability of future generations to meet their needs."

[7] For a recent review of the literature pertaining to Lateral Pressure Theory see Wickboldt and Choucri (2006).

12.2.1 The Theory of Lateral Pressure

Developed by Nazli Choucri and the late Robert C. North, *Lateral Pressure Theory* refers to the dynamics of growth and development of states in an international environment and posits that external behaviors – including environmental impacts – are shaped by the interaction among fundamental master variables. The master variables are defined as: (1) Population (P), the amount of people residing in, demanding from, and producing for a country. (2) Resources (R), the amount and accessibility of natural resources regardless. (3) Technology (T), or the level of economic productivity as a result of technological and organizational knowledge and skills. Different combinations of the P–R–T attributes generate different types of state profiles. Some of these are technology intensive, other population intensive, and still others are resource intensive. These differences generate commensurate differences in patterns of external behavior of environmental degradation.

Given that the three master variables are seen as the foundation for a country's capacity and intent to pursue particular social, economic, and political goals, it is interesting to explore whether these three measures, as independent variables (IV), can explain and predict the overall environmental impact of a country, which is the dependent variable (DV). Below we explain how P, R, T, and "environmental impact" are measured.

Lateral Pressure Theory argues that the dynamics of interaction are influenced by the capabilities of states, and these capabilities in turn can be "measured" or indicated on a first order approximation by the relative "positions" of population, resources, and technology (each variable's position being "measured" as a share or percent of the global total of the level of population, resources, and technology, respectively, that each country owns). As a consequence, the capabilities of states, a function of a country's relative position of population, resources, and technology, can explain and predict among other things the dynamics of conflict, migration, trade, and possibly environmental impact. Previous work in Lateral Pressure Theory operationalizes the "population position" of a state as its "percent of global population," the "resource position" as its "percent of global land area," and the "technology position" as a "percent of global GDP." We want to then visually explore how this theory organizes the IVs through profiles to explain environmental performance as measured through carbon dioxide emissions, a proxy for environmental impact, which is our DV.

By utilizing the GIS software to visually convey the basic message embodied in the data, we show in this chapter how the visual exploration of a large dataset with complex inter-relationships between variables, across a geographic space, and over time can expedite the process of hypothesis generation and testing. In particular, we will be visually illustrating the geographic distribution, temporal evolution, and cross-sectional inter-relationships of relevant variables, the categorical proxy of country profiles, and related variables of growth and development across all countries over a time frame of *several decades until the present.*

12.2.2 Highlights of Lateral Pressure Theory

According to Lateral Pressure Theory, interactions in the global political system are driven by these three different activities and conditions: “(a) the domestic growth and the external expansion of activities and interests [growth]; (b) competition for resources, markets, superiority in arms, and strategic advantage [competition]; and (c) the dynamics of crisis [conflict]” (Choucri et al., 1992). Moreover, Lateral Pressure originates from the interactions of key master variables that largely determine the properties and dynamics of nation-states: population, resources, and technology (Choucri et al., 1992). A brief characterization of key elements central to the case investigations of this chapter can be framed as follows:

Firstly, to the extent that a country has a greater *population*, more needs, wants, and demands are exerted upon the social and natural system (i.e. national institutions and natural resources). Secondly, to the extent that a country has a great level of *technology* in terms of applied knowledge and skills, a wider and greater amount of resources are required. Thirdly, to the extent that a country has access to *resources* via domestic extraction, the more or less constrained a country is in meeting its internal demands. Finally, given the relative levels of *population*, *technology*, and *resources*, countries can be roughly characterized into distinct categories or *country profiles*: for example, if country X has less of a global population share than a global technology share, and less of a global technology share than a global resources share, then country X belongs to profile A (Choucri et al., 1992).

A recent application and extension of Lateral Pressure Theory is presented in Lofdahl in *Environmental Impacts of Globalization and Trade: A Systems Study* (2000). Lofdahl adopted the theoretical and methodological framework of Lateral Pressure Theory to design a study concerning the effects of global economic activity upon the environment. He applies GIS, statistical analysis of geopolitical diffusion, and system dynamics simulations to conclude that North–South trade amounts to increased economic activity in the North in exchange to natural resource depletion in the south (Lofdahl, 2002). Lofdahl, however, does not characterize the three master variables in the same sense Choucri and North do; in particular, he acknowledges Choucri and North’s concern that the three master variables can be further disaggregated into many intervening variables with confounding causal mechanisms and feedbacks.

At the same time, Lofdahl recognizes that there are specific aspects of the macrovariables (technology, resources, and population), which are themselves a refinement of Waltz's original variable-concept of power in international relations (Waltz, 1959), and a political analogy to land, labor, and capital – that are more important to examine than the mastervariables themselves (Lofdahl, 2002).[8] Therefore, Lofdahl adopts from Choucri carbon dioxide emissions as the key measure of environmental degradation (Lofdahl, 2002).[9] Thus, recognizing a strong empirical link between energy consumption and GNP, but at the same time pointing out a strong empirical link between net carbon dioxide inputs and deforestation, Lofdahl keeps GNP as his technology variable, but chooses forest stocks as his resource variable (Lofdahl, 2002). Accordingly, Lofdahl's re-characterization of the master variables also changes the concept of country profiles, appropriate to his study of environmental degradation. Against this background, we now turn to the exploration of global visualization, as motivated by the challenges posed by the theory of Lateral Pressure.

12.2.3 Visual Exploration – The Base Line

To commence our visual exploration, we start of with a view of the world absent of any political boundaries or superimposed data. The map in Figure 12.3 provides a frame of reference about the physical world we inhabit – up until now simply a celestial body in the solar system, whose foregoing map representation delineates land masses in gray and water masses in no color.

Aside from the fact that we can see land masses and we can infer water bodies, we can place no other judgments on the map above, save for the fact that some of us have taken geography and world history courses. In such a case, our mind immediately populates the map above with simple facts such as, "the map is centered about the Greenwich Meridian Line, which crosses through the continents of Europe, Africa, and Antarctica," or "the continents to the west are North and South America, and the remaining continents are Asia and Australia." We might also be tempted to identify additional regions, such as the Middle East, the Indian Subcontinent, the Mediterranean Sea (and adjacent coastal lands), the Far East, the Pacific Ocean, and others.

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[8] Choucri commented to the author that in refining Waltz's power variable to several key variables, the concepts of land, labor, and capital were theoretically and empirically recast in the international political setting as resources, population, and technology. Accordingly, the concept of country profiles was derived from these; in particular, technology was mostly left out from production function of the neo-classical growth model as an exogenous factor, later modeled as the cause of the Solow residual.

[9] Consider the central policy role of carbon dioxide emissions abatement in global warming debates as seen in the several UN global warming summits and COPs (Rio Summit, Kyoto Protocol, Hague Convention, etc.).

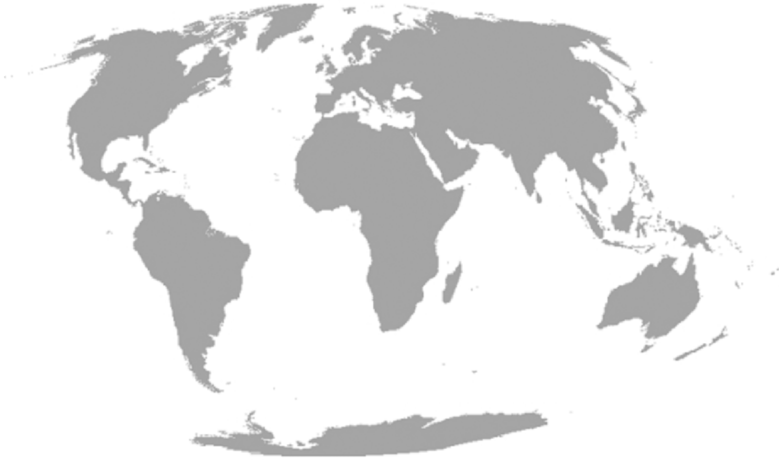

Figure 12.3 **A familiar map of the world.**

The dataset chosen to test the GIS implementation portion of this chapter is obtained from the Environmental Information Administration's *International Annual* (Grillot et al., 2002). From this dataset, we obtain the following measures for our variables of interest: (a) population: number of inhabitants (in millions); (b) resources: total primary energy production (quadrillion BTU); (c) technology: gross domestic product at market exchange rates (in billions of 1995 US Dollars); and (d) environmental impact: carbon dioxide emissions from the consumption and flaring of fossil fuels (in million metric tons of carbon dioxide). The dataset on world energy and global warming trends will serve as the case-study from which sample graphics will be produced and qualitatively assessed in anticipation of – not in lieu of – conventional small or large-N analysis that can be subsequently produced from the data.

12.2.4 Use of Shade and Two-Dimensional Maps

A simple geographic illustration of carbon dioxide emissions among countries in the year 2002 can prove quite useful. Aside from missing observations, we observe in Figure 12.4 the univariate geographic distribution of carbon dioxide emissions in equivalent carbon dioxide tons per country.[10] Two-dimensional color maps have been the standard of geographically-referenced data presentation for some time.

This map is shown firstly to convey a simple picture of carbon dioxide emissions for the year 2002. Top contending countries for highest carbon

[10] Several countries, including Argentina, Zaire, and Tanzania, had missing data.

dioxide emissions include the United States, followed by the former Soviet Union and China. Other than the facts that the United States is emitting somewhere between 4,600 and 5,750 million metric tons of carbon dioxide and the former Soviet Union and China are each emitting somewhere between 2,300 and 3,450 million metric tons of carbon dioxide, we also know that the rest of the countries are emitting somewhere between 0 and 1,150 million metric tons. However scarce in quantitative detail the map is, we already see carbon dioxide emissions in the year 2002 nontrivially distributed across the globe –heavily concentrated on the "big" three countries of the United States, China, and the former Soviet Union.[11]

Figure 12.4 **Equal interval five-shade stratum of carbon dioxide emissions per country for the year 2002.**

In Figure 12.5 we see the same data reclassified into 10 quantiles so that each shade corresponds to a 10% chunk of observations, with each shade being preceded by the previous tenth of observations and/or succeeded by the next tenth of observations.

The foregoing exercise on two-dimensional shading map creations served us a dual purpose. On one hand, we evaluated the specific strengths and weaknesses of different classification schemes of quantitative data into categories to be illustrated through shades in a map. As two-dimensional shade-maps are a mainstream option for illustrating geographically referenced data, it is of use to us to explore how different aspects of our univariate distribution of interest can be discovered or omitted by choosing different ways of

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[11] Although the former Soviet Union undoubtedly is not a country in the year 2002, we include this former country as a relevant territory in our analysis given that we will be also inspecting a range of years starting at 1980.

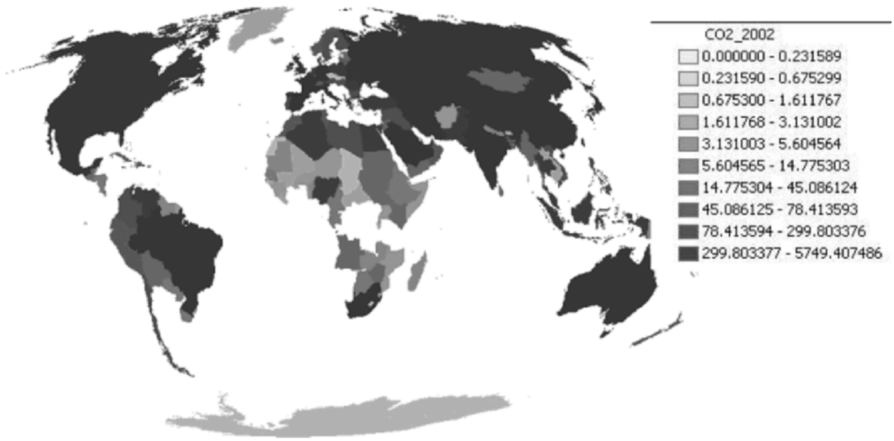


Figure 12.5 **Ten-shading quantile classification scheme for carbon dioxide emissions in millions of metric tons of carbon dioxide for the year 2002.**

categorizing the data. On the other hand, regardless of the potential gains of understanding derived from univariate displays by degrees of shading, we have concluded that using shaded (colored) maps to represent quantitative data is generally not the best way to go, in the sense that we wish to display the magnitude and direction of our quantitative data by recoding it into partially selective or meaningless categories (as illustrated through shade).

12.2.5 Three-Dimensional Map of Carbon Dioxide Emissions

In Figure 12.6, we see carbon dioxide emissions displayed in a three-dimensional map using height, by vertical extrusion of a country's territorial area upward into a volumetric figure. Similar to a bar chart, a country's height is now indicating the magnitude of an individual country's observation in the sense that the height of each country represents the magnitude of carbon dioxide emissions for the same country. Using height to represent carbon dioxide emissions, a scalar quantity (or specifically, *not* a categorical quantity), is a marked improvement over the use of color in the previous maps discussed here (and in general).

Notice that the particular way we chose to display carbon dioxide emissions – volumetric extrusion – extends the base area of a country to a height specified by the data producing a volume. This volume's height is accurately representing our scalar datum, yet the cross-section of this volume bears no information about the data. However, admitting the possibility for a person to misinterpret the volume of the extruded country as the visual proxy for a single data point, it then follows that the cross-section of the extrusion – namely the territorial area of the country – will distort a person's estimate of the magnitude of a scalar datum.

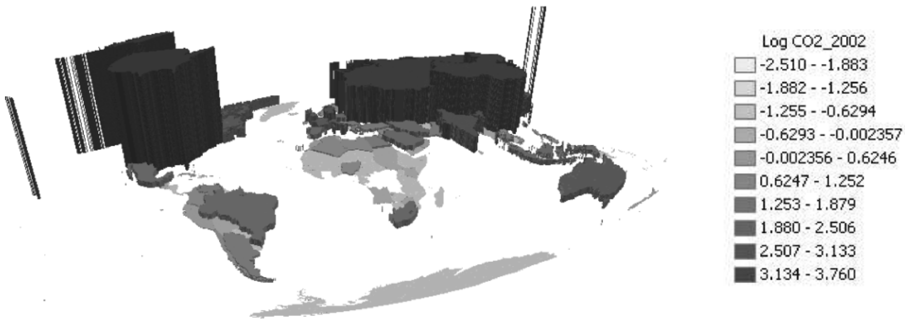


Figure 12.6 **Three-dimensional height (carbon dioxide emissions) and shaded (logarithmic carbon dioxide emissions) map for a univariate distribution of carbon dioxide emissions, 2003.**

For example in our last map, the former Soviet Union is lower in height but larger in area than China, so in our case, we may be lead to believe that the area of the former Soviet Union is giving us additional information about carbon dioxide emissions, when in fact it is not. If we were to believe that the resulting extruded volume represents carbon dioxide emissions (by thinking, for instance, that height represents carbon dioxide density, which also equals emissions per unit of area), then we may wrongly conclude that the Soviet Union, although lower in carbon density, emits on the whole more carbon dioxide than China.

What we should learn from this example is not necessarily to avoid confusing the volume for height when evaluating carbon dioxide emissions. Rather the message is that visual representation of data must done accurately and unambiguously in order to present the information of interest.

Focusing on the height of extruded country-shapes to evaluate the cross-national distribution of carbon dioxide emissions for the year 2002, we now turn to the substantive story behind the said distribution. We immediately notice from the shade maps and the height map that a great deal of countries show vanishingly small amounts of carbon dioxide emissions. Moreover, these countries are not randomly scattered around the globe, but rather clustered around different regions of the globe according to similar orders of magnitude. For instance, Africa shows the lowest set of values among all countries across the globe, followed by South America, Europe and Australia, Asia, and finally North America (particularly the United States).

Countries that stand out over and above the rest of observations include the United States, Japan, the former Soviet Union, China, India, Brazil, Australia, Germany, Saudi Arabia, Canada, Mexico, Iran, and others. Explanations immediately come to mind from our prior knowledge of social, economic, and geographic contexts of these countries – but we will delay any such discussion and examine more closely emissions over time.

Let us now look at carbon dioxide emissions from 1980 and 2000 to confirm whether or not this unequal distribution of carbon dioxide emissions across the globe for the year 2002 is a mere aberration occurring in that particular year.

12.3 Investigations of Three-Dimensional Map Displays

Extending our studies of topographical representation, we now turn to multi-dimensional map displays, with specific reference to the master variables in the theory of Lateral Pressure. The theory is anchored in the assumption that three sets of critical drivers best represent the characteristic features of states, namely population, resources, and technology. Accordingly we present a set of three-dimensional maps showing carbon dioxide emissions, the dependent variable, and the master variables – P, R, and T – as the independent variables, for each country worldwide at two points in time.[12] In each case we show the global patterns at two points in time, in 1980 and in 2000.

Figure 12.7 shows carbon dioxide emissions in 1980 and 2000. This variable is used here to represent environmental degradation in broad terms. Whereas height represents raw carbon dioxide emissions (in millions of metric tons), the eight shades are an equal-interval partition of logarithmic carbon dioxide emission values.

A visual inspection of the carbon dioxide emissions observations in 1980 and 2000 shows a remarkably stable geo-spatial distribution prevailing over time. The African continent, Europe, and South America showed trivial changes. Whereas the United States only experienced modest fractional increases in emissions, China showed a remarkably large increase in emissions, as well as more modest yet still noticeable increase in emissions from India. The former Soviet Union on the other hand faced a steady and noticeable decreasing trend in emissions throughout the two decades, eventually surpassed by China shortly after its dissolution.

Nevertheless, carbon dioxide emissions over the past two decades remained in a course of steady and slightly changing trends. More importantly, carbon dioxide emissions where heavily concentrated about a handful of countries and regions. We may conjecture then from Lateral Pressure theoretic considerations that this select sample of countries share any number of these traits: (a) they are relatively highly populated; (b) they are relatively resource abundant; and (c) they have relatively high economic outputs. By

[12] This is a summary representation of the results, since the entire record is developed on an annual basis in order to explore the potential contributions of topographical visualization to time-series analysis and inter-temporal dynamics.

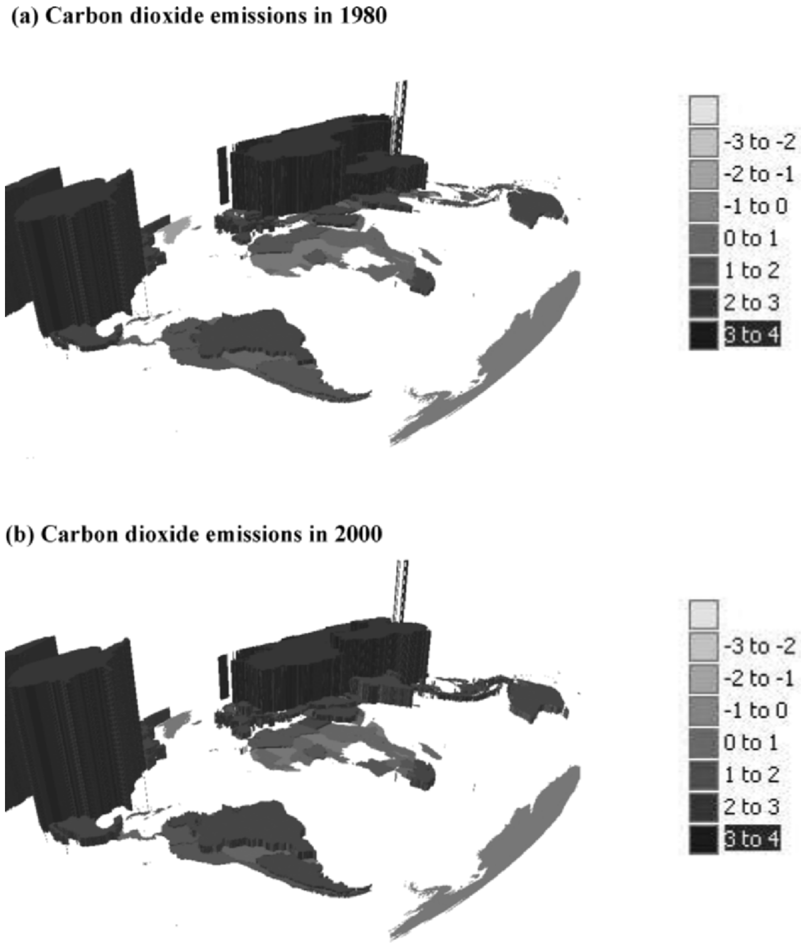


Figure 12.7 **Three-dimensional height and color maps for univariate distribution of carbon dioxide emissions, years (a) 1980 and (b) 2000.**

"relative" abundance or high levels it is meant that the share of population, resources, or technology (economic output) a given country owns from the global total is significantly larger than the majority of the other countries.

Instead of conjecturing from thin air what the population, resources, or technological levels of countries were during the same period, let us now turn to a visual inspection. Figure 12.8 shows the patterns of population in 1980 and in 2000.

It may come as no surprise that we see similar stable time evolution of our population, resources, and technology variables. Moreover, as we predicted from our Lateral Pressure hypothesis, the big countries controlled a significantly large portion of the world's population, resources, and technology.

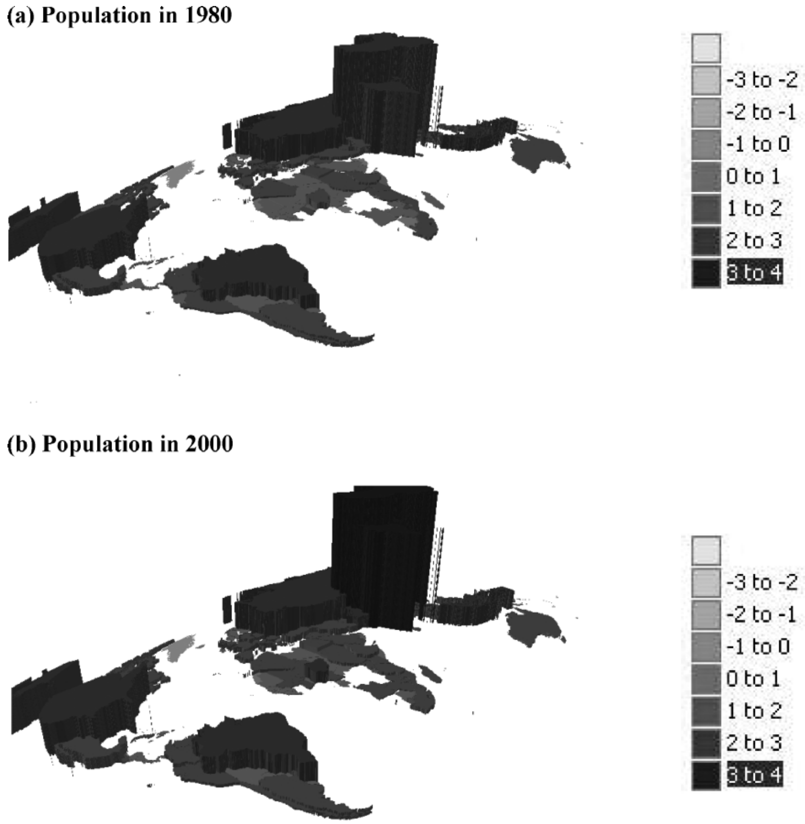


Figure 12.8 **Three-dimensional height and shaded map for univariate distribution of population across the world, years (a) 1980 and (b) 2000. Whereas height represents raw population values (in millions), eight-color spectrum is an equal-interval partition of logarithmic population values.**

Recall that United States carbon dioxide emissions slightly yet steadily increased from 1980 to 2000, whereas the former Soviet Union showed steadily yet significantly decreasing emission trends and China showed an explosion of emissions. India also showed some considerable increase in emissions given its initially low emission levels in 1980, and Japan showed high but relatively constant emission levels.

In Figure 12.9 we show the patterns of energy resource production worldwide. This set of visual representations is also put forth for 1980 and 2000.

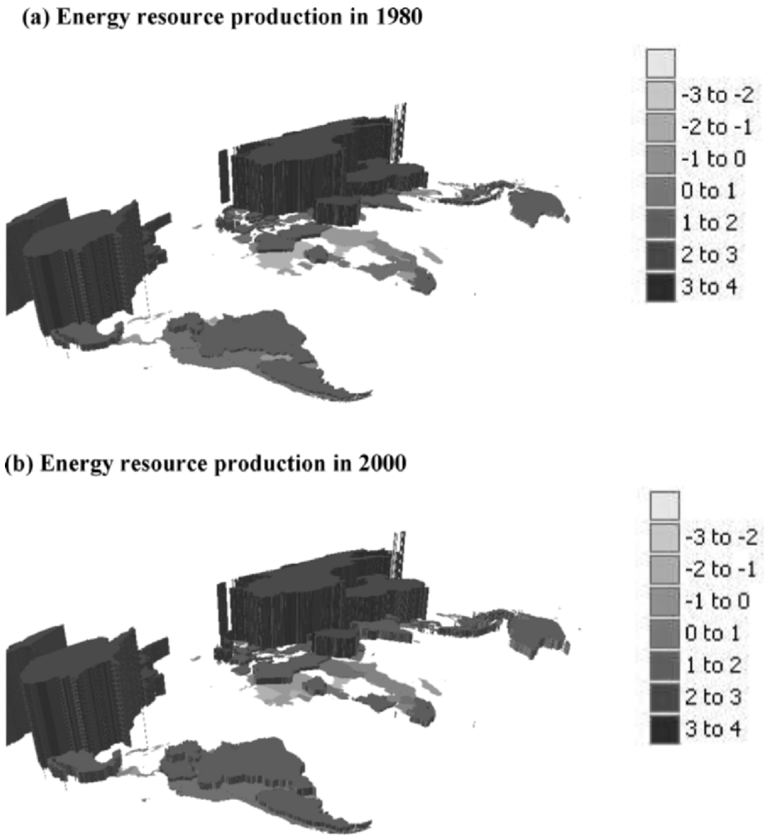
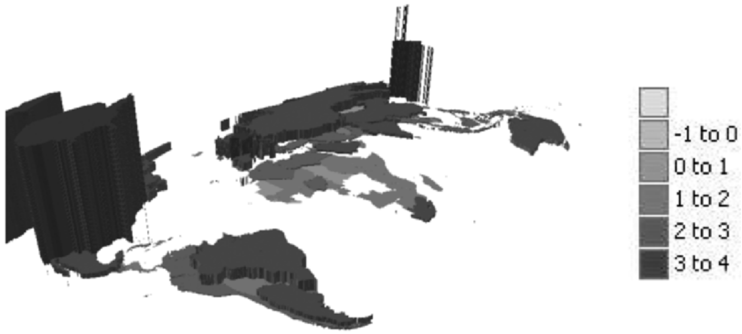


Figure 12.9 **Three-dimensional height and shaded map for univariate distribution of total primary energy resource production, years (a) 1980 and (b) 2000. Whereas height represents raw energy production (in Quads), eight-color spectrum is an equal-interval partition of logarithmic energy resource production values.**

Taking now these observations and comparing emission levels to other possible explanatory factors, we can immediately call to attention at least three sets of possible relationships. First, in the United States, China, India, and Japan domestic economic production, or technological output, grew substantially in this period, while the former Soviet Union's technological output decreased significantly, into its dissolution around 1992 and afterwards, as we can see in Figure 12.10. Second, in China and India the population increased throughout these decades; in Japan and United States population growth was much more modest. Third, resource production was mostly constant throughout the world, as it is most likely due to increasing discoveries in coal and natural gas reserves in this same period.

(a) GDP in 1980



(b) GDP in 2000

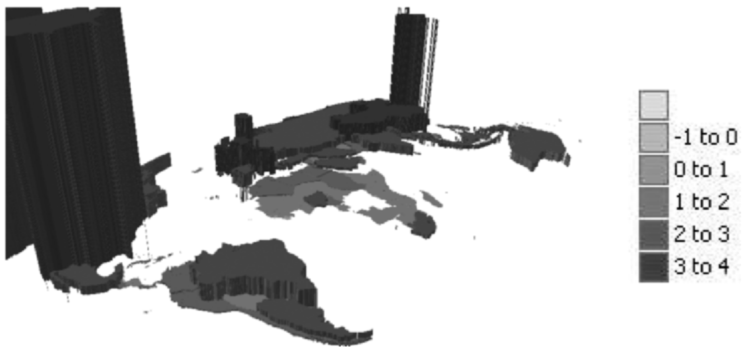


Figure 12.10 **Three-dimensional height and shaded map for univariate distribution of gross domestic production (technology as productivity), years 1980 and 2000. Whereas height represents raw dollar figures (in billions of constant US dollars), six-color spectrum is an equal-interval partition of logarithmic GDP values.**

12.3.1 Visual Display of Multivariate Relationships

Among the ways in which way we can visually inspect for multivariate relationships in the geographically referenced data is by producing a hybrid map/bar chart as shown in the previous figures. We can verily confirm that for our outliers of interest we have our Lateral Pressure explanatory variables systemically dominating carbon dioxide emissions. In some cases, like China and India, population intensity seems to heavily dominate its emission levels, whereas in other cases – like Japan and the United States – technological output heavily dominates carbon dioxide levels. Moreover, energy resource production levels for the various countries seem to be in the vicinity of corresponding carbon dioxide emission levels. Figure 12.11 extends the analysis in a pair wise comparison.[13] GHG stands for carbon dioxide emissions; POP stands for population; RSR stands for fossil fuel reserves; and TCH stands for technology (as measured by GDP).

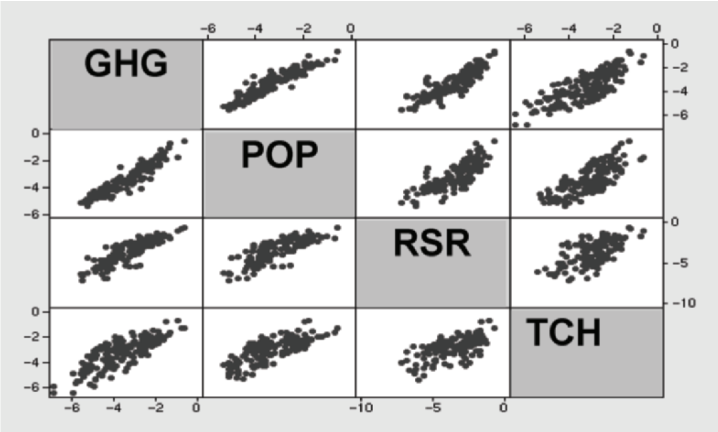


Figure 12.11 **A matrix of a bivariate logarithmic plot comparing population, resources, and technology to carbon dioxide emissions.**

These comparisons allow us to explore the strong correlations between explanatory Lateral Pressure variables and carbon dioxide emissions. We see in this matrix of bivariate plots that our chosen Lateral Pressure variables of population, resources, and technology strongly and positively correlate (particularly after a logarithmic transformation) with green house gas emissions across many orders of magnitude. The fact that the monotonous (almost linear) associations hold across many orders of magnitude implies that our previously ignored set of vanishingly small scalar observations, which consist a large part of our sample space, also support strong pair wise correlations between our explanatory variables and emission levels.

However, depending on which Lateral Pressure master variable dominates in size, we see a different explanatory variable dominating carbon dioxide emission levels for a given country – in other words, if a country is significantly more population intensive than resource or technology intensive (intensity measured as "percent a country shares of variable X from the global total), then population is going to primarily drive carbon dioxide emissions for that country.

[13] The matrix of bivariate plot would also allow us to inspect the rest of the observations across the globes whose values were vanishingly small in comparison to our few outlier observations, and hence left out of our text discussion.

12.3.2 Visualization of Carbon Dioxide Emissions across State Profiles

These conclusions from our visual exploration exercise thus set the stage for introducing the concept of Lateral Pressure profiles. The Lateral Pressure stipulation of the combinations among the master variables acknowledge relative differences in population, resource, and technology levels in determining Lateral Pressure impacts writ broad. We suspect that the relative ordering of intensities among three master variables resources, and bears a noticeable impact on a country's carbon dioxide emissions. Figure 12.12 shows the patterns at two points in time. These trajectories suggest a pattern in carbon dioxide emissions across profile groups.

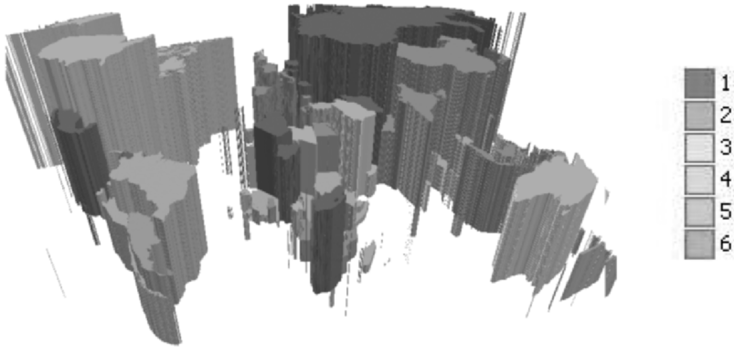
We can tell that generally, the more technologically intensive a profile of some country is, the higher we can expect their carbon dioxide emissions to be. Moreover, among low technologically intensive countries (that is, where the countries are more population and resources intensive than technology intensive), being relatively more populous than resource abundant leads to greater emissions on average (except for the year 1995). For countries in profiles of medium to higher relative technologic intensity, being more populous than being resource abundant leads to lower carbon dioxide emissions on average.

We can account for these observations in several possible ways. Up until the early 1990s, we can suspect that countries with low technological levels largely consist of labor-intensive economies with a strong dependency on agriculture and polluting manufacture sector and with correspondingly smaller developments in the service sector. Hence larger populations are going to increase the level of carbon dioxide emissions resulting from employment in agriculture and in "dirty" industries.

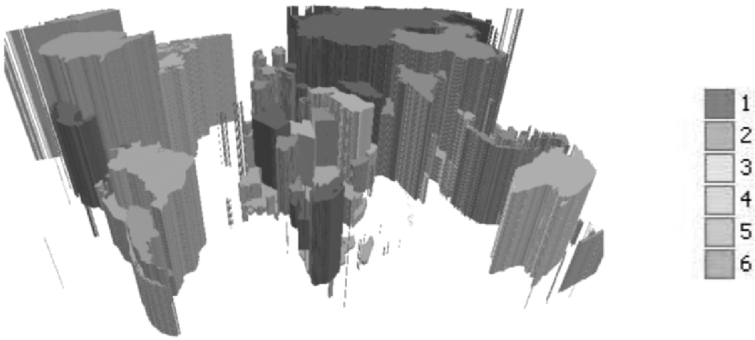
With the development of service economies into the later years of the 1990's, coupled with more mature industry sectors, national economies are now more reliant on energy production and less on labor for the production of goods and services. Hence in later years, more resource intensive countries – that is, countries with higher energy production from conventional fuel stocks (i.e. fossil fuels) relative to their population intensity (R > P) will end up releasing more carbon dioxide emissions into the atmosphere (by as much as half to an order of magnitude on average).

Setting aside impacts on carbon dioxide emissions from relative differences in population and resources, we expect that countries with higher technological output (measured as GDP) relative to either or both population and/or resource levels will show substantial increase in carbon dioxide emissions. Technological output, qualitatively defined in Lateral Pressure Theory applications of knowledge and skills, managerial and organization – and

(a) Carbon dioxide emissions in 1980



(b) Carbon dioxide emissions in 1995



(c) Carbon dioxide emissions by profile group

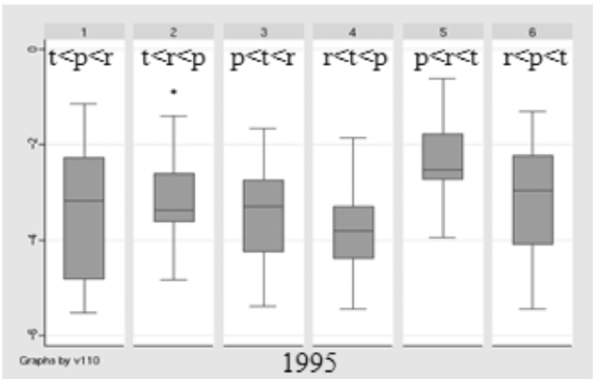


Figure 12.12 **Categorical comparison of carbon dioxide emissions (log) against Lateral Pressure profiles, (a) 1980, (b) 1995, and (c) a single box-whisker graph from 1995. Values in the 25–75% percentile range are inside the box, with the horizontal line inside the box representing the median observation. The "whiskers" or tails show the 10–90% range of observations, whereas dots plotted beyond the whiskers are considered outliers.**

hence indicated by level of production – will have a strong effect on carbon dioxide emissions as economies are increasingly more reliant on fossil-fuel derived energy sources for economic growth. Hence those countries that are more technologically intensive than they are population and resource intensive show a disproportionate increase in emission levels on average. Countries that are dominantly population intensive or resource intensive on average will not show nearly as much emissions as countries with dominant technology intensity.

We can thus conclude, in advance of any hypothesis testing and confirming what we have learned from our foregoing visualization exercise, that the explanatory variables afforded from the Lateral Pressure perspective largely dominates global carbon dioxide emission trends, both through the influence of relative intensities captured by the categorical profiles, as well as through the separate contributions of each explanatory variable upon our dependent emissions variable. These conclusions, inspired by the visual exploration exercise narrated above, can also be analytically confirmed through statistical hypothesis testing. More importantly, however, is the fact that our visual inspection of emissions and the three master Lateral Pressure variables revealed that geography implicitly but substantially influences global green house gas emission patterns.

The master or explanatory variables afforded from Lateral Pressure Theory, which heavily influence carbon dioxide emissions, face serious constraints within the underlying geographic space. Certainly energy resources, people, and goods and services flow across borders in an increasingly more interconnected global system. Nonetheless, factors of growth within territorial borders are largely endogenous and determined by internal social, economic, and institutional factors.

Population growth is still largely due to internal birth and death rates (with migration facing greater barriers face to face with heightened security concerns and increasing military sophistication). Moreover, resource production is largely predetermined by the abundance of fuel types within territorial borders. Finally domestic economic production (technological output) is largely determined by domestic factors of production such as a skilled labor force and physical capital.

Coupled with the fact that our Lateral Pressure explanatory variables change at most a few percentage points year after year, carbon dioxide emissions as a result will show a gradual time-evolution with relatively stable heterogeneous geo-spatial distributions (as we saw from the carbon dioxide emission maps). Hence, in the discourse of global warming policy investigation, a country's location in the world will significantly factor into the domestic Lateral Pressure factors that will dominate green house gas emissions yesterday, today, and well into the future.

12.4 Conclusion and Next Steps

In this chapter, we have introduced the concept of topographical representation and explored visually the data relevant to the case study in geopolitics. Specifically, ArcGIS – a GIS program – is employed to illustrate the results obtainable from a server-client solution, capable of retrieving data from a geopolitical database, obtaining user display options, and accordingly produce maps visually rendering the geopolitical data subset. Several visualization techniques, or modes in which to display the same kind of data, are treated and critically assessed for utility and relevance given the type of data at hand. We find that non-stochastic distributions in our main explanatory variables – population, technology, and resources shares – exist across the globe. Since the explanatory variables do not change in a volatile fashion for each country year after year, and given that green house gas emissions strongly depend on these variables, we find that basically most countries experience a consistent albeit gradually evolving pattern in green house gas emissions over time – as illustrated by similar cross-sections of emissions across the globe at each point in time.[14]

By way of conclusion, we first point to several venues for capturing the added value due to visualization technologies and applications. Then we propose, tentatively to be sure, key features of an approach for the design and development of a server-client application for GIS.

12.4.1 Value Added Due to Visualization

Here we consider the potential gains due to visualization, addressing in sequence some key conceptual, empirical, and inference issues. Then we put forth an integrated view of the added value as the pieces are pulled together. The integration, however, is contingent on the contents of each of the three sets of issues therein.

12.4.1.1 Conceptual Value

A rough guideline for implementing information visualization in general science research can be sketched from our foregoing theoretical discussion. It is hard to commence any scientific work without some initial conception and perception of a problem. Assuming we have identified a problem and a

[14] A major dilemma arises, of course, when countries break-up (such as the former Soviet Union) and the challenge is to then generate the commensurate visualization representations for the new states defined by new territorial boundaries. Exploring this contingency remains outside the scope of our investigations in this chapter.

set of related experiences, what follows is a description of an iterative procedure of visualization, deduction, and induction.[15]

From our set of observations and problem identification, we first construct a set of observables, more commonly known as data, which we can translate into a perceptual (visual) medium. How exactly can we conceive of a "visual translation" for a set of observables? It usually starts with how we first perceived our set of observations from prior experience. If we are analyzing political behavior, what we initially perceive is literally people voicing the concerns in the media followed by political commentary in the news. However, to proceed into theoretical deduction and empirical induction in order to organize our experience into systems of thought, we probably want to simplify how we perceive our set of observables. For instance, analyzing millions of hours of raw video footage of people expressing their political opinions is probably a very time-consuming task that will lead to not as comparable progress in scientific research – but raw video footage is certainly a start for visualizing a set of observables.

Then we proceed to theoretical deduction where we may review previous related theories or come up with new theories. To proceed to this step, we visually explore the data in the previous step to determine what emerging relationships exist among our observations. Given that we at least start with a problem identification (and a possible prior theory), and some natural abilities at describing observations, we identify from our visual exploration qualities about our observations that hint towards some sort of relationship.

Returning now to deduction, we motivate the generation of new theories or modification of old ones related to our identified problem through the visually or perceptually identified relationships, and even generate testable hypotheses or predicted observations which can be visually imagined in order to compare to present observations.

12.4.1.2 Empirical Value

Following this logic, testable hypotheses can then be empirically verified against observations. That is to say, whatever relationships a hypothesis claims about the way observations are behaving in the real world can be compared to actual observations through qualitative or quantitative analysis. Ideally, the analysis will determine the likelihood or probability that a prediction matches what is really going on among the set of observables. This likelihood or probability is the generalization of how true or false our hypothesis or prediction is when applied to our actual observations.

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[15] In this discussion, we do not seek to derive an explanation of what consists of problem identification or a set of related experiences – these are deep questions concerning the philosophy of mind and science that shall not be explored here.

Assuming that the test for a hypothesis is constructed properly by the researcher, statistical analysis can readily provide results on such likelihoods. In our example on video footage where we interview people about their political opinions, it might be very hard to construct a robust statistical test that confirms the existence of social networks between people who have similar political beliefs; it might be easier to conclude though the likelihood of a correlation existing between left-right ideological stance and income (among other possible variables).

Results from our hypothesis testing return us to the other two stages: hypothesis exploration (visualization) and generation (theoretical deduction). Having an idea of the likelihood of our recently tested hypothesis allows us to reevaluate our supporting theories by updating the truth values of logical claims and implications as they propagate through our network of knowledge.

For instance, our theory formerly depended heavily upon the assertion that people who had plenty of political opinion have strong religious beliefs and that the presence or lack thereof of religious beliefs is strongly connected to financial prosperity. A hypothesis test confirming the likelihood of any of these statements is going to update our knowledge about political behavior and hence modify the falsehood or fallacy of several predictions belonging to our theoretical framework of political behavior.

12.4.1.3 Inference Value

Accordingly with our new found knowledge, we return to the drawing board on how to perceive and interpret our observations. In particular, we may decide that certain qualities about our observations are not as important, and therefore we must seek new explanations driving the phenomena we are studying. Hence we redefine the scope of our visualization to include or exclude certain aspects of our experience as represented by a set of observables and seek new patterns and relationships based on our newer rendition of the observations available to us. Through continued exploration we may eventually identify new possibilities on how our observations seem to organize and return to our theoretical stage to frame our exploration of observations into formal hypotheses, and so on.

By way of delineating a manner for scientific inquiry involving methods of visualization, we propose a six-step process.

1. Identify prior notions of problem along with related explanations (theories) and experiences (observations) to determine what aspects of our set of observations we are interested in visually representing.
2. Relationships are identified from visual exploration of observations for subsequent theoretical framing.

3. Hypotheses are generated from theoretical framework for empirical verification of likelihood.
4. Simulated predictions from generated hypotheses are produced for qualitative visual rendition.
5. Simulated predictions are qualitatively compared to actual observations in preparation for likelihood test.
6. The likelihoods that simulated predictions from our hypotheses match actual observations are assessed, updating both our prior understanding of the problem (theories) and how we judge prior experience (observations).

Figure 12.13 illustrates this process of scientific inquiry, which cycles through information visualization (hypothesis exploration), theoretical deduction (hypothesis generation), and empirical analysis (hypothesis testing). The corresponding numbers show the six-step process next to the arrows where each step takes place.

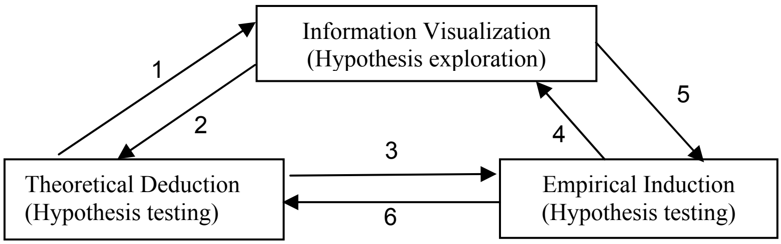

Figure 12.13 **Diagram illustrating the process of scientific inquiry from visualization to deduction to induction – and back again through the same process.**

12.4.2 Design for Client-Server Visualization System

Future work extending upon the proof of concept for visualization specifically in the area of geopolitical research suggests a design and development of a server-client application for GIS, which will automate the visual inspection of predictions and observations as pursued in this chapter. Accordingly, we now propose the feasibility of such an endeavor by providing a conceptual design of a graphical user interface that mimics the various visualization techniques on the user-end machine explored in this chapter.

At the core of a Geographic Information System's functionality is the ability to visually represent geographically-referenced information as maps. In addition, GIS implies the involvement of computers, developers, users, and methods to simulate, explore, analyze, and act upon the information which is being visually produced in maps. In the domain of geopolitics in International Relation, relevant research data resides in a geographic space – in the sense that individual observations correspond to geographic locations or features. To this end, the challenge is to better explore visually the geo-spatial dependencies of observations about attributes or behaviors of entities interacting in the global system (i.e. "how are trade or migration patterns related to geographic distance between cities or length of contiguous borders?").

12.4.2.1 Elements of a GIS Client-Server System

In the server-client GIS solution, the Graphic User Interface (GUI) client allows: (a) navigation of visual renditions on user display to spatially locate features and data records; (b) manipulation of visual rendition of data for research purposes and qualitative treatment; and (c) analysis of data by exporting data, generating additional graphic displays, or performing real-time quantitative computation. Moreover, GUI client interacts with GIS server by sending data requests and display options. The GIS server is then responsible for: (a) retrieving data from repository dataset; (b) linking retrieved data to relevant map layer files; and (c) generating map projections according to user-specified display options. Finally, the GIS server sends back visual data output to GUI client for display and further user interaction.

The client, on the other hand, is an user-end application that provides the human-machine interface, i.e. in the form of GUI, in order for the user to remotely request the data off the sever, display the data through several different options in his local screen, and interact with the data on his or her end.

The server-client application concept in itself is not new and this author is certainly not innovating upon this particular feature. The server to be developed for future work is quite simply a machine that will contain both the data to be retrieved, as well as the software tools (i.e. scripts and run-time server environments) to generate visual renditions of the said data. From the perspective of global analysis and/or social science research program, servers fulfill the need of storing datasets or databases of real-world observations or simulated data, coupled with the software necessary for accessing the data, in order to carry out the relevant quantitative analysis required to test hypotheses in political science research.

12.4.2.2 Learning-by-Exploring

The learning curve for typical data GIS application development would otherwise make the prospect of generating customized GIS applications for visually analyzing the data for navigational and analytical interaction unattractive and complicated. A user-friendly GIS application will essentially permit the prospective user to focus on generating a model of the global reality and explanations of how data is structured and interacting, and accordingly confirm expected patterns and behaviors by observing visual representations of the data and empirical results through the interface – instead of becoming experts in data visualization tools and techniques. Thus, the visual data exploration performed in this thesis will serve as a proof of concept or demonstration of how a GIS server-client solution customized for geopolitical studies could facilitate identification of underlying relationships in the data for the researcher-observer, by decreasing the computational complexity of exploring, formulating, and testing alternative hypotheses in geopolitical research.

12.4.2.3 Added Value

The value added is a synergistic result of the several components of such a final application. On the server side, geographically-referenced datasets will be collected for this thesis (although a server not formally developed) and made available for interaction with the client interface. With all the data preparation done beforehand, the user's primary concerns are to retrieve the data, choose display settings depending on personal preferences, and generate a visual rendition of the requested data for data exploration. On the client side, pre-existing GIS applications (such as ArcGIS used in the analysis in this chapter) are available to the user such that he or she does not have to be concerned with the programming code to generate visual renditions of the data.

References

Achen, C. H. and Snidal, D. (1989). Rational deterrence theory and comparative case studies. *World Politics*, 41, 143–169

Almond, G. and Genco, S. (1977). Clouds, clocks, and the study of politics. *World Politics*, 29(4)

Ball, P. (2002). Data visualization: picture this. *Nature*, 418 (6893), 11–13

Campbell, D. and Stanley, J. (1963). *Experimental and quasi-experimental designs for research*. (Boston: Houghton-Mifflin)

Chertow, M. (2001). The IPAT equation and its variants: changing views of technology and environmental impact. *Journal of Industrial Ecology*, 4, 13–29

Choucri, N. (1991). Population and the global environment. (In J. W. Tester, D. O. Wood, and N. A. Ferrari (Eds.) *Energy and the environment in the 21st century*. Cambridge, MA: MIT Press)

Choucri, N. (1993). Introduction: theoretical, empirical, and policy perspectives. (In N. Choucri (Ed.) *Global accord: environmental challenges and international responses*. Cambridge, MA: MIT Press)

Choucri, N. and North, R. C. (1993). Growth, development, and environmental Sustainability: profile and paradox. (In N. Choucri (Ed.) *Global accord: environmental challenges and international responses*. Cambridge, MA: MIT Press)

Choucri, N., North, R. C., and Yamakage, S. (1992). *The challenge of Japan before World War II and after: a study of national growth and expansion*. (London: Routledge)

Dietz, T. and Rosa, E. A. (1994). Rethinking the environmental impacts of population, affluence and technology. *Human Ecology Review*, 1.2, 277–300

Easterly, W. and Sewadeh, M. (2002). *Global development network growth database*. World Bank. Retrieved May 2006 from http://www.worldbank.org/research/growth/GDNdata.htm

El Serafy, S. (1997). Green accounting and economic policy. *Ecological Economics,* 21, 217–229

George, A. and McKeown, T. (1979). Case studies and theory development: the method of structured, focused comparison. (In P.G. Lauren (Ed.) *Diplomacy: new approaches in history, theory, and policy*. New York: Free Press)

Griliches, Z. (1990). Patent statistics as economic indicators: a survey. *Journal of Economic Literature*, 28(4), 1661–2007

Grillot, M. (2002). *International energy annual 2002 environmental information Administration*. Retrieved March 31, 2005, from http://www.eia.doe.gov/iea

Hall, B. H., Jaffe, A. B., and Tratjenberg, M. (2001). The NBER patent citation data file: lessons, insights, and methodological tools. *National Bureau of Economic Research Working Paper*, No. 8498

Hall, M. (2002). Review article: international relations and world history. *European Journal of International Relations*, 8(4), 499–516

Jupille J., Caporaso J. A., and Checkel, J. T. (2003). Integrating institutions – rationalism, constructivism, and the study of the European Union. *Comparative Political Studies*, 36(1–2), 7–40

Koch, A. (1995). *Linking multi-agent systems and GIS – modeling and simulating spatial interactions*. Retrieved March 31, 2005 from http://www.rwth-aachen.de/geo/Ww/deutsch/MultiAgentsKoch.PDF

Lofdahl, C. L. (2002). *Environmental impacts of globalization and trade: a systems study*. (Cambridge, MA: MIT Press)

Mathews, S. A. (2002). Political science and GIS. *GIS Resource Document*, 02-11. Retrieved March 31, 2005, from http://www.pop.psu.edu/gia-core/pdfs/gis_rd_02-31.pdf

Midlarsky, M. (Ed.) (1989). *Handbook of war studies*. (Boston, MA: Unwin Hyman)

Orford, S., Harris, R., and Dorling, D. (1976). Geography: information visualization in the social sciences. *Social Science Computer Review*, 17(3), 289–304

Ragin, C. (1987). *The comparative method: moving beyond qualitative and quantitative strategies*. (Berkeley: University of California Press)

NBER. (2005). A review of findings, methods, and policy implications. *NBER Property and Environmental Research Center*, 02–1

Snyder, J. (Winter, 1984–85). Richness, rigor, and relevance in the study of Soviet foreign policy. *International Security*, 9(3), 89–108

Solow, R. M. (1994). Perspectives on growth theory. *The Journal of Economic Perspectives*, 8(1), 45–54

Starr, H. (2002). The "nature" of contiguous borders: ease of interaction, salience, and the analysis of crisis. *International Interactions*, 28(3), 213–235

Starr, H. (2002). Opportunity, willingness and geographic information systems (GIS): reconceptualizing borders in international relations. *Political Geography*, 21(2), 243–261

Tufte, E. R. (1983). *The visual display of quantitative information*. (Cheshire, NY: Graphics Press)

Van Evera, S. (1997). *Guide to methods for students of political science*. (Ithaca: Cornell University Press)

Waltz, K. N. (1959). *Man, the state and war: A theoretical analysis*. (New York: Columbia University Press)

Waltz, K. N. (1979). *Theory of international politics*. (Reading, MA: Addison-Wesley)

Chapter 13

EXPLORING e-GOVERNANCE

Salience, Trends, and Challenges

Dinsha Mistree

Introduction

Around the world, individuals and institutions are introducing new technologies, increasingly relying upon automated systems and other advances to produce better government. In this chapter, we review recent trends in electronic governance at the time of this writing, and we identify several ramifications for sustainability by examining 'good' governance in general.[1]

First, we define electronic governance, and distinguish electronic governance from electronic government, the latter itself a subset of the broader e-governance domain. Drawing on empirical data, we further proceed to examine the current state of e-governance across the countries of the world.[2] Not surprisingly, we find that rich countries have better e-government platforms in place, but surprisingly we do find that they are improving at roughly synonymous rates. We then engage in a discussion of the Digital Divide and e-governance. The Digital Divide refers to those who are left behind due to inequalities in technology distribution, and such inequity can have profound effects on the ability and efficacy of e-governance. Finally, we close with a few parting thoughts about what we expect in the future of e-governance.

Because e-governance is often portrayed as an immediate solution to the many forms of government inefficiency, it is not surprising that e-governance policies are frequently identified as "silver bullets." At the same time, however, is the very real possibility that e-governance may actually be nothing more than a "lead bullet," or a detrimental force to effective governance. Critics frequently highlight the potential negative uses of technology by government

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[1] This chapter is intended to capture the current state of electronic governance. Undoubtedly, things will change.

[2] Throughout, we are hampered by the fact that all existing data focuses on e-government rather than e-governance, a distinction that we shall make clear in the next section.

N. Choucri et al. (eds.), Mapping Sustainability: Knowledge e-Networking and the Value Chain, 261–275.

instruments, bringing needed skepticism to a domain that is filled with potential, but rife with dangers. Understanding the current conditions and dimensions of the state of e-governance will help us avoid these potential pitfalls and will allow us to fully exploit the advances of technology.

13.1 Defining e-Governance

The phenomenon known as electronic governance, or colloquially referenced as e-governance, has captivated bureaucrats (Bonham, Seifert, and Thorson, 2001), politicians (Pacific Council, 2002), voters and citizens (Backus, 2001), as well as academics. From developing to industrialized countries and from local to national governments, e-governance has been identified as a tool to fight corruption (Governments on the WWW, 2004),[3] to combat poverty (IACD, 2002), and to bring democracy and increased decision-making capabilities to the masses (Riley, 2003). As a result, thousands of local and national governments, as well as many international organizations across the world have made significant investments in bringing better governance to the people through the improved information and communication technologies available today (UNDESA, 2001). Even China, a country that ranked 93rd out of 133 countries in terms of its e-government capabilities in 2004 (UNPAN, 2004), had an e-governance-related market value estimated at 40 billion Yuan, or about 4.8 billion U.S. dollars (Bei, 2004: 6).[4] So what is e-governance exactly?

Technology and governance interact in two distinct ways. First, advances in technology and corresponding emergent domains (such as the Internet) may be regulated in various manners by different organizations and governments. Technology is governed. Oppositely, governance can also be affected by technology. *e-Governance* pertains to the latter condition, whereby governance is improved by advances in technology. Formally, e-governance is defined as *"the computerization and automation of common government processes with the goal of lowering costs, improving efficiency and generally*

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[3] "Governments on the WWW" estimates that as of 2001 there were well over 50,000 official government websites, a huge spike compared to the fewer than 50 official sites that the UN recognized in 1996 (UNPEPA, 2001). For more information, "Governments on the WWW" is available online at: http://www.gksoft.com/govt/, accessed August, 2004.

[4] Although in fairness, China has spent much of this 40 billion yuan on internal infrastructures while the UNCTAD measurement is tabulated by only measuring the capabilities of the government web portals. While a cynic may argue that presenting such statistics is twisting the numbers to make the phenomenon seem inflated, this discrepancy between measuring electronic governance is at the heart of a major problem. Electronic governance and electronic government have many different definitions, but these terms are oftentimes used interchangeably in the existing literature.

providing better services to citizens" (Ahmed, 2004).[5] This definition comes from the technocratic literature, yet it captures the essence of e-governance without introducing biases and prejudices as to technology's effects. Furthermore, the three ways in which electronic governance changes government performance – through lowering costs, improving efficiency, and providing better services to citizens – are general principles of 'good' governance.

The concept of e-governance can be further differentiated into three elements, further clarifying the features of this definition. These are (1) *e-efficiency*, whereby technology is used to improve efficiency, most typically by staving corruption; (2) *e-government* or *e-democracy*, whereby technology is used to improve government-to-citizen and citizen-to-government linkages; and (3) *e-business*, whereby technology is used by governments to help improve the performance of the economy. These three elements of e-governance are included in Table 13.1, which has been adapted from Okut-Uma (2000).

Table 13.1 **The three elements of e-governance. Table has been adapted from Okut-Uma, 2000.**

Element	Brief Description	Examples
e-Efficiency	Internal efficiency, anticorruption.	Vigilance reporting sites, cheaper transaction costs for purchasing public goods, open bidding for government contracts.
e-Government or e-Democracy	Providing better services.	Government web portals where one can get driver's licenses and death certificates, and file taxes over the Internet. Voting initiatives and policy-critiquing initiatives as well.
e-Business	Fostering the economy.	Field-specific best practice databases, international standards publications, web-based tax forms and anti-corruption tools.

Each aspect of e-governance is depicted from the 'provider' perspective (government) – from a top-to-bottom viewpoint, so to speak – rather than from an interactive discourse with the recipients (citizens). In other words, the main actor for implementing changes is the government (as opposed to citizens). Of the three elements within e-governance, most analysis to date has focused on the element of e-government. Among the common claims is that e-government offers a path towards new and unprecedented levels of

[5] Ahmed's paper (2004) is available on the Internet in html form, and there are no page numbers provided.

democracy. In the last ten years, several governments across the world have tried to reach out to their citizens by making large investments in web portals, in better voting technologies, and in improvements to other citizen feedback services – all intended to promote better citizen participation in government. United Nation's *Benchmarking e-Government: A Global Perspective*, defines e-government as, *"utilizing the Internet and the world-wide-web for delivering government information and services to citizens"* (emphasis in italics added by the original authors; UNDESA, 2001). To clearly differentiate e-governance from e-government, e-governance refers to the overall advancement of technology in governance activities, while e-government describes utilizing technology, and particularly the Internet, to better connect with citizens.[6] These are the best definitions at this point in time.

13.2 The State of e-Governance Worldwide

13.2.1 Modes of Measure

Currently, empirically measuring e-governance has been constrained to measuring e-government, and more specifically, to measuring the web portal capabilities of government. And instead of measuring citizen-feedback to various e-government initiatives, most surveys instead utilize a rubric for analyzing a country's web portal. Notable surveys of e-government capabilities include Holzer and Kim's 2003 study of 80 municipalities' web services (2003) and the American Customer Satisfaction Index's analysis of e-government portals within the United States (IACD, 2002), but the clear standard bearer of measuring e-government comes from UNDESA's *Global e-Governance Readiness Report*, conducted every year from 2003 to 2005. While the UNDESA project also does not survey citizens, the UNDESA's e-Government Readiness Index includes not just a web measurement for a country portal, but also factors the country's telecommunications infrastructure and the country's human capital, as defined in terms of literacy and education (UNDESA, various years). In the future, we fully expect to see the adoption of more sophisticated measures for measuring e-government and for measuring e-governance, but the UN's *Global e-Government Surveys* does provide a baseline for analysis.

[6] In the future, we expect the United Nation's definition of e-government to include non-Internet based technologies to better capture the several ways in which technology can aid in the government–citizen relationship. However, any domain centered upon improvements through technology is a domain in constant flux, and in such an emerging domain, there will be few agreed-upon assumptions and definitions. Eventually, we expect better definitions for *electronic governance* and for *electronic government* to emerge.

13.2.2 Wealth and e-Government

The UN produces two measures of e-government.[7] The first, the e-Government Readiness Index, is a score meant to capture a country's ability and willingness to incorporate information technologies for e-government-related purposes. The Index is calculated by measuring a country's web presence along an established (but annually adaptive) rubric, combined with a measure of the telecommunications infrastructure for the country and that country's Human Capital Index. The second measure is the e-Participation Index. e-Participation is a measure of the ability for democratic participatory processes to be aided through technology. The researchers measured the various governments' abilities to provide services in e-information, e-consultation and e-decision making.

There are few surprises when one examines the data. Countries with stronger economies tend to have higher e-Government Readiness Index scores. In Figure 13.1, we see the strong trend in 2003.[8] The cluster of countries in the

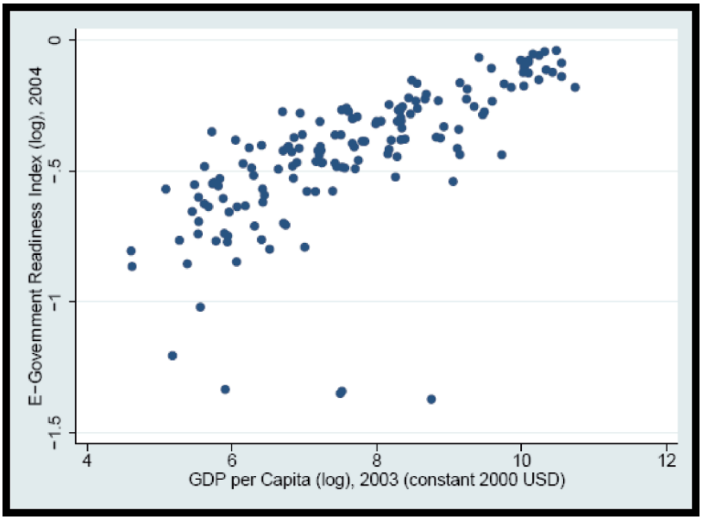

Figure 13.1 **Wealth vs e-Government Readiness Index. Based on data from UNDESA, 2003–2005, and UNPAN, 2003–2005.**[9]

[7] The data is available through the UN documents, however, for aggregated spreadsheets, please contact the author at dmistree@alum.mit.edu.

[8] Interestingly, the countries defying this trend (at the bottom of the graph) tend to be small nations: Timor-Leste, Micronesia, the Marshall Islands, and Palau are the obvious trend breakers. Also, e-Government Readiness Scores refer to performance in the previous year, so these are both 2003 variables.

[9] Figures have been produced using Stata 9.

top right are predominantly European; predominantly African countries comprise the bottom-end of the distribution. This trend holds true for 2004 and 2005 as well, with rich countries outperforming other countries.

This finding that richer countries outperform poorer countries is reinforced by the pattern displayed in Figure 13.2. While the graph is inverted, the message is still the same. The horizontal axis once again shows a measure of a country's wealth, again in terms of GDP per capita. The vertical axis shows the e-Participation Rank, which shows the ability for democratic participatory processes in that country to be aided through technology, with a lower number corresponding to a better ranking. Not surprisingly, the three countries with the best e-Participation Ranks in 2004 were also among the leaders in terms of GDP per capita: they were the United Kingdom, the United States, and Canada, respectively. Countries with the best access to technologies tend to also be the richest.[10] But the rich countries also implement technology in government, matching their capabilities with performance.

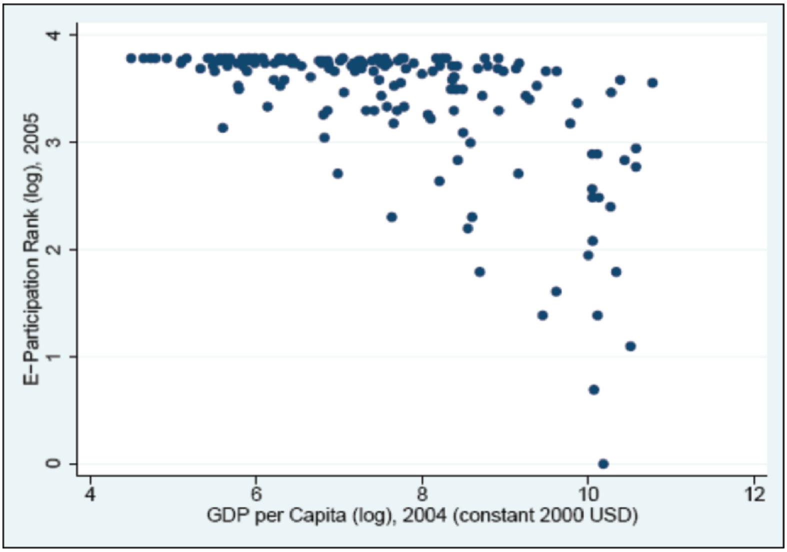

Figure 13.2 **Wealth versus e-Participation Rank. Based on data from UNDESA, 2003–2005, and UNPAN, 2003–2005.**

[10] We have only shown a correlation between strong participation in technology-enabled governance and having a thriving economy; however, we speculate that the same conditions which lead to a thriving economy also bring about high e-participation.

13.2.3 Current Performance versus Future Trajectories

Based upon the observation that rich countries are performing best in the e-government domain, one would expect that rich countries are also improving faster than the poorer countries. In other words, we would expect the richest countries to both be leading in performance while also showing the most historical improvement. Looking at changes from 2003 to 2005 in e-government readiness and in e-participation, higher GDP per capita values are not strictly associated with improved country performance, as can be observed in Figures 13.3 and 13.4.

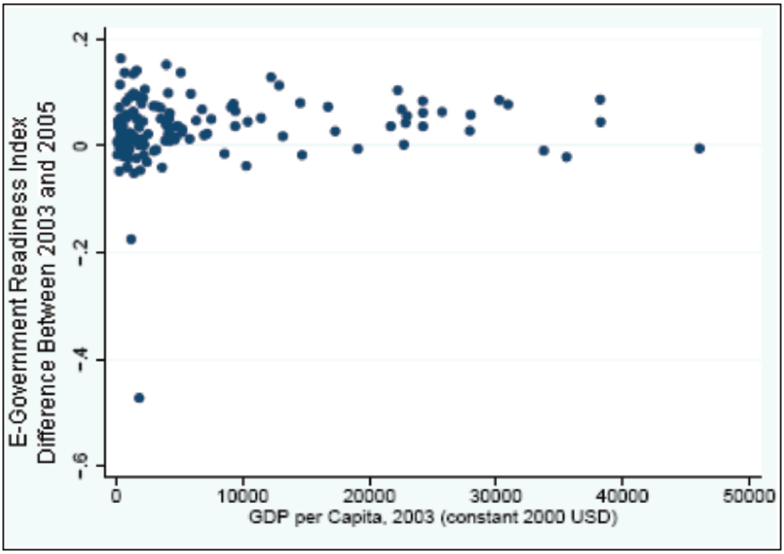

Figure 13.3 **Wealth versus difference in e-Government Readiness Index. Based on data from UNDESA, 2003–2005, and UNPAN, 2003–2005.[11]**

It is puzzling that we do not observe a difference between rich countries and less developed countries in their levels of improvement over the past three years. To be clear, in other aspects where technology is a factor, richer countries and less developed countries cannot even be compared with one another on the same scale, but in terms of improving e-government, we find astonishing parity.[12]

[11] The most significant trend breaker in this figure is Micronesia, having severely decreased in e-Government Readiness.

[12] Consider patents or carbon dioxide emissions, where the richer countries overwhelmingly outpace the developing nations.

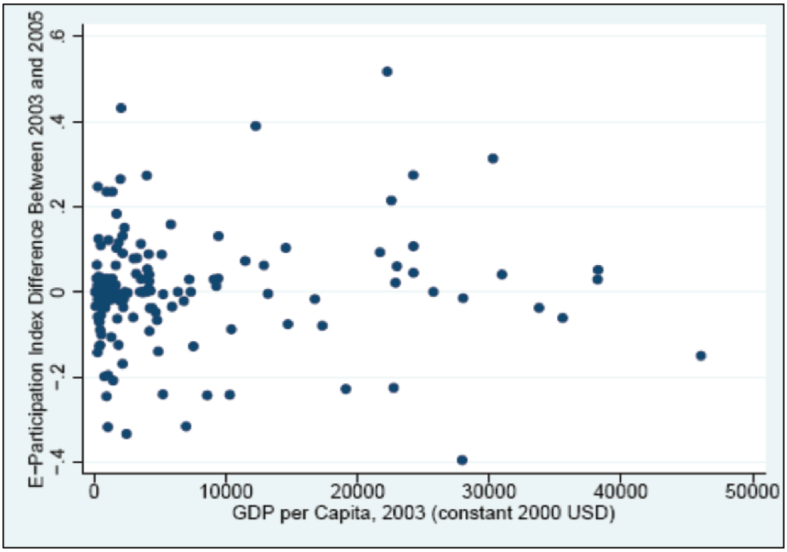

Figure 13.4 **Wealth versus difference in e-Participation Index. Based on data from UNDESA, 2003–2005, and UNPAN, 2003–2005.**

There are two possible explanations as to why we observe such uniformity in e-government improvement. Firstly, rich countries started in a better position and simply do not have as much to improve upon as their poorer counterparts. Once the rich countries achieve a certain level of e-government infrastructure, they only need to maintain a constant level as the rest of the international community catches up. Over this time period, however, e-government has aggressively expanded in the developed countries. In the United States, for instance, if one looks at federal tax filings from 2003 to 2005, there is a huge rise in e-filing. In Figure 13.5, we show the stellar rise in filing taxes online, as reported by the Internal Revenue Service. What is more, the percentage of individuals who electronically filed rose from 40.6% in 2003 to 51.7% in 2005. The United States and its developed counterparts are not remaining stagnant, waiting for the rest of the world to catch up. Instead, they are rapidly advancing in the e-government revolution: they are huge players that are committed to computerizing government. Their poorer counterparts share this same conviction. And while the United States is not waiting for other developing nations to catch up, developing nations are catching up nonetheless.

Similarly, developing countries are not playing the game of trickle-down technology. Consider the case of Malaysia, which in 2004 found the Microsoft Corporation making sweeping overtures to install various e-governance systems at significantly discounted rates. Later in 2004, Malaysia chose to develop its own open source e-governance platforms, largely rebuking Microsoft

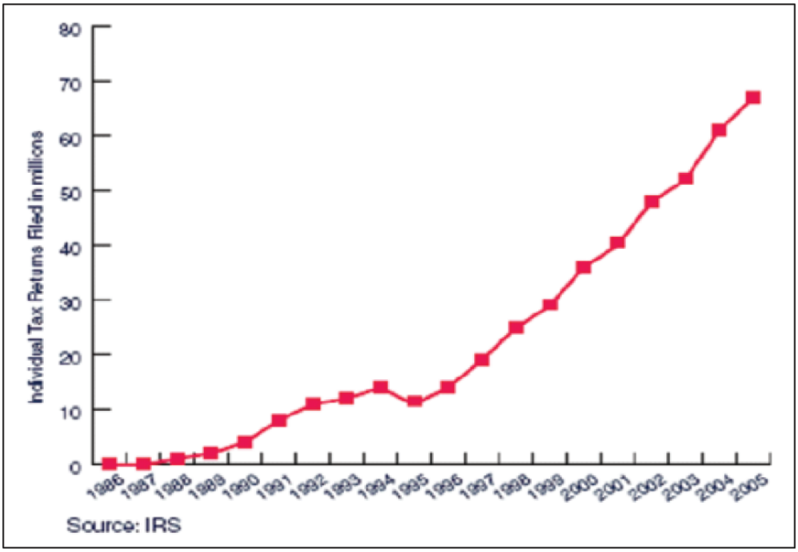

Figure 13.5 **Electronically filed individual tax returns by year. Source: IRS Oversight Board, 2006.**[13]

(Bajkowski, 2004). The Malaysian government recognized that a Microsoft-based platform would make it dependent upon a singular proprietor, which could unfairly increase prices for future upgrades. Further jeopardizing Malaysian national interests were the facts that Microsoft codes in English (as opposed to Malay), and that Microsoft is an American-based firm.[14]

This brings us to the other possible explanation as to why we observe parity in e-government improvement. Administrations in developing countries may see e-government as a potential tool for leap-frogging. Leap-frogging refers to the notion that previous development trajectories need not be followed due to advances in technology or due to other advances. In other words, a developing country need not try to copy the development pattern of the United States or Europe. Examples of leap-frogging initiatives outside of the realm of e-government include India's technology initiatives, whereby India has largely skipped the industrial revolution as it instead immediately entered into the computer revolution. Another way in which leap-frogging has occurred is in telecommunications. Today, several developing countries

[13] This graph is reproduced from a report published by the IRS Oversight Board, and is available online (http://www.ustreas.gov/irsob/reports/2005_e-Filing_report.pdf). Equally impressive in the United States' e-government revolution has been the initiative to electronically publish reports like these for individual consumption.

[14] While some may argue that multinational corporations are truly multinational and therefore independent of any singular country, if American and Malaysian interests diverged for instance, it is hard to imagine that Microsoft would take the side of Malaysia given the corporation's holdings in the United States.

do not have the land lines and grounded telephone infrastructure of the developed countries, but their citizens instead rely upon cellular phones. In so developing their wireless telecommunications industries, the developing countries skipped on the traditional alternative.

With regards to e-governance and e-government, one must wonder what exactly developing countries are attempting to leap-frog. Corruption is one such problem that developing countries seek leap-frog solutions. While all governments and nations suffer from corruption, corruption is much more endemic in developing nations. Traditionally, the only successful remedies for corruption were institutions made strong over long amounts of time. In technology, developing nations have found ways to stem corruption without having to wait for their institutions to mature. Computerizing records allows for better monitoring, while direct citizen-government interactions (as opposed to citizen-bureaucrat-government interactions) reduce the number of greedy hands.

Developing countries also recognize e-governance as a modicum for economic growth. In a speech at the World Bank e-Government Workshop in 2005, Azerbaijan Minister Ali M. Abbasov explained how e-government was contributing, and will contribute to, further economic growth. In one of many points about how e-government stimulates economic growth, Abbasov declared that "e-government systems can reduce transaction costs for citizens and businesses, improve connectivity between rural communities, support better local governance, [and] improve dissemination of agricultural knowledge and best practice[s]" (Abbasov, 2005: 3). Sharing knowledge and best practices, particularly in primary industries such as agriculture, is one of the most direct 'e-government for economic growth' initiatives. What is more, such linkages are not only fostered in Azerbaijan: a simple web search found dozens of e-government initiatives for improving agriculture, common in both developed countries as well as developing countries.

13.3 Tackling the Digital Divide

The Digital Divide refers *to the gap between those who are being left behind in a quickly-changing technology world and those who are benefiting from this revolution* (Keniston, 2004). This divide usually manifests itself along pre-existing inequalities, magnifying the inequalities as those who can afford access get richer while those without access are left behind. Inequalities exist across several different units of analysis, dividing individuals as well as states and countries. Similarly, the Digital Divide may further separate rich and poor individuals, as well as rich and poor states.

In the previous section, we observed the effects of the Digital Divide taking place between nations that sought e-government: countries with larger economies tended to start with better conditions than countries without such resources, but even though they are still behind, poorer countries are keeping pace with their richer counterparts in improving their e-government infrastructures. Beyond differences between nations, the Digital Divide transcends the arena of e-governance into the domestic level, existing in all realms where individual inequalities may be exacerbated by uneven distributions of technology. In the United States, individuals are increasingly able to comment on new regulations online, with bureaucracies frequently requiring responses to any comments made. However, these responses may be filtered, as only those who can afford access to the Internet may make suggestions for new regulations.[15] Even worse, by moving forward, we may leave behind the illiterate, the poor and the disenfranchised, even though these groups typically depend upon government organizations the most (Margetts, 2002). This problem has already attracted a significant amount of attention in the United Kingdom, as older people – who are more reticent to use online services – are missing out on pension opportunities and other government services (BBC, 2006). The government has responded with a strategy to promote "silver surfers" through educational and other initiatives. Put simply, there are not only uneven distributions of information, knowledge, resources, and technology between countries, but also such inequalities within countries, and such inequalities may exacerbate pre-existing inequalities.

To combat the Digital Divide, several developing countries include increasing access as part of their overall e-governance plans. Venezuela, a country which has seen its e-Government Readiness and e-Participation Indices both increase from 2003 to 2005, has constructed hundreds of *Infocentros*, or free Internet centers, across the country, for any citizen to use.[16] Dozens of other developing countries have constructed similar centers.

While the United Kingdom and Venezuela strive to be inclusive, many other countries are less concerned with equality. We suspect that in such divided countries, e-governance will still take place, but with a different thrust. Rather than providing increased access or improved government monitoring, we would expect such countries to engage in e-governance for the purposes of aiding the pre-existing elites. In North Korea, for instance, we see the

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[15] In the United States, only an estimated 68% of the population has access to a personal computer (Pew, 2005). Those who do not have personal computers are at a disadvantage as they must pay a higher cost compared to their better-connected fellow citizens.

[16] For a list of *Infocentro* locations, visit http://www.infocentro.gov.ve/ and go to "en todo el país" on the right side of the window. Accessed July, 2006.

government investing in electronic libraries for its students, rather than creating public Internet kiosks or providing free access to computers (AP, 2006).

Regretfully, we cannot move beyond allegory in this discussion, as even the best measures of e-governance and e-government fall far short. Despite the fact that one of the United Nation's measures purportedly gauges the participation of citizens in e-government, there is no real cross-country estimate for how much these implementations are actually being used by the people. To be clear, certain e-government initiatives such as electronic voting require complete participation, but other e-government initiatives, such as usage of agricultural web portals or frequency of online tax filings, are elective. With these elective initiatives, how many more people actually take advantage of these increased services? Is access to government actually spreading as services are put online? Beyond complete participation versus elective participation, of the e-governance initiatives designed to increase access, which actually work best? Scrutinizing such trends beyond a singular case-study or beyond one country would be especially beneficial for future assessments of e-governance.

13.4 Concluding with Some Future Predictions

e-Governance and e-government are quickly spreading throughout the world. Such technology-driven, government-improving initiatives are currently best-implemented by rich countries, but rich and poor countries alike are making significant strides in introducing technology to government. In the future, we expect this trend to continue, with developing country governments not simply waiting for e-governance innovation to trickle down, but also engaging in new and varied technology-based policies.

e-Governance, like other technology-motivated polices, can be a unifier or a divider. Governments interested in democracy (or at least increased citizen participation) should be especially concerned with providing access and services to all citizens in addition to engaging in other e-governance initiatives. Furthermore, both rich and poor countries have such Digital Divides within their societies, and all countries must be conscious of furthering inequalities through unequal access to government.

In the future, better metrics also need to be adopted for e-governance. Despite knowing that many governments have spent millions (or even billions) of dollars on e-governance, we do not know the returns for most initiatives. Indeed, the only initiatives for which we do have estimates for these returns are typically contained to *Best Practices* in e-government, offering allegorical stories for what works, but obviously not reporting on failed initiatives.[17] As a result of only recording successful policies, we are developing potentially skewed perspectives of e-government. Beyond e-government, we also need to scrutinize policies across e-governance, including technological improvements in governance that are not directly citizen-related. Unfortunately, there has been very little research conducted in e-governance beyond e-government and e-business, despite the many ways in which e-efficiency may be improved. In the future, analysis of e-governance must extend beyond e-government and e-business to also include e-efficiency.

On a parting note, the e-governance revolution shows no signs of slowing down. Countries are increasingly placing more resources, corporations are increasing their e-governance services, and international institutions and organizations are increasingly preaching the possibilities of technology. In this chapter, we have discussed how technology has had – and will have – profound effects on the face of governments around the world as individuals and businesses are increasingly able to interact with governments. But technology is also changing the nodes of government, or the inner workings of these institutions, as bureaucratic structures are transforming due to improved technologies (especially Information and Communication Technologies), as government bidding contracts are increasingly offered in larger markets, and even as inter-governmental relationships are increasingly shaped by the digital world. Also, between technology and government, there is feedback as government also affects the development and diffusion of technologies. Understanding the complex relationship between technology and government is a worthwhile pursuit for the 21st century.

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[17] There are many such *Best Practice* sites: The European Union has a "Good Practices in e-Government" website: http://www.egov-goodpractice.org/; the United Nations provides a similar list of Best Practices (available through http://www1.worldbank.org/publicsector/egov/), as well as a Compendium of Innovative Practices: http://unpan1.un.org/intrdoc/groups/public/documents/UN/UNPAN022196.pdf (this document links to Volume 1). These sites are not limited to international organizations, as corporations such as Microsoft (http://www.microsoft.com/emea/government/newsletters/ssn.mspx), educational institutions such as Rutgers (http://www.rci.rutgers.edu/~eagleton/e-gov/e-ideas.htm), and even individual governments such as the United States (http://www.firstgov.gov/webcontent/improving/marketing/awards/best_practice_awards.shtml) are all measuring *Best Practices* in e-Government. All sites accessed July, 2006.

References

Abbasov, A. M. (2005). Speech of Minister Ali M. Abbasov: *World Bank e-government workshop*, April. Retrieved September 26, 2006, from http://siteresources.worldbank.org/INTEDEVELOPMENT/Resources/559323-1114798035525/1055531-1114798256329/1055556-1114798371392/Abbasov.pdf

Ahmed, A. S. (2004). Automating government with e-governance. *The Linux Journal*, 121, May. Retrieved September 26, 2006, from http://linuxtoday.com/news_story.php3?ltsn=2004-05-21-001-26-OS-SW-PB

Associated Press (AP). (2006). North Korea is going digital. *MIT Technology Review*, May 30. Retrieved September 26, 2006, from http://www.technologyreview.com/read_article.aspx?id=16937

Backus, M. (2001, March). E-governance in developing countries. *IICD Research Brief* No 1. Retrieved September 26, 2006, from http://www.ftpiicd.org/files/research/briefs/brief1.pdf

Bajkowski, J. (2004, July 20). Malaysia mandates open source. *Computerworld*. Retrieved May 30, 2007, from http://www.cio.com.au/index.php/id;654675239;fp;4;fpid:21

Bei, X. (2004, August). Make e-governance effective public service. *China Daily*. Retrieved September 26, 2006, from http://www.chinadaily.com.cn/english/doc/2004-08/10/content_363725.htm

Bonham, G. M., Seifert, J. W., and Thorson, S. J. (2001). The transformational potential of e-government: The role of political leadership. *Panel on Electronic Governance and Information Policy at the Fourth Pan-European International Relations Conference*, September, University of Kent at Canterbury, U.K. Retrieved September 26, 2006, from http://www.maxwell.syr.edu/maxpages/faculty/gmbonham/ecpr.htm

British Broadcasting Corporation (BBC). (2006). Older people ‘missing out’ online. *BBC Online*, July 4. Retrieved September 26, 2006, from http://news.bbc.co.uk/2/hi/technology/5146222.stm

Holzer, M. & S. Kim. (2003). Digital governance in municipalities worldwide: An assessment of municipal web sites throughout the world. *United States of America: National Center for Public Productivity*. Retrieved August 2004, from http://www.andromeda.rutgers.edu/~egovinst/Website/

Inter-American Agency for Cooperation and Development (IACD). (2002). *Application of best practices for development: E-government programs description*. Retrieved August 2004, from http://www.iacd.oas.org/template-ingles/110602_egov.pdf

Internal Revenue Service Oversight Board (IRS). (2006). *Annual report to Congress*. Retrieved September 26, 2006, from http://www.ustreas.gov/irsob/reports/2005_e-Filing_report.pdf

Keniston, K. (2004). Introduction: The four digital divides. (In K. Keniston and D. Kumar (Eds.) *Experience in India, bridging the digital divide*. New Delhi: Sage Publications India Pvt Ltd.)

Kumar, D. (2004). Digital development. (In K. Keniston and D. Kumar (Eds.) *Experience in India, bridging the digital divide.* New Delhi: Sage Publications India Pvt Ltd.)

Margetts, H. (2002). Better public services through e-government: Academic article in support of better public services through e-government. *The National Audit Office*. Report by the Comptroller and Auditor General. HC 704-III Session 2001–2002: April 4

Okot-Uma, R. W. (2000). Electronic governance: Re-inventing good governance. Retrieved September 26, 2006, from http://www1.worldbank.org/publicsector/egov/Okot-Uma.pdf

Okot-Uma, R. W. (2004). Electronic Governance: Leading to Good Government. (In R. W. Okot-Uma, *Electronic governance and electronic democracy: living and working in the connected world*. London: The Commonwealth Centre for e-Governance)

Pacific Council on International Policy (Pacific Council). (2002). *Roadmap for e-government in the developing world: 10 questions e-government leaders should ask themselves*. Retrieved September 26, 2006, from http://www.pacificcouncil.org/pdfs/e-gov.paper.f.pdf

Riley, C. G. (2003). *The changing role of the citizen in the e-governance & e-democracy equation*. Dissertation. London: Commonwealth Centre for e-Governance

UNDESA: United Nations Department of Economic and Social Affairs. various years. *United Nations global e-government readiness report*

UNPAN: United Nations Online Network in Public Administration and Finance. (various years). *UN global e-government readiness*

Chapter 14

GROWING CLEAN?

Property Rights, Economic Growth, and the Environment

Anne-Katrin Wickboldt

Introduction

This chapter examines the relationships among economic growth, property rights protection and environmental pollution. The relationship between economic growth and pollution has been the subject of much debate. Some scholars argue that, although technological advances and innovation may mitigate the impact of economic growth on the environment, natural resource consumption is ultimately constrained.[1] Others feel that limiting growth in light of the uncertainties surrounding its eventual environmental impacts is unwarranted. The most optimistic among them suggest that economic growth, while detrimental to the environment at lower levels of wealth per capita, will eventually benefit the environment, and thus should not be seen as a problem, but rather, in the long-term, as the solution to problems of environmental degradation.

This argument has become known as the environmental Kuznets curve (EKC) hypothesis. The purported tendency of environmental degradation to slow at higher levels of wealth is believed to be caused by a multitude of factors that occur with increasing levels of economic development after a certain threshold, such as structural transformations in the economy, advances in technology, and shifts in peoples' priorities.[2]

[1] Classical formulations of this argument for limits to growth are Meadows (1972) and Daly (1977).

[2] The name *Kuznets curve* refers to research by Kuznets (1955) on income inequality and economic growth. He found the relationship between the two to follow an inverted-U curve, which is the functional form posited here between economic growth and environmental degradation. Where one stands on this issue greatly influences environmental policy preferences. President Bush, for instance, famously endorsed the environmental Kuznets curve argument and rejected the Kyoto Protocol on Climate Change in favor of

N. Choucri et al. (eds.), Mapping Sustainability: Knowledge e-Networking and the Value Chain, 277–300.

The issue is far from resolved. Although many hypotheses have been advanced in the literature, the exact causal link between levels of economic growth and environmental outcomes remains elusive. Empirical research on the relationship between wealth and environmental quality attempts to arbitrate the debate, yet is often hampered by data availability. Results typically vary depending on the respective pollutants used as indicators for environmental outcomes, their temporal and spatial coverage, and the functional forms tested in the analyses.

Given the great significance of the issue for the formulation of environmental and policy priorities, we retest the inverted-U shaped relationship between economic growth and pollution in this chapter. We do so using both a broader sample of countries and a statistical method different than those used in many previous analyses.[3]

The relationship between economic growth and institutional quality, such as the nature of the property rights regime, has also been studied. A secure property rights regime is held to provide an environment conducive to economic growth by lowering transaction and information costs in the marketplace, and by providing the incentive structure necessary for investment. Using available proxies such as political stability and freedom, empirical studies have generally confirmed a significant positive relationship between economic growth performance and institutional quality. We retest this relationship using two indices measuring business risk for investors instead, as they may be better proxies for the quality of the property rights regime.

The relationship between property rights protection and environmental pollution has to our knowledge not yet been studied empirically on a cross-national sample. In theory, a well-defined and enforced property rights regime over environmental resources should promote more judicious patterns of use. One of the most prominent scholars making this argument was Ronald Coase (1960), who suggested that defining property rights over resources would allow stakeholders to bargain among themselves and lead to the most efficient use of the resource. His stance has been echoed by free market environmentalists. They argue that most cases of environmental degradation can be effectively addressed by creating and enforcing property rights over environmental assets, which are then to be traded in the marketplace (Anderson and Leal, 1991; Bennett and Block, 1991). Moreover, within a secure property rights regime, owners of an environmental asset have an incentive to protect its long-term value through judicious use, as current value always reflects the value of future services (Stroup, 1990).

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an alternative plan, arguing that it is now 'common sense' that economic growth is a necessary prerequisite for environmental progress.

[3] The choice of sulfur dioxide as dependent variable, functional form, and method of analysis is explained further below.

Many caveats have been advanced as to the effectiveness of assigning property rights over environmental assets to prevent environmental degradation. It does not seem feasible when the costs associated with establishing and enforcing rights over a resource are very high. Moreover, all stakeholders cannot be brought to the table to negotiate an equitable outcome when effects of resource use are inter-temporal or even inter-generational (Turvey, 1963).

Empirical tests of the purported effect of the quality of the property rights regime on environmental quality have, to our knowledge, not been undertaken, perhaps not least because the necessary data on both dependent and independent variable for a meaningful sample is hard to come by. We attempt to tackle this task, using (with appropriate caveats and qualifications) existing air pollution data and the proxies of the property rights protection quality mentioned above.

This chapter is in four parts. The first outlines the main theoretical lines of argument on each of the three relationships in turn, and briefly reviews pertinent empirical findings to date. The second outlines a research design to empirically test the respective relationships by listing the sources of the three main study variables, generating scatter plots of the respective relationships, and briefly touching upon relevant econometric issues. In a third part, we construct the regression equations, and present the results of the analyses. In the forth part, we conclude and suggest policy implications of this research.

14.1 Reviewing the Theory of the Triangular Relationship

14.1.1 Economic Growth and Environmental Pollution

All economic activity invariably entails some degree of environmental degradation. Production needs inputs, some of which derive from natural resources, and often generates externalities in the form of solid waste and effluents. Some analysts fear that as economic output grows, its externalities may at some point overburden the environment and compromise its ability to sustain and regenerate itself (Daly, 1977). Others counter that many intervening variables may mitigate the detrimental effects of growth on the environment, especially as economies reach a certain threshold level of wealth. They believe that structural transformations in the economy, advances in technology, and shifts in peoples' priorities de-link the positive correlation between growth and degradation beyond a certain level of per capita income (Grossman, 1995; Syrquin, 1989).

None of these explanations in support of the so-called environmental Kuznets curve hypothesis are beyond dispute. Although we have seen production composition shift from more to less polluting sectors historically, the aggregate impact of this shift is not necessarily conducive to favorable environmental outcomes. For instance, De Bruyn et al. (1998), argue that some service sector activities have a negative impact on the environment (such as air travel, or mass tourism). Although a change in the composition of production is likely to decrease the environmental impact per unit of GDP, overall detrimental effects on the environment may thus not decline as income grows.

Likewise, the impact of technology on the environment is invariably complex. While technological improvements may offer solutions to many environmental problems in the future (such as improving long-distance communication and thus reducing travel), technological change is also among the root causes of environmental degradation. Whether the positive or negative impact of science and technology on the environment will prevail in the future is as of yet impossible to foresee (Skolnikoff, 1993).

The impact of wealth on the behavior and preferences of individuals is also far from straightforward, and potentially influenced by at least three intervening factors. First, popular demand for environmental protection and improvement can only be voiced effectively and translated into policy in democratic regimes, in which citizens can influence policy outcomes to a certain extent. Regime type thus matters for whether wealthy citizens, and nations, effectively voice their wishes for a cleaner environment and whether environmental improvements will materialize.

Second, system boundaries matter. Individuals may be concerned about environmental quality in their vicinity, or country, and decide to simply shift polluting activities, either within or outside their national borders. Existing EKC relationships within certain borders thus do not necessarily indicate a cleaner environment overall. Within a country, dirty production is often located in, or relocated to sparsely populated areas, or along borders, to mitigate its effect on the local population. Across nations, an EKC for some pollutants in industrialized countries may simply mean that developed countries have shifted polluting production processes to developing countries, from which they then import the products they want to consume. If EKC relationships in industrialized nations are due to externalization to developing countries, the latter will obviously not be able to 'clean up' the way the former did, regardless of their income level, for lack of places to which to externalize their polluting industries. They will instead become so-called 'pollution havens.'[4]

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[4] Existing evidence on the emergence and prevalence of pollution havens is mixed. Some studies suggest they exist (Low and Yeats, 1992; Rock, 1996; Mani and Wheeler, 1998; Dowell, Hart, and Yeung, 2000), while others find that pollution abatement expenses do not figure prominently into firms' decisions to relocate (Tobey, 1990; Jaffe et al., 1995; Eskeland and Harrison, 1997).

Moreover, pollution that is transboundary in nature may not be addressed because the collective cooperative action required for success is difficult to establish and maintain.[5] Hardin's (1968) tragedy of the commons is perhaps the most pointed description of the fate of a common property resource in the absence of cooperation among its users.[6]

Third, the characteristics of the respective pollutant matter. Individuals may value environmental quality beyond a certain income level in general, but their concern is likely related to how much a certain pollutant actually affects their lives or living space.[7] The same is true for nations. The degree to which wealthy nations care about and demand a decrease in pollution levels is likely a function of how much it affects them. If the detrimental effect of pollution is dispersed to others in time and space (as is the case with many air pollutants) there is no reason to expect wealthy nations to lobby against it.[8]

Empirical research on the relationship between wealth and environmental quality spans a wide variety of pollutants and spatial and temporal domains, and thus, not surprisingly, does not reach a unanimous verdict. Table 14.1 summarizes previous research.[9] As can be seen, empirical studies vary in the data they use, the temporal and spatial domains they cover, and in the functional forms they test.

Two issues have shaped the research design presented below to re-test the EKC hypothesis. First, as mentioned above, the attributes of the respective pollutant used to measure environmental outcomes matter. If the pollutant has immediate local effects on people and their quality of life, the latter are more likely to mobilize resources to mitigate these effects. In line with research on the dynamics of collective action, successful abatement most likely also depends on the number of pollution sources, and how readily they can be identified. Not least, successful cleanup is more likely when abatement costs are low. Overall, empirical research to date bears out these hypotheses. A wide range of pollutants has been tested, and evidence for the

[5] Olson (1965) pointedly describes the challenges associated with collective action.

[6] Hardin concludes that resources held in common, such as air, oceans, or parklands are subject to massive degradation. Access to common property resources cannot be restrained, and their use by one diminishes all other's capacity to benefit from them. Rational individuals in pursuit of their maximum utility thus have an incentive to deplete such resources to an extent that is undesirable from the point of view of society as a whole.

[7] As Shafik (1994) points out, there are few incentives to incur abatement costs when environmental problems can be externalized.

[8] A crucial test for an environmental Kuznets curve would thus involve a pollutant with localized negative effects on both human health and environmental quality.

[9] This section draws heavily on Stern (1998). It is not exhaustive, and lists mainly research that includes sulfur dioxide as a dependent variable, to serve as comparison for the research we undertake further below.

Table 14.1 **Previous studies on sulfur dioxide.**

Study		Spatial Domain	Temporal Domain	Dependent Variable	N-curve Tested?	EKC Tested?
Shafik and Bandyo-padhyay	1992	Select cities in developed and developing countries	1977–1988	Urban ambient air quality	Yes, not found	Yes, and found
Selden and Song	1994	Mostly developed countries	1973–1984	Aggregate emissions	No	Yes, and found
Grossman and Krueger	1995	Select cities in developed and developing countries	1977–1988	Urban ambient air quality	Yes, and found	Yes, and found
De Bruyn	1997	Sample of OECD and formerly socialist economies	1980s	Sulfur dioxide	No	Yes, and found
Panayotou	1997	Thirty developed and developing countries	1982–1994	Ambient sulfur dioxide	No	Yes, and found
Torras and Boyce	1998	Select cities in developed and developing countries	1977–1988	Urban ambient air quality	Yes, and found	Yes, and found
Roca et al.,	2001	Spain	1980–1996	Annual flow estimates	No	Yes, and found
Stern and Common	2001	Wide range of countries, OECD and non-OECD countries separately	1960–1990	Emission levels	No	Yes, not found

existence of an environmental Kuznets curve has indeed been found most often for sulfur dioxide emissions and suspended particulates, both of which are local pollutants with immediate effects on environment and health.[10]

In light of these insights, we will use sulfur dioxide, a local pollutant, as dependent variable. In addition to the benefits associated with replicating previous studies to an extent, using sulfur dioxide presumably creates a 'best case scenario.' If there is a case to be made for an inverted-U relationship between economic growth and environmental pollution, sulfur dioxide should be an easy candidate to demonstrate its validity. Conversely, if an EKC cannot even be found for an 'ideal case' pollutant such as sulfur dioxide, chances are it will not for pollutants with more challenging attributes.

Second, previous studies vary in the functional forms they test. As Table 14.1 shows, some studies include and find a cubic functional form between environmental pollution and income (For instance, Shafik and Bandyopadthyay, 1992; De Bruyn and Opschoor, 1997).[11] This cubic function implies that beyond a certain point, higher income will again correlate with higher

[10] See Stern (1998) for a summary of EKC studies to date.

[11] Dasgupta et al. (2005: 403) note more generally that the inclusion of higher order polynomial terms in the analysis most likely influences results.

pollution levels, thus greatly weakening the optimistic long-term outlook that some associate with EKC findings. As with the EKC hypothesis, interpreting empirical findings and drawing causal inferences from a cubic relationship is difficult. Torras and Boyce (1998) hypothesize that the N-curve may be the result of scale effects outrunning initial mitigating effects of output composition and technology.[12] Despite these challenges associated with interpreting functional forms we may find, we will test for an N-shaped functional form in addition to the inverted-U shaped relationship by including both a square and a cubic term of per capita income among the independent variables in the regression equation.

14.1.2 Economic Growth and Property Rights Protection

The neoclassical model of the economy typically attributes economic growth to capital deepening and technological change. Assuming identical commodities and stable preferences across consumers, it predicts that poorer countries grow faster than richer ones due to their lower capital–labor ratios and thus higher marginal products of capital. As it became apparent that the relative income gap between rich and poor nations was not narrowing as predicted, growth economists turned to endogenous growth models, and acknowledged the importance of human capital for the ability of developing countries to catch up (Romer, 1986). Neo-institutionalists have offered another explanation for the lack of convergence between growth rates in industrialized and developing countries. They point out that both neoclassical and endogenous growth models assume that the institutional framework within which economies function is stable and given. Economic historians have shown, however, that institutional constraints vary considerably across time and economies and are crucial for long-term growth (North and Thomas, 1973; Rosenberg and Birdzell, 1986). Secure property rights, in particular, are held to be crucial for the smooth functioning of economic exchange. They lower information and transaction costs and promote allocative efficiency by directing resources towards productive, rather than rent-seeking activities. They also attract investors, by ensuring that they will be able to reap the rewards for their investment.

Until recently, data that directly measure the degree to which property rights are protected has not been available. Researchers instead used proxies

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[12] Interestingly, recent EU regulations on national ceilings for certain atmospheric pollutants implicitly acknowledge and take into account the possibility of pollution levels increasing after an initial decline as income keeps rising. EC Directive (2001), for instance, states that members are to limit certain annual emission levels to a certain fraction of those in a base year, and then indicates that emissions are not to exceed those ceilings in any year thereafter.

measuring political stability or political freedom and civil liberties (for example, see Barro, 1991; Scully, 1988; Alesina and Perotti, 1996), and generally confirmed a significant positive relationship between economic growth performance and institutional quality.

Although a convincing case for a link between regime stability and the quality of the property rights regime in a given country can be made (Olson, 1993), the use of such proxies to measure the quality of the property rights regime is problematic, for several reasons. First, the indices typically capture only non-constitutional events, such as revolutions, coups, and assassinations. Yet, rulers may adopt the short-term view associated with less secure property rights simply because they expect their leadership tenure to be limited. Whether it is ended unconstitutionally or constitutionally has no effect on this incentive structure. Second, we cannot assume that politically stable countries have secure property rights regimes. In fact, powerful dictators may be able to both effectively suppress dissent and opposition, and disregard their citizens' right to private property. Third, as political instability has been shown to be sensitive to economic performance, using it in growth regressions as a proxy for property rights protection can lead to problems of simultaneity (Barro, 1991; Knack and Keefer, 1995). Given these drawbacks associated with using these proxies, we retest the relationship between economic growth and the quality of the property rights regime using data on the quality of national property rights protection published by a private international investment risk service instead.

14.1.3 Property Rights Protection and Environmental Pollution

Free market environmentalists argue that most of our environmental problems can be addressed effectively by creating and enforcing property rights over the environment, which are then to be traded in the marketplace (Anderson and Leal, 1991; Bennett and Block, 1991). Although delineating rights over attributes left in the public domain is costly, economic theory predicts that it will occur as the value of the common property resource increases (Barzel, 1997: 16). In general, ownership patterns tend to conform to the most valued use of any given resource at any given time.[13] For the quality of the Earth's atmosphere, this seems to be, for the time being, the one of a resource sink for the byproducts of energy production, and a host of other anthropogenic activities. In a Coasian world where transaction costs are negligible, matters change when those adversely affected by externalities

[13] Barzel (1997: 145ff) illustrates this using the example of wildlife use in Britain and the United States, tracing changes in the respective property rights regimes to shifts in the value of the resource.

associated with the economic use of a resource find it worthwhile to bribe the polluters to change their behavior (Coase, 1960). Both parties then strike a deal that reflects the degree to which they value the respective outcomes, namely environmental quality and economic gain associated with polluting externalities. In a world where transaction costs do not exist, we would thus expect ownership patterns to adjust as soon as the value of environmental goods surpass the benefits associated with energy consumption, as well as the cost associated with establishing, enforcing, and monitoring property rights.

In the case of atmospheric pollution, however, this is unlikely to happen, for two main reasons. First, establishing and enforcing rights over atmospheric resources is prohibitively expensive.[14] Second, all stakeholders cannot be brought to the table to negotiate an equitable outcome due to inter-temporal and inter-generational effects of resource use. Long-time lags typically separate today's polluters from future generations who may bear the brunt of the adverse effects of current activities. For a Coasian solution to be equitable, a reliable trustee would have to represent future generations at the negotiation table.[15]

Even if stakeholders could negotiate and agree on an equitable and efficient use of a resource, however, one fundamental dilemma remains. While markets may efficiently allocate resources, a sustainable scale of the economy relative to the ecosystem still has to be determined (Daly, 1977).[16]

Keeping all these caveats in mind, we will test the relationship between the quality of the property rights regime as measured by the proxies mentioned above, and environmental degradation, proxied by sulfur dioxide emissions. We chose SO_2 as the dependent variable for three main reasons.

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[14] Perhaps advances in technology may reduce these costs some day. Anderson and Leal (1991: 166), for instance, describe potential ways in which technology may aid air pollution control. Tracers, such as odorants, coloring agents, or isotopes could be added to pollutants, or available technologies that map atmospheric chemical concentration from orbit could be refined to make pollutants traceable to their sources and thus greatly enhance the ability to assign property rights over them, and enforce regulation, and make polluters pay. However, as mentioned before, as long as these technologies are out of reach, it is perhaps better to assume technical progress as zero.

[15] The government is usually called upon to take this role, although incentive structures in government typically do not reward long-term thinking, and politicians can rarely afford to think beyond their tenure or brief electoral cycles. Moreover, as Solow (1993) notes, there is something distinctly phony about anyone claiming to care about the welfare of future generations who is not deeply concerned about the plight of fellow human being currently alive.

[16] To borrow Eckersley's (1993: 18) analogy, if the overall load of anthropogenic pollution associated with economic growth exceeds the carrying capacity of the planet, efficient allocation of resources may merely ensure the boat to sink on an even keel, yet not prevent it from sinking altogether.

One, it has a long residency time. Sulfur remains in the atmosphere for roughly one thousand years, long enough to potentially pose problems for many generations.[17] Two, it is a pollutant with fungible local effects, most notably on health, and also on buildings and forests by way of acid rain.[18] This makes sulfur a good test case for the EKC hypothesis. Several analysts have argued that government regulatory responses may be stronger when adverse effects of pollution are primarily within national borders rather transnational or global (Arrow et al., 1995; Max-Neef, 1995). Three, among the local pollutants currently known, data on sulfur dioxide emissions cover by far the widest temporal and spatial range of countries.[19]

Figure 14.1 summarizes the study hypotheses we test with our analysis, based on the preceding theoretical discussion on the relationships among the quality of the property rights regime, environmental degradation, and economic growth.

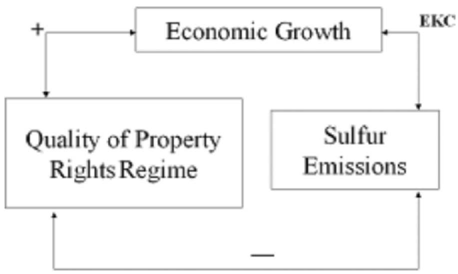

Figure 14.1 **Summary of theory-deduced study hypotheses.**

14.2 Research Design

To empirically test the hypotheses on the relationships among environmental quality, property rights protection, and economic growth, we will perform a cross-sectional time-series analysis using annual data from 1970 to 2000 and as broad a sample of countries as data allows. In the following, we list the sources of the three main study variables used, and generate scatter plots to

[17] By this criterion alone, carbon dioxide would be the pollutant of choice, because it stays in the atmosphere much longer. The least serious pollutants by that measure are short-lived compounds such as methane and nitrous oxide, among others.

[18] The health effects of sulfur emissions are, by some British estimates, still uncertain. In general, it appears to have been difficult to separate the health effects of sulfur from those of other pollutants, especially NO_x and particulates (Harrison, 1995: 8).

[19] There are other localized pollutants, such as CH_4 and NO_x but available data cover much smaller spatial and temporal domains.

gain a preliminary feel for the respective relationships.[20] We then briefly touch on econometric issues pertinent to the analysis. In the next chapter, we present the regression equations and results of the analyses.

14.2.1 Sources for the Dependent Variables

GDP per capita is commonly used to measure economic growth in cross-country comparisons. Data was obtained from Summers and Heston (1995), and extended forward to 2001 using data published by the World Bank as part of the World Development Indicators. [21] Country-level aggregate yearly sulfur dioxide emission data was obtained from Lefohn, Husar, and Husar (1999). These are estimates, covering a broad range of countries in the developed and developing world, and years spanning 1970 to 1990. Pollution flow levels seemed more appropriate than stock levels because concentrations, while adequately gauging the ambient air quality in particular areas, do not necessarily accurately reflect the aggregate burden on the environment (Stern, 1998: 182).

As the emergence of direct measures for the quality of the property rights regime are fairly recent, we describe them in a bit more detail. Knack and Keefer (1995) compare the explanatory power of several property rights protection variables. They find that direct measures such as those provided by the International Country Risk Guide (ICRG, various years) and Business Environmental Risk Intelligence (BERI, various years) are not highly correlated with and fare much better in growth regressions than both the proxies measuring revolutions, coups, and assassinations used by Barro (1991), Levine and Renelt (1992), and Gastil's (various years) indices of civil liberties and political freedom. BERI covers 51 countries and uses four indicators to gauge business environmental risk.[22] ICRG includes more than twice as many countries and consists of five indicators of institutional quality.[23] Its indicators are highly correlated. Due to its superior spatial coverage, we decided to use ICRG for the current analysis. Following Knack and Keefer

[20] To capture long-term trends in the relationships among the variables, we calculate averages over five-year intervals for most variables. Using five-year rather than longer intervals seemed to strike a reasonable compromise between sample size and cross-period correlation considerations. The earliest period for the property rights protection measure is the value for 1982, the earliest year for which the measure is available.

[21] The correlation between the measures in the two data sets for overlapping years was 0.97. Merging data from both sources thus seemed unproblematic.

[22] These are bureaucratic delays, nationalization potential, contract enforceability, and infrastructure quality.

[23] These are the rule of law, quality of the bureaucracy, corruption in government, expropriation risk, and repudiation of contracts by government.

(1995), we aggregated its five indicators to a single index (Σ(ICRG)) for the regression analysis.

We also considered using the property rights index published by the Heritage Foundation as part of their yearly Index of Economic Freedom (Gastil, various years). Since the index only covers 1997 through 1999, however, it did not overlap with the other variables enough to make it a feasible alternative to ICRG for the analysis.[24]

14.2.2 Scatter Plots of the Relationships

Scatter plots were generated to gain visual clues of the nature and functional form of the relationships of interest. Figure 14.2 shows sulfur emissions plotted with GDP per capita for all years and countries included in the analysis. It suggests that the correlation is positive, but that, as the EKC suggests, the curve flattens at higher levels of wealth. Visually, it is hard to ascertain a dip, but it is not implausible.

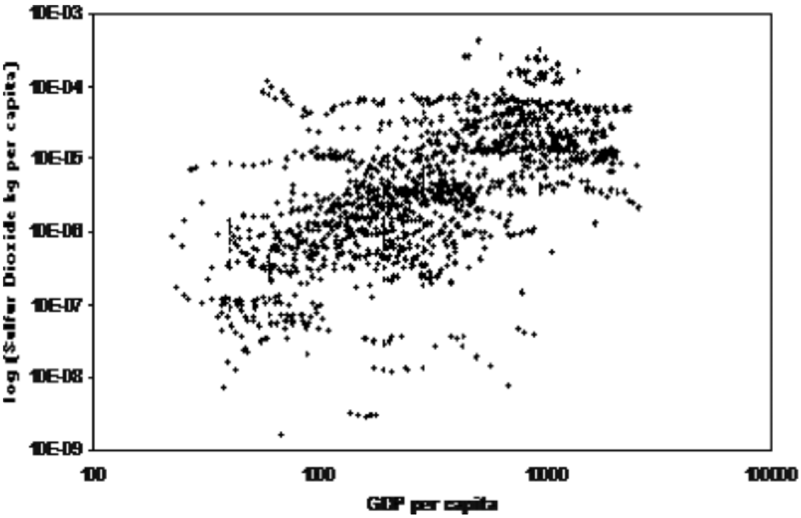

Figure 14.2 **Growth (constant USD per capita) and sulfur dioxide (kg per capita). Based on data from Summers and Heston, 1995 and World Bank, various years.**

Contrary to the linear function theory predicts, the distribution of the data points in Figure 14.3 suggests that medium levels of prosperity are attainable at all but the lowest levels of institutional quality. A glance at the outliers

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[24] Interestingly, for the year ICRG and Gastil's indices overlap (i.e. 1997), they have a correlation of 0.71. Thus, both indices seem indeed to measure similar phenomena independently, which reinforces their credibility.

(virtually all OPEC countries in the lower right corner of the graph) suggests that comparatively high levels of per capita GDP at low levels of property rights protection may be due to income generated by oil exports. If we disregard the OPEC countries, we can see the clear positive correlation between the quality of the property rights regime and wealth we expected. High levels of GDP per capita indeed seem to coincide with superior property rights regimes.

As Figure 14.4 shows, there seem to be no clear patterns in the relationship between the quality of the property rights regime and sulfur emissions. Oil-exporting countries and countries with communist regimes are among the worst polluters in the upper third of the graph. Countries with reliable property rights regimes spread across a great range of pollution levels. In line with neo-institutionalist theory, the figures suggest that for non-oil exporting countries, the quality of the property rights regime is positively correlated with economic performance.

The plots also seem to confirm that the quality of the property rights regime in a country does not impact aggregate air pollution levels. As for the relationship between economic growth and sulfur emissions, the plots do not show the clear inverted-U shape relationship we expected to find.

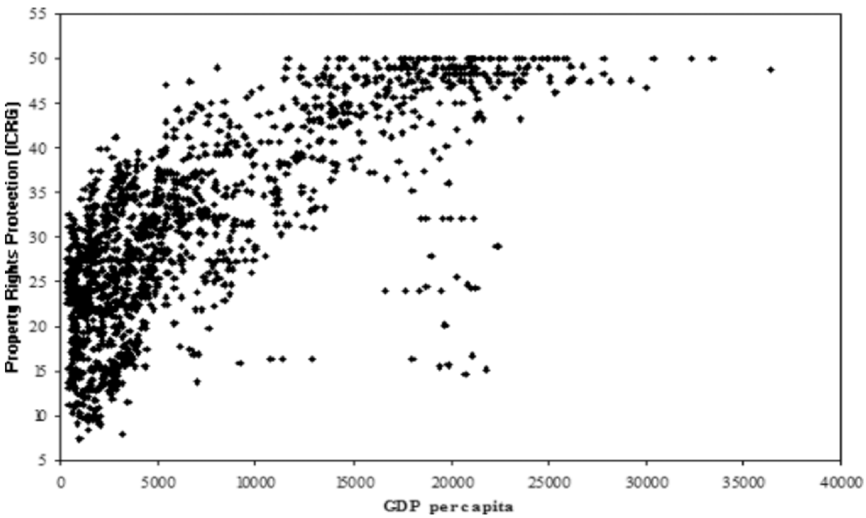

Figure 14.3 **Growth (constant USD per capita) and property rights protection. Based on data from Summers and Heston, 1995 and World Bank, various years.**

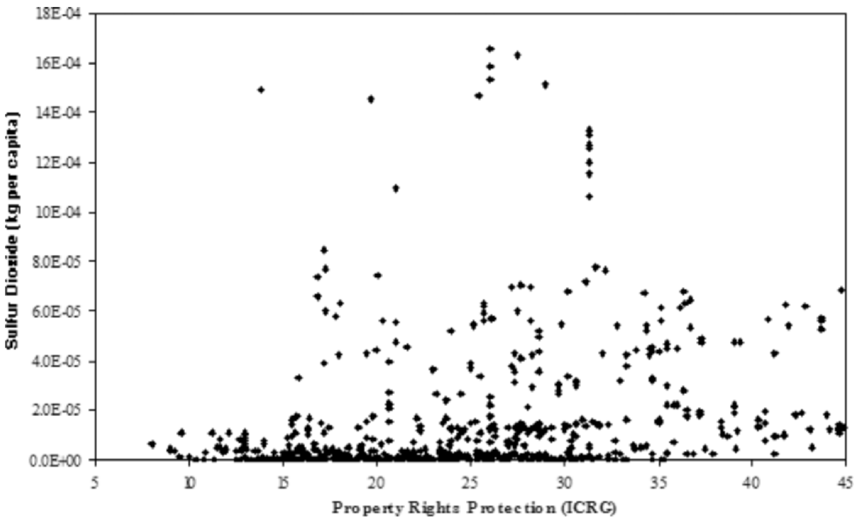

Figure 14.4 **Property rights protection and sulfur dioxide (kg per capita). Based on data from Summers and Heston, 1995 and World Bank, various years.**

14.2.3 Econometric Considerations

In a majority of cases, cross-section time-series data analysis differs somewhat from either cross-sectional or time-series data analysis. So-called panel data and the ways in which it should be analyzed have been studied extensively (see for example Baltagi, 1995; Hsiao, 1986; Matyas and Sevestre, 1996; Sayrs, 1989). Many previously published studies on the correlates of growth and environmental pollution have used ordinary least squares analysis to deal with cross-section time-series data.[25] Based on the literature above and the characteristics of the data at hand, however, Generalized Least Squares with Error Components (GLSE) seemed to be a more appropriate estimation method for our purposes.[26]

[25] With growth as the dependent variable, OLS estimation is used, for instance, by Scully (1988), Torstensson (1994), Leblang (1996), Knack and Keefer (1995), Goldsmith (1995), and Alesina et al. (1996). Shafik and Bandyopadhyay (1992) and Holtz-Eakin and Selden (1995) use OLS with environmental indicators as the dependent variable.

[26] Along with the literature on statistical methods mentioned above, Stimson (1985) informed this decision. We also check for misspecification (of random effects rather than fixed effects) using both the LM and the Hausman test.

14.3 Regression Equations and Findings

Three sets of regression equations are developed and presented in turn.[27] Each set is followed by a list of annotated control variables included in the respective regression equations.

14.3.1 Explaining Pollution

We test for both an inverted-U relationship between pollution and growth, and the N-shaped curve that some previous studies suggest may exist (see for instance, Grossman and Krueger, 1995; Shafik and Bandyopadhyay, 1992). As GDP per capita, (GDP per capita),^{2} and (GDP per capita) are highly correlated,[3] they are used in three separate regression equations, as follows:

$$SO_2/\text{Capita} = \beta_0 + \beta_1(\text{GDP/Capita}) + \beta_2(\text{Year}) + \beta_3(\text{Population Density}) + \beta_4\,(\Sigma(\text{ICRG})) + \varepsilon$$

$$SO_2/\text{Capita} = \beta_0 + \beta_1(\text{GDP/Capita})^2 + \beta_2(\text{Year}) + \beta_3(\text{Population Density}) + \beta_4\,(\Sigma(\text{ICRG})) + \varepsilon$$

$$SO_2/\text{Capita} = \beta_0 + \beta_1(\text{GDP/Capita})^3 + \beta_2(\text{Year}) + \beta_3(\text{Population Density}) + \beta_4\,(\Sigma(\text{ICRG})) + \varepsilon$$

14.3.1.1 Control Variables

- Time has a significant impact on environmental quality in some of the previously published studies. It serves in part as a proxy for technological development, and possibly as a measure of increasing public awareness for environmental issues.[28]
- Environmental degradation is a function of the number of people living in a particular space. Although aggregate population density measures the degree of pressure on natural resource inaccurately (inasmuch as it does not capture local variation among urban and other areas, and thus about the capacity to mitigate environmental stress by

[27] Their selection closely follows previous empirical work where available.

[28] While technology plays a potentially crucial role in alleviating environmental pollution, indicators for the level of technological advancement are controversial. Moreover, data on the number of inventions, patents, or resources allocated to research and development are not available for a wide cross-section of countries.

relocating polluting activities), the aggregate measure still seems to be a good proxy for the number of people affected by a pollutant, especially if the pollution at issue is localized, as is the case for sulfur emissions. Population density values were calculated using population and area data published in World Development Indicators (various years) published by the World Bank.

14.3.2 Explaining Economic Growth

The growth regression was estimated using OLS. After eliminating all cases with missing data, a mere thirty-five observations were left, which is too few for meaningful GLSE estimation. The growth regression was operationalized as follows:

$$\text{Average per capita growth rate} = \beta_0 + \beta_1\,(\Sigma(\text{ICRG})) + \beta_2\,(\text{GDP70}) + \beta_3\,(\text{Gross domestic investment}) + \beta_4\,(\text{General government consumption}) + \beta_5\,(\text{Fertility rate}) + \beta_6\,(\text{SECM25}) + \beta_7\,(\text{Trade openness}) + \varepsilon$$

where Σ(ICRG) is the aggregated index of the five institutional indices contained in the ICRG dataset. GDP70 refers to the initial level of growth. SECM25 stands for the human capital endowment proxy, namely the level of male secondary school enrollment beyond the age of twenty-five, trade openness refers to exports divided by imports, and ε designates the error term.

14.3.2.1 Control Variables

There are several variables known to commonly influence growth. The list of control variables is not exhaustive, but a reasonable compromise between the need to obtain accurate results and the desire to retain as many cases as possible.

- Initial Level of Growth: Some analyses suggest that initial GDP is a significant predictor of growth when a measure of human capital investment is included in the equation (Levine and Renelt, 1992). For this study, initial GDP refers to GDP in 1970. It was obtained from Summers and Heston (1995).
- Investment Share in GDP: Several empirical studies have shown a significant positive correlation between economic growth and the share of investment in GDP. Levine and Renelt (1992) find this correlation to be robust. The data are again drawn from Summers and Heston (1995).

- Government Expenditure: Although the variable does not pass the stringent robustness test proposed by Levine and Renelt (1991), government expenditure has been shown to have a negative effect on growth in some tests (Landau, 1983).
- Fertility Rate: Barro (1997) identifies low fertility as being conducive to growth. In theory, in a society with fewer children, less resources are tied up for childrearing while more people pursue economically productive activities. Countries with lower fertility rates should thus have higher growth rates. The data are drawn from World Development Indicators (various years).
- Human Capital Endowment**:** As mentioned earlier, the investment in human capital has been one of the factors frequently suggested as a determinant of growth performance (Romer, 1990). Several empirical studies of growth have used proxies for human capital (see for example Barro, 1991; Romer, 1990). We are using measures of educational attainment from Barro and Lee (1996).
- Trade Openness: One way in which trade openness is believed to affect growth performance is through the transfer of technology between trading partners (Grossman and Helpman, 1991). A commonly used proxy is the ratio of exports to imports, which we include in the growth regression. Exports and imports are measured in constant 1995 US dollars, and are available as part of the World Development Indicators published by the World Bank.

14.4 Results of the Analysis

14.4.1 Explaining Pollution

Based in part on existing empirical studies and theoretical arguments outlined in Chapter 2, we expected to find an inverted-U relationship between environmental degradation and economic growth. Table 14.2 shows the results for the GLSE analysis with sulfur dioxide emissions as the dependent variable.[29] Only one of the terms measuring growth, the simple linear term, turns out to be significantly, and positively, related to emission levels. This suggests that, contrary to the EKC hypothesis, sulfur emission levels appear to rise monotonically with economic growth. Of the independent variables, the quality of the property rights regime turns out to be significantly and

[29] Note that with GLSE estimation, R^2 is not as reliable an indicator of fit as in OLS models. χ^2 values are more appropriate in this context. For appropriate use of commercial statistical software, the initially unbalanced dataset was balanced, which resulted in fewer observations.

positively related to growth across all three models. Among the control variables, the variable measuring temporal effects (Year) is significantly negatively correlated with emission levels across all three models. With time, then, sulfur emissions appear to decrease.

Table 14.2 **GLSE results: dependent variable sulfur dioxide.***

Independent Variables	**Coeff. (Std. Error)**	**P > |z|**	**Coeff. (Std. Error)**	**P > |z|**	**Coeff. (Std. Error)**	**P > |z|**
GDP/Cap	0.66 (0.32)	0.036				
$(GDP/Cap)^2$			6.7E–6 (0.00)	0.526		
$(GDP/Cap)^3$					3.9E–12 (3E-10)	0.991
Year	–290.6 (116)	0.012	–209.61 (108.9)	0.054	–198.7 (107)	0.063
Pop. density	1.045 (3.36)	0.756	2.93 (3.35)	0.382	3.434 (3.34)	0.304
Σ(ICRG)	351.2 (142.2)	0.014	0.039 (0.01)	0.046	255.03 (139.6)	0.068
Constant	5.7E5 (2.2E5)	0.011	46.67 (21.76)	0.050	4E5 (2E5)	0.058
Overall R^2		0.1558		0.0667		0.051
Θ		0.8772		0.8825		0.8867
$\chi2$		10.09		5.88		5.40
Prob. > $\chi2$		0.0389		0.2081		0.2490

* Number of Cross-sections = 56; Time Intervals = 3 (1980, 1985, 1990); Observations = 168

14.4.2 Explaining Growth

The growth estimation was performed using Ordinary Least Squares.[30] As Table 14.3 shows, all independent variables have the signs predicted by theory and mirror several previous empirical studies reviewed in other papers.

Yet only two of them turn out to be statistically significant, namely human capital endowment (SECM25), and the quality of the property rights regime Σ(ICRG). In line with the hypothesis advanced earlier, better protection of property rights coincides with higher growth rates. Surprisingly, all remaining independent variables are not statistically significant.[31]

[30] Empty cells due to lacking data and the need to balance the resulting dataset for GLSE estimation would have narrowed the number of cases to the point where meaningful analysis seemed impossible.

[31] This may be due in part to the limited number of cases.

Table 14.3 **Regression results: growth as dependent variable.**

Independent Variables	**Dependent Variable: Growth Coefficients (Std. Error)**	**P-Value**
Constant	–1518.68 (3675.96)	0.6828
Σ(ICRG)	142.42 (58.34)	0.0215
GDP 70	0.54 (0.66)	0.4203
Gross Domestic Investment	6.38 (57.58)	0.9126
Government Consumption	–0.78 (87.77)	0.9929
Fertility Rate	–278.27 (376.80)	0.4666
SECM 25	194.05 (50.67)	0.0007
Exports/Imports	–85.08 (1945.35)	0.9654
N	35	
Adjusted R^2	0.8567	

14.4.3 Examining the Role of Property Rights for Pollution Control

Presumably, it could take a while until changes in the quality of the property rights regime manifest themselves in environmental outcomes. To pin down the direction of a possible relationship between the quality of the property rights regime and environmental outcomes more precisely, we thus devise a lagged model, in which we use property rights protection as the dependent variable, and lag all independent variables by a 5-year interval. The lagged regression equation is as follows:

$$\Sigma(\text{ICRG})t{-}1 = \beta_0 + \beta_1(\text{GDP/Capita})t + \beta_2(\text{Year})t + \beta_3(\text{Population Density})t + \beta_4(\text{SO}_2/\text{Capita})t + \varepsilon$$

where Σ(ICRG) is the aggregated index of the five institutional variables published in the International Country Risk Guide. The remaining specification and variables parallel the ones used above. The correlation between SO_2 per capita and GDP per capita was not particularly high, so both are included in the second regression equation.[32] Results of the analysis using the lagged model are shown in Table 14.4.

As noted, only one independent variable is significantly related to the quality of the property rights regime five years prior, namely population density. GDP per capita as well as SO_2 have the expected signs, yet they are not statistically significant. Improvements in the quality of the property rights regime then do not seem to trigger a decrease in sulfur dioxide emissions.

[32] For sulfur dioxide emissions per capita and GDP per capita, correlation values were 0.82.

Table 14.4 **GLSE results: dependent variable property rights protection.***

Independent Variables	Coefficients (Std. Errors)	P > |z|
GDP/Capita	–0002945 (0.001989)	0.139
Year	0.1425252 (0.0891255)	0.110
Pop. density	0.003552 (0.0008477)	0.000
SO_2	35855.17 (29639.54)	0.226
Constant	–265.8185 (176.984)	0.133
Overall R^2	0.2094	
X2	21.63	
Prob. > $\chi 2$	0.0002	

*Number of Cross-sections = 55; Time Intervals = 2 (lag model: 1980, 1985, 1990); Observations = 110

14.5 Conclusion

This chapter examined the relationships among economic growth, property rights protection and environmental pollution. Despite plausible theoretical arguments and several empirical studies that support them, we did not find an inverted-U relationship between sulfur dioxide emissions and economic growth. Our results suggest, by contrast, that sulfur emission levels monotonically increase with economic growth.

Despite unanimous theoretical and empirical consensus on the significance of secure property rights for economic growth, the relationship in our analysis was not robust across estimation methods. When tested as part of a regression estimated by ordinary least squares, the quality of the property rights regime turns out to be significantly, and positively related to growth across all three models. The association all but vanished, however, when tested in a lagged model estimated by Ordinary Least Squares. This discrepancy of results from different estimation methods may mean that inferences drawn from analyses which use ordinary least squares estimation for cross-section time-series data – including the one undertaken in this study – are fundamentally flawed.

Improvements in the quality of the property rights regime do not seem to trigger a decrease in sulfur dioxide emissions either. This may mean that it just takes longer than five years for improvements in the property rights regime to trigger a decrease in emission levels, or, conversely, that the quality of the property rights regime does not influence environmental quality at all.

Overall, our results seriously weaken the case of free market environmentalism. Neither economic growth nor property rights protection should be expected to lead to improvements in environmental quality. We may in fact grow dirtier rather than clean. While searching for alternative strategies to promote environmental health, we should continue to gather data on pollutants across countries, and carefully match it with appropriate estimation methods.

References

Alesina, A., Özler, S., Roubini, N., and Swagel, P. (1996). Political instability and economic growth. *Journal of Economic Growth*, 1, 189–211.

Alesina, A., and Perotti, R. (1996). Income distribution, political instability, and investment. *European Economic Review*, 40(6), 1203.

Anderson, T. L., and Leal, D. (1991). *Free market environmentalism*. (San Francisco: Pacific Research Institute for Public Policy)

Arrow, K., Bolin, B., Costanza, R., Dasgupta, P., Folke, C., Holling, C. S., Jansson, B. O., Levin, S., Mäler, K.-G., Perrings, C., and Pimentel, D. (1995). Economic growth, carrying capacity, and the environment. *Science*, 268(5210), 520.

Baltagi, B. (1995). *Econometric analysis of panel data*. (New York: John Wiley)

Barro, R. (1991). Economic growth in a cross section of countries. *Quarterly Journal of Economics*, 106, 407–433.

Barro, R. (1997). *Determinants of economic growth: a cross-country empirical study*. (Cambridge, MA: The MIT Press)

Barro, R., and Lee, J. W. (1996). International measures of schooling years and schooling quality. *Economic Reform and Growth*, 86(2), 218–223.

Barzel, Y. (1997). *Economic analysis of property rights*. (New York: Cambridge University Press)

Bennett, J., and Block, W. (1991). *Reconciling economics and the environment*. (Perth: Australian Institute for Economic Policy)

BERI. various years. Political risk index, Retrieved May 1, 2006, from http://www.beri.com/brs.asp

Coase, R. (1960). The problem of social cost. *Journal of Law and Economics*, 3, 1–22.

Daly, H. E. (1977). *Steady-state economics: the economics of biophysical equilibrium and moral growth*. (San Francisco: W.H. Freeman)

Dasgupta, S., Laplante, B., Wang, H., and Wheeler, D. (2005). Confronting the environmental Kuznets curve. (In R. N. Stavins (Ed.), *Economics of the environment: selected readings*, New York: W.W. Norton and Company)

De Bruyn, S. M. (1997). Explaining the environmental Kuznets curve: structural change and international agreements in reducing sulphur emissions. *Environment and Development Economics*, 2(4), 485–503.

De Bruyn, S. M., and Opschoor, J. B. (1997). Developments in the throughput-income relationship: theoretical and empirical observations. *Ecological Economics*, 20(3), 255–268.

De Bruyn, S. M., Van den Berg, S. M., and Opschoor, J. B. (1998). Economic growth and emissions: reconsidering the empirical basis of environmental Kuznets curves. *Ecological Economics*, 25(2),161–175.

Dowell, G., Hart, S., and Yeung, B. (2000). Do corporate global environmental standards create or destroy market value? *Management Science*, 46(8), 1059–1074.

EC Directive. (2001). Directive 2001/81/EC on national emission ceilings for certain atmospheric pollutants. *Official Journal of the European Communities*, 309, 22–30.

Eckersley, R. (1993). Free market environmentalism: friend or foe? *Environmental Politics*, 2(1), 1–19.

Eskeland, G., and Harrison, A. (1997). Moving to greener pastures? Multinationals and the pollution-haven hypothesis. (In World Bank policy research department working papers. New York: World Bank)

Gastil, R. D. various years. *Freedom in the world: political rights and civil liberties*. (New York: Freedom House)

Goldsmith, A. A. (1995). Democracy, property rights and economic growth. *The Journal of Development Studies*, 32(2), 157–175.

Grossman, G. M. (1995). Pollution and growth: what do we know? (In I. Goldin and L. A. Winters (Eds.), *The economics of sustainable development,* Cambridge: Cambridge University Press)

Grossman, G. M., and Helpman, E. (1991). *Innovation and growth in the global economy*. (Cambridge, MA: The MIT Press)

Grossman, G. M., and Krueger, A. B. (1995). Economic growth and the environment. *Quarterly Journal of Economics*, 110(2), 353–379.

Hardin, G. (1968). The tragedy of the commons. *Science*, 162, 1243–1248.

Harrison, J. S. (1995). Reduction of sulphur emissions: the economic equation. *Symposium Series*, 138, 3–8.

Holtz-Eakin, D., and Selden, T. M. (1995). Stoking the fires? CO_2 emissions and economic growth. *Journal of Public Economics*, 57(1), 85–101.

Hsiao, C. (1986). *Analysis of panel data*. (Cambridge: Cambridge University Press)

ICRG. various years. *International country risk guide*. (New York: The PRS Group)

Jaffe, A., Petterson, S., Portney, P., and Stavins, R. N. (1995). Environmental regulation and the competitiveness of U.S. manufacturing: what does the evidence tell us? *Journal of Economic Literature*, 33(1), 132–163.

Knack, S., and Keefer, P. (1995). Institutions and economic performance: cross-country tests using alternative institutional measures. *Economics and Politics*, 7(3), 207–227.

Kuznets, S. (1955). Economic growth and income inequality. *American Economic Review*, 45(1), 1–28.

Landau, D. (1983). Government expenditure and economic growth: a cross-country study. *Southern Economic Journal*, 49, 783–792.

Leblang, D. A. (1996). Property rights, democracy, and economic growth. *Political Research Quarterly*, 49(1), 5–27.

Lefohn, A. S., Husar, J. D., and Husar, R. B. (1999). Estimating historical anthropogenic global sulfur emission patterns for the period 1850–1990. *Atmospheric Environment*, 33(21), 3435–3444.

Levine, R., and Renelt, D. (1991). Cross-country studies of growth and policy: methodological, conceptual, and statistical problems. *Policy Research Working Paper Series* 608 New York: The World Bank.

Levine, R., and Renelt, D. (1992). A sensitivity analysis of cross-country growth regressions. *The American Economic Review*, 82(4), 942–963.

Low, P., and Yeats, A. (1992). Do “dirty” industries migrate? (In P. Low (Ed.), *Trade and the environment*, Washington, DC: The World Bank)

Mani, M., and Wheeler, D. (1998). In search of pollution havens? Dirty industry in the world economy, 1960-1995. *Journal of Environment and Development*, 7(3), 215–247.

Matyas, L., and Sevestre, P. (Eds.) (1996). *The econometrics of panel data: handbook of theory and application*. (Dordrecht: Kluwer-Nijoff)

Max-Neef, M. (1995). Economic growth and quality of life: a threshold hypothesis. *Ecological Economics*, 15(2), 115–118.

Meadows, D. H. (1972). *The limits to growth: a report for the Club of Rome's project on the predicament of mankind*. (New York: Universe)

North, D. C., and Thomas, R. (1973). *The rise of the western world: a new economic history*. (Cambridge: Cambridge University Press)

Olson, M. (1965). *The logic of collective action: public goods and the theory of groups*. (Cambridge, MA: Harvard University Press)

Olson, M. (1993). Dictatorship, democracy, and development. *American Political Science Review*, 87(3), 567–576.

Panayotou, T. (1997). Demystifying the environmental Kuznets curve: turning a black box into a policy tool. *Environment and Development Economics*, 2(4), 465–484.

Roca, J., Padilla, E., Farre, M., and Galletto, V. (2001). Economic growth and atmospheric pollution in Spain: discussing the environmental Kuznets curve hypothesis. *Ecological Economics*, 39(1), 85–99.

Rock, M. T. (1996). Pollution intensity of GDP and trade policy: can the World Bank be wrong? *World Development*, 24(3), 471–479.

Romer, P. (1986). Increasing returns and long-run growth. *Journal of Political Economy*, 94, 1002–1037.

Romer, P. (1990). Human capital and growth: theory and evidence. *Carnegie-Rochester Conference Series on Public Policy*, 32, 251–286.

Rosenberg, N., and Birdzell, L. (1986). *How the west grew rich: the economic transformation of the industrialized world*. (New York: Basic Books)

Sayrs, L. (1989). *Pooled time series analysis*. (Newbury Park, CA: Sage)

Scully, G. (1988). The institutional framework and economic development. *Journal of Political Economy*, 96(3), 652–662.

Selden, T. M., and Song, D. (1994). Environmental quality and development: is there a Kuznets curve for air pollution emissions? *Journal of Environmental Economics and Management*, 27(2), 147–162.

Shafik, N. (1994). Economic development and environmental quality: an econometric analysis. *Oxford Economic Papers*, 46, 757–773.

Shafik, N., and Bandyopadhyay, S. (1992). Economic growth and environmental quality: time series and cross-country evidence. (In *Policy Research Working Paper* 904. Washington DC: World Bank)

Skolnikoff, E. B. (1993). Science and technology: the sources of change. (In N. Choucri (Ed.), *Global accord: environmental challenges and international responses*, Cambridge MA: MIT Press)

Solow, R. M. (1993). The economics of resources or the resources of economics. (In R. Dorfman and N. S. Dorfman (Eds.). *Economics of the environment: selected readings*, New York: W.W. Norton and Company)

Stern, D. I. (1998). Progress on the environmental Kuznets curve? *Environment and Development Economics*, 3(2), 173–196.

Stern, D. I., and Common, M. S. (2001). Is there an environmental Kuznets curve for sulfur? *Journal of Environmental Economics and Management*, 41, 162–178.

Stimson, J. (1985). Regression in space and time: a statistical essay. *American Journal of Political Science*, 29(4), 914–947.

Stroup, R. (1990). Chemophobia and activist environmental antidotes: is the cure more deadly than the disease? (In W. Block (Ed.), *Economics and the environment: a reconciliation*, Vancouver, BC: The Fraser Institute)

Summers, R., and Heston, A. (1995). The Penn Mark V world table: an expanded set of international comparisons, 1950–1988. *Quarterly Journal of Economics*, 106, 327–369.

Syrquin, M. (1989). *Patterns of development, 1950 to 1983*. (Washington, DC: World Bank Discussion Papers 41)

Tobey, J. A. (1990). The effects of domestic environmental policies on patterned of world trade: an empirical test. *Kyklos*, 43(2), 191–209.

Torras, M., and Boyce, J. K. (1998). Income, inequality, and pollution: a reassessment of the environmental Kuznets curve. *Ecological economics*, 25(2), 147–160.

Torstensson, J. (1994). Property rights and economic growth: an empirical study. *Kyklos,* 47(2), 231.

Turvey, R. (1963). On divergences bnetween social cost and private cost. (In R. Dorman and N. S. Dorfman (Eds.), *Economics of the environment: selected readings*, New York: W. W. Norton and Company)

World Bank. various years. *World development indicators*. (Washington, DC: World Bank: Development Data Group)

Chapter 15

GLOBALIZATION AND INTERNATIONAL TRADE

Utilizing Insights from Graph Theory

Behram F. T. Mistree and Dinsha Mistree

Introduction

Individuals are mutually linked within an estimated six degrees of separation (Watts, 2003).[1] The notion of such an intertwined world has fascinated many, and serves as a fundamental principle for new and exciting technologies. Inventions ranging from the Internet to the cellular phone make use of a deep and persistent interconnectedness. In turn, these inventions create and destroy new links amongst people, as do many other phenomena such as disease, natural disasters, and trade. Measuring the quality and the quantity of these links between individuals has been a popular pursuit of sociologists.[2] But what can be learned when one implements those same empirical techniques at other societal and political levels?

In this chapter, we explore a new approach to identifying the complex hierarchical order that shapes international relations. By applying techniques from graph theory to examine relationships between countries, we break from a long line of international systems' scholars to take a new path, a path that should help us better understand the dynamic interactions of nations. We approach our analysis along two layers of the international system: the *macrolayer*, or overarching structure of the international order involving all nations, and the *submacrolayer*, whereby groups of nations interact.[3] We conclude with a brief discussion on the applicability of our methodology,

[1] The authors would like to thank Hanyin Lin for her research assistance, and Ramy Arnaout, Nazli Choucri, and Kenneth A. Oye for their advice and feedback.

[2] Watts (2003) provides a good review of the sociological research on interconnectedness.

[3] The third and final layer is the *microlayer*, involving dyadic relationships between two countries.

N. Choucri et al. (eds.), Mapping Sustainability: Knowledge e-Networking and the Value Chain, 301–336.

and how our findings may be used to tackle other questions in international relations.

Theoretical Perspectives of the International System

Scholars in international relations have been extensively engaged in analyzing systemic effects in international politics. Given the broad corpus of literature on this issue and the seemingly perpetual debate over certain definitions and conjectures, we shall consider the literature while avoiding entrance into any particular arguments. In *Man, the State, and War*, Kenneth Waltz introduces three images for analyzing international relations (1954). Each image includes an area of study that can affect world politics. The first image includes individuals, the second image includes the domestic institutions of the nation, and the third image involves the international structure, or system. Waltz's two chief goals are to justify realism in the context of international politics (that nations are driven by power-maximization rather than by simple desires for peace and harmony), and to stress the importance of research in the third image, and more broadly, for understanding systemic patterns of international relations.

Kaplan offers a framework for exploring international systems by considering six such states of equilibrium of the international order; note that only one of these over-arching systems can exist at any given time (1957: Chapter 2):

The Balance of Power System: Exists in a null political subsystem (anarchy). There are at least five "essential" actors/nations in a Balance of Power System that implement the "essential" rules which govern the characteristic behavior of the population of actors.

The Loose Bipolar System: Formalized, supranational actors as well as national actors both participate in such a system. Two subclasses of supranational actors must exist to form the bipolar system. During the time of the Cold War, NATO and the Communist blocs formed a Loose Bipolar System.

The Tight Bipolar System: Similar to the Loose Bipolar System except all national actors belong to one of the subclass supranational organizations. Such a system would resemble the international system during the Cold War if all of the members of the Third World had allied with NATO or the Communists.

The Universal System: The previous three systems include an anarchic political order; the universal system assumes that national actors are governed by a universal actor. If the United Nations and the World Trade Organization had greater power in the contemporary international system, we would call our modern-day international system a Universal System.

The Hierarchical System in Directive and Non-Directive Forms: The Hierarchical System is one in which a universal power rules directly over the people, with no independent national political systems. In its Non-Directive Form, the Hierarchical System is a world-wide democracy; in its Directive Form, the system is authoritarian.

The Unit Veto System: The Unit Veto System can occur when either national actors or bloc actors control the system. The Unit Veto System stipulates that all members have the capability of destroying each other, suggesting that all members are equally powerful.

While Kaplan was writing in the 1950s and 1960s, understanding the over-arching structure of the international system again became popular following the end of the Cold War.[4] Richard Ned Lebow observes that due to the collapse of the USSR, "prominent realists maintain that a shift is under way in the international system from bi- to multipolarity" (1994: 249). For Lebow, a Multipolar System is most similar to a Balance of Power System, except that in a Multipolar System, anarchy could be supplanted by a universal actor. Contending that the paradigm of realism requires the condition of international anarchy, Lebow calls for theorists to explicitly state which system paradigm their theories exist within, and to search for theories that would hold across multiple systems. Lebow explains that theories with carry-over capacity across the various types of international orders form the backbone of neorealism (Lebow, 1994).

Kaufman further considers the nature of international orders in the context of neorealism (1997). Kaufman explains that simply because the 20th Century has been dominated by bipolar and multipolar systems does not mean that these are the only two such systems in existence. History is replete with examples where the international order is best described on a complete gradient, from Hegemony (Universal) to fragmented and wholly separate smaller units (Kaufman, 1997). More importantly, Kaufman explains that "the causes of system variance include not only power-balancing dynamics, which work only imperfectly, but also principles of unit identity [and] economic interdependence ..." (Kaufman, 1997: 200).[5] As a result, Kaufman calls for analyzing economic interdependence and international sub-systems within the context of the overarching international system.

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[4] Between Kaplan and Lebow, several prominent scholars have considered the meta-structure of the international system, coming up with a whole slew of various orders. One system that deserves mentioning is that of Hegemonic System, where one national actor maintains stability across the international system. However, the Hegemonic System is really a derivative of the Universal System. The key readings on the Hegemonic System are Gilpin, 1981 and Keohane, 1984.

[5] Kaufman also calls for investigating technologies for governance and how they affect the international order. This topic encompassed the thrust of a class the author co-taught with several other GSSD affiliates in January, 2006.

To summarize, some nations are stronger than others, suggesting hierarchies exist in the international system. As different alliance structures exist, some nations are also more closely connected with one another. This *homophily*, or level of interconnection among groups of countries, varies across the international system.[6] Moreover, the hierarchies of the macrosystem and the levels of homophily of the various subsystems vary over time. These systemic variations may have a variety of consequences, leading to several questions such as: does a system with a Balance of Power hierarchy tend to be peaceful compared to an imbalanced hierarchy? Are systems with bipolar hierarchies more peaceful than systems with multipolar hierarchies? Do systems with tight poles (with high homophilies) tend to be more peaceful than systems with loose poles (with low homophilies)? As we shall explain in the next section, to answer these questions empirically, we must consider alternative approaches to identifying and analyzing the international system.

Previous Empirical Investigations of the International System

Previous empirical examinations pertaining to these questions have exhibited several problems. Previous research, and the corresponding flaws endemic to most of this work, is best exemplified by Bruce Bueno de Mesquita and David Lalman in "Empirical Support for Systemic and Dyadic Explanations of International Conflict" (1988). Using both systemic and dyadic statistical techniques, Bueno de Mesquita and Lalman's research suggests that systemic differences do not seem to affect international conflict. In contrast, individual country calculations of expected utilities of war are far better predictors for the breakout of international conflict.

While Bueno de Mesquita and Lalman should be applauded for undertaking such an ambitious project, their research methodology could be improved in several ways. First, Bueno de Mesquita and Lalman constrain their analysis of the international system only to European countries. A more rigorous approach should include all of the countries in the international system. Second, Bueno de Mesquita and Lalman do not consider different levels of the international system. While purportedly conducting an analysis of the entire international system, their analysis only includes countries that are deemed to be major powers, meaning that Bueno de Mesquita and Lalman are only examining the highest part of the hierarchy of interactions in the international system. Equally important, Bueno de Mesquita and Lalman do not consider the layers of the international system. By "layers," we mean that the international system is comprised of interactions at the *microlevel*,

[6] The terms "hierarchy" and "homophily" have been adopted from Dodds, Watts, and Sabel (2003). Bueno de Mesquita and Lalman did not use them, despite expressing similar ideas.

whereby countries interact in a one-on-one fashion, at the *submacrolevel*, where countries join regional blocs or alliances, or at the *macrolevel*, where global accords and worldwide institutions shape international interactions (which we have previously identified as the overarching international system). Bueno de Mesquita and Lalman explore microlevel conditions while conducting their dyadic analysis, but they refrain from discussing what they mean by “international system,” and what layer they are examining in their systemic analysis. There is a better way to determine the systemic structure of the international order, and what effects these system properties may have.

15.1 Graph Theory: an Alternative Approach

While scholars in international relations have theorized, and even empirically investigated the international system, sociologists, scientists, and engineers have increasingly engaged in studies of systems pertinent to their own domains and disciplines (Newman, 2003).[7] As scholars recognized the commonality of studying systems, a new mode of analysis grew out of their collaborations. Known as *graph theory*, it now stands as a robust – but still developing – arena within academia.[8] More importantly, techniques of graph theory offer a way of approaching the three levels of the international system at once, by using dyadic relationships to identify and explore submacro and macrosystem structures.

Not surprisingly, one of the chief pursuits of graph theorists rests in analyzing system stability and the spread of system instability. Albert and Barabási examine the stability of certain types of systems and networks in the context of the Internet and the World Wide Web (2002); Maslov and Sneppen investigate stability in protein networks (2002); Dunne, Williams, and Martinez consider system stability in the network of food webs (2002). Indeed, while international relations scholars such as Robert E. Keohane complain that predictability is elusive as “[t]oo many factors interact in complex ways to produce the results we see,” including “[r]andom shocks

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[7] Newman’s “Structure and Function of Complex Networks” represents the best compendium of graph theory (2003). Citing 429 other references, Newman leaves few stones unturned.

[8] Graph theory is also known as network theory. While the terms are used interchangeably throughout the literature (see Newman 2003 for example), we anticipate that in time, network theory will come to classify relationships where flows between actors are involved, while graph theory will describe relationships between various actors. If we accept such a dichotomy, both the fundamental concepts and the mathematics of network theory and graph theory are nevertheless tremendously similar, making such a distinction a moot point. However, since we are primarily focused upon relationships of trade rather than flows of trade, we shall describe our approach as a graph theoretic approach.

[that] disrupt the system," graph theorists do not shy away from this challenge (1997: 150). Instead, they embrace it. The attitude that complexity needs be better understood rather than avoided guides our project, as it is necessary for execution of a proper graph theory methodology.

In order to better understand system stability and instability in the context of sustainability, we seek to identify the structure of the international system. Recognizing that the international system includes a diverse and diffuse set of relationships among an equally diverse and diffuse set of actors (states), we seek to identify the system structure across of one type of common interaction: international trade.[9] Further recognizing that a whole host of non-country actors – including individuals, grassroots movements, multinational corporations, and other non-governmental organizations – all affect international politics, we contain our analysis of the international system exclusively to relationships between countries. While other elements of the international system are important, nations form the backbone of international politics, and it is their relationships among themselves and with the overall structure that we are chiefly interested in identifying (Gilpin, 1981: 26; Kaufman, 1997).

As we alluded to earlier, there are three layers in the international system of trade: the micro (relationships between two countries), the submacro (relationships between more than two countries, but fewer than all countries), and the macro (relationships between all countries). In analyzing trade, much work has already been conducted across all three levels. Micro/dyadic/bilateral relationships have been examined by several scholars of international relations, most recently by Beck, King, and Zeng (2000; 2004) and by Bennett and Stam (2000).[10] At the opposite end of the spectrum, macrorelationships have been considered by Waltz (1954) and Walt (1985), to name just two of many theorists. And between micro and macro, submacrorelationships have been studied in terms of geographic country groupings (Schirm, 2002), in terms of political and military alliances (Krebs, 1999), in terms of culture (Huntington, 1996), and in terms of economic bonds, especially by way of trade blocs (Mansfield and Milner, 1999).

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[9] We shall later explain why we chose trade over other measures. To be clear, there are several options: for instance, it is widely believed that the Asian financial crisis was not caused by changes in trade, but rather by changes in capital and investment flows. Modeling such other economic structures would also be a useful and worthwhile project.

[10] Each of these works use micro relationships to explore the causes and consequences of dyadic conflict. Beck, King, and Zeng's work received significant backlash as they were also introducing a new methodology (by way of neural network analysis) to interpreting long-standing theories. While neural network analysis and graph theory are computationally and methodologically distinct, with the introduction of graph theory, resistance should also be expected from the old-guard.

15.1.1 Key Concepts

If techniques in graph theory can help us improve both submacro and macrosystemic research, then we need to clarify and define the key methodological concepts. To begin, a *graph*, or a *network*, is simply a representation of a system.[11] In our case, the network includes all countries and their relationships in a given time period. A *node*, also known as a *vertex*, represents an individual component of the system.[12] For our purposes, a node represents a country within the international system. Interactions among the nodes can be considered as the unit of analysis. These interactions are usually expressed as an *edge*, which represents a relationship between two nodes.[13]

An edge may be *directed* or *undirected*. A directed edge represents a flow, while an undirected edge simply depicts the existence of a relationship between two nodes. A directed edge is usually displayed with an arrowhead showing the direction of the relationship; an undirected edge is simply a line connecting the two nodes.[14] For example from international politics, a directed edge could represent the flow of migrants from one country to another, while an undirected edge could represent the existence of diplomatic relations between two nations. In Figure 15.1, a network with its basic components is presented; note that the edges are undirected.[15]

Graph theorists frequently discuss the number of *degrees* of a certain node. Degrees correspond to the number of relationships that a certain node enjoys. The number of degrees can be counted by counting the number of edges of a node. In Figure 15.2, Nodes A, C, and E all have only one degree (A–F, C–B, and E–D, respectively). Node B has two degrees (B–C and B–F), Node D has two degrees (D–E and D–F), and Node F has three degrees (F–A, F–B, and F–D).

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[11] Most of the terms and descriptions have been identified and adapted from Newman (2003), but they are all among the standard lexicon in graph theory. Some of these terms are presented in this section, but are not used until later sections. We group the terms together because it is helpful to make one repository of all the terms for ease of reading.

[12] Graph theory is plagued by multiple labeling of similar concepts. In physics, a vertex is known as a *site*; in sociology a node is often referred to as an *actor* (Newman, 2003).

[13] Some individual edges can connect more than two nodes, but these are rare and are typically contained to very complex graph theory. In physics, edges are also known as *bonds*; computer scientists call edges *links*; sociology labels these connections as *ties*. For an excellent summary of the concepts of graph theory that both a novice graph theorist and a network veteran would appreciate, read Newman's "The Structure and Function of Complex Networks" (2003).

[14] Any existing relationship between two nodes is either directed or undirected.

[15] Directed edges are oftentimes known as arcs, and they are represented as arrows (rather than lines) to show directionality.

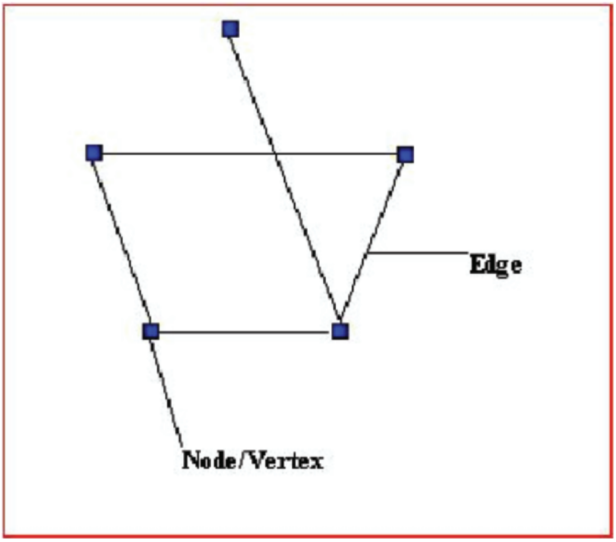

Figure 15.1 **A labeled network.**

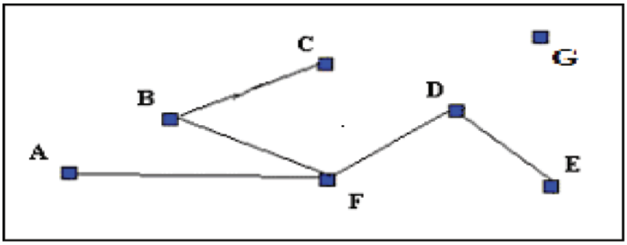

Figure 15.2 **A network with nodes A–G.**

Sometimes one node may be included in the system, but may not connect to the larger grouping. Node G is one such example, with zero degrees. In practice, one would be hard-pressed to identify a country entirely isolated from the rest of the modern-day network, but it is nevertheless theoretically possible.

In a previous section, we discussed several possibilities of the macrosystem, derived from the international relations literature, and one can imagine a list of possibilities even beyond those presented. In graph theory, there is a corresponding set of possibilities, each of which may capture the structure of the macrosystem in the context of the international system. There are at least two broad categories of network types, with a whole range of network subsets in between.

The first type of network in the graph theory literature is the *Random Network* (Newman, 2003; Barabási and Albert, 1999). A Random Network is one in which the degree distribution is Gaussian, or evenly distributed. In a Random Network, a hierarchy could exist with certain nodes playing more important roles than others, but the bulk of the nodes have a similar set of degrees. Hence, Random Networks have interactions taking place across a global arena: there are few submacrogroupings, if any. In Figure 15.3(a) we present such a network structure.

In contrast, a Scale-Free Network is one in which the degree distribution follows a Power-Law, where most nodes have few degrees while just a few nodes exhibit a high number of degrees. A Scale-Free Network tends to be dominated by submacrointeractions. It must also have a hierarchical structure, as certain nodes are more central to the network than others. These types of networks have recently received special attention by theorists as "citation networks, the World Wide Web, the Internet, metabolic networks, telephone call graphs and the network of human sexual contacts" all appear to be Scale-Free Networks (Newman, 2003: 188). In Figure 15.3(b), we display a Scale-Free Network. Notice the shaded nodes, which indicate nodes that are more central to the system structure than the peripheral nodes surrounding them.[16] All networks that have hierarchies involve such Hubs and Spokes, where certain nodes are central to the system structure (Hubs), while others are at the fringes of the system structure, both literally and figuratively (Spokes).

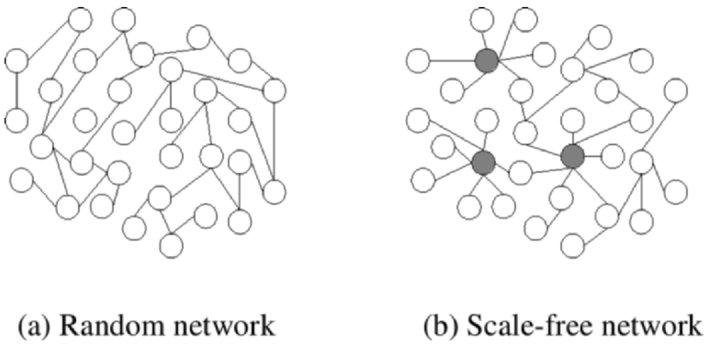

Figure 15.3 **(a) A random network versus (b) a scale-free network. Source: Wikipedia, 2006.**[17]

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[16] Discussions of core- and peripheral- countries are common in international relations literature (Wallerstein, 1976; Denemark et al., 2000). However, such terms have developed a pejorative connotation as they are frequently associated with colonization and imperialism. In order to jump this semantic hurdle, we shall utilize their graph theoretic terms: Hubs and Spokes.

[17] We realize that using Wikipedia should be done with caution, but they present one of the clearest images of a random versus a scale-free network. The image is located in *Scale-Free Networks* at http://wikipedia.org/ (accessed 2006).

15.2 Identifying the Type of System Formed by Trade

To test which type of network best represents the macrosystem, we gathered export data from 1962 to 2003 from the UN Comtrade Database.[18] We selected trade data for this experiment for three reasons. First, trade relationships are easy to measure.[19] Data is easily accessible, and unlike war or conflict, trade relationships are generally agreed upon. Second, trade is one of the most important relationships in international relations: all countries engage in some level of international trade. At the same time, with economic globalization, the World Trade Organization, and the unification of currencies in Europe, patterns of trade have undergone profound changes over the last 40 years. Understanding how these changes have affected the international system is worthwhile. Third, trade is a strong proximate indicator for power relationships between countries and power relationships are the fundamental building blocks of the international system at large (Hirschman, 1980). In other words, we may be analyzing the international system of trade, but such analysis helps us better understand the international economic system, as well as the international system in general.

Despite the advantages of using this dataset, the most fundamental threat to the validity of our findings still rests in the Comtrade dataset. We have to assume that the Comtrade dataset provides all trade relationships in the international trade system. The exclusion of a singular country from our initial runs could potentially have profound and dramatic implications for our findings. By way of validation, we also consulted international trade datasets from other prominent political economists, and we are currently considering the merits and demerits of the various datasets. However if Comtrade is exhaustive, what follows are several empirically-grounded results that could have profound implications for international relations systems theory. If Comtrade is not exhaustive, the value of "walking through" the methodology should also be appreciated.

In our analysis of the macrosystem, all relationships are undirected. This means that we are studying interactions not in terms of flows between countries, but instead we are looking at the aggregate numbers and sizes of the interactions themselves. The database itself provides dollar value relationships

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[18] Behram Mistree extracted the data from the database by constructing a computer program that interfaced with the United Nation's website using standard http protocols. The program requested, parsed, and stored information from the site.

[19] We are analyzing relationships over time, but we want measures that are time-appropriate. Imagine receiving a measure that Country A received six million dollars in capital from Country B in a given year. Due to the tremendous fluidity of capital, this number might become inflated as over the course of the year, some of the capital given to Country A is returned to Country B, only to be again returned to Country A. Therefore, measuring relationships in terms of capital flows does not work.

between all countries. The level of detail of the UN Comtrade data is actually quite impressive. For instance, Comtrade lists that Egypt exported $575 worth of goods to Bermuda in 2003. However, Egypt's exports to Bermuda account for a negligible fraction of its overall exports. Afraid that the inclusion of such superfluous relationships may obfuscate the fundamental dynamics we are attempting to uncover, we only include "major" export flows.

For the purposes of this chapter, we define "major" in such a way that an export flow will only be included when Country A receives a quantity of exports from Country B that is in the top 70% of total exports for Country B.[20] In as much as quantitative analysis is an art, we recognize that such a cutoff introduces a level of subjectivity, but this subjectivity is minimal. More important, this cutoff is rendered consistently throughout the analysis.

To discern results, we shall use two tools: visualization and statistical analysis. Visualizations are one of the key aspects of graph theory. Newman explains that "[t]he human eye is an analytic tool of remarkable power, and eyeballing pictures of networks is an excellent way to gain an understanding of their structure" (Newman, 2003: 170–171). Beyond graph theory, Ortiz discusses the potentials of visualization as a methodology in political science, as visualizations may reveal patterns and relationships which would have gone undetected using traditional analysis (2005). When implementing visualizations as a methodology, however, the researcher must be wary. McGrath and Blythe discuss the dangers of visualizations as methodologies as visualizations may appear different to different people, conveying different meanings and relationships to different researchers (2004). Fortunately, graph theory has recently begun to adopt empirical techniques as complex networks with millions and billions of relationships are now common, and simply visualizing these networks with millions and billions of interconnections is relatively ineffectual (Newman, 2003). As a result, statistics are also being introduced to graph theory to better explain how components in complex systems affect one another.

There are several different ways of portraying networks. After reviewing several of these different ways, we decided to employ a *spring embedding function*, a special type of energy minimization function.[21] An energy minimization function plots the nodes with higher degrees in the center of the

[20] We believe that using 70% as the cutoff adequately strikes a balance between reducing the relatively minor data that would shroud the depiction of the macronetwork while preserving the general and major international trade trends. In the future, we shall conduct sensitivity analysis to see how greatly our results change with various cutoff rates.

[21] These figures were drawn using Netdraw with 100 iterations of the spring embedding function with distance between components equaling 5. Due to the nature of these graphing programs, images are never completely replicable, although the significant relationships should still stand out. After experimenting with another widely-available program known as Pajek, we found Netdraw to be more user-friendly.

image as the algorithm tries to minimize the distance of each edge while allowing a minimum set space between each node. As a result, Hub countries are centered in the image, while outer Spoke countries are placed at the fringe of the image.

15.2.1 Initial Results and Corresponding Implications

Using our methodology, we find that a Scale-Free Network best describes the system of international trade. In Figure 15.4 and 15.5, export relationships among the nations of the world are presented for 1965. Throughout the rest of this chapter, we will often show one network image without country labels and one with country labels so that the reader can first get a general feel for the system structure without being impeded by the country labels, and in the following graph, the reader can then identify the specific countries.

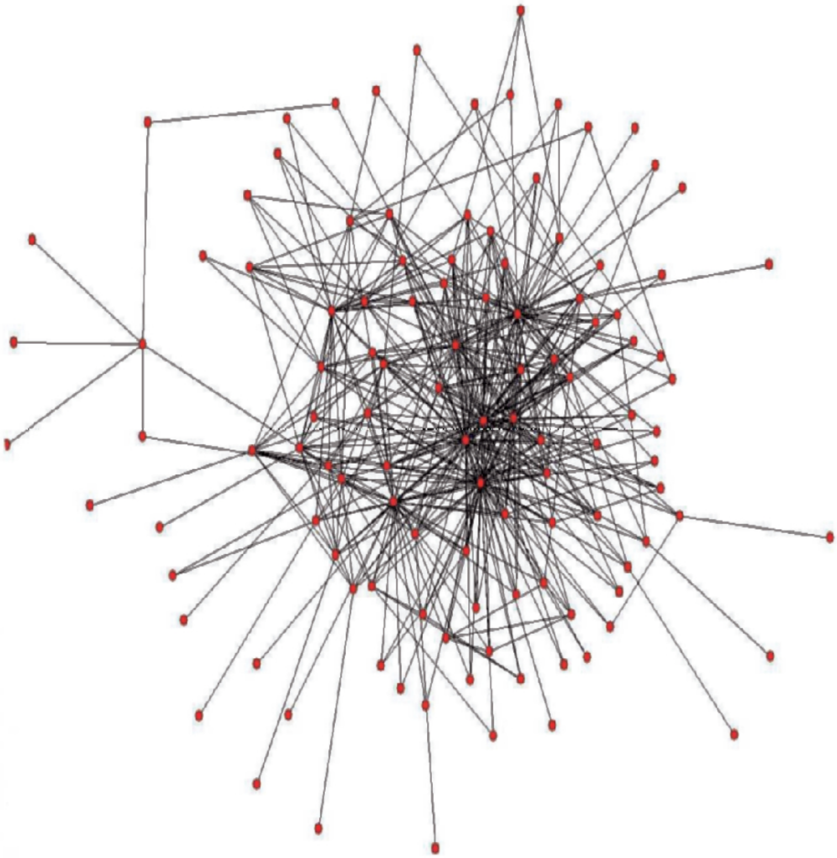

Figure 15.4 **Visual depiction of export network in 1965.**

In Figures 15.6 and 15.7, the state of the macrotrade network in 2000 is presented. Looking at Figure 15.4 in comparison to Figure 15.6, one can easily observe that the central part of the graph contains more nodes. Furthermore, those central countries are increasingly linked with one another.

However, before making any more observations about the changes between 1965 and 2000, two caveats are worth noting. First, since the Comtrade data only offers data for selected countries (typically only for countries that are members of the UN), some countries are not captured in these images, particularly the countries that are not somehow attached to the main network. Second, more countries are included in the dataset in 2000 than in 1965. There could be two reasons for such a condition: more countries may have joined the UN database and/or more countries have entered the macrotrade system. Despite these caveats, we can observe that the overall structure of the network has remained the same, with the center countries maintaining their importance to the overall network stability (if not assuming more

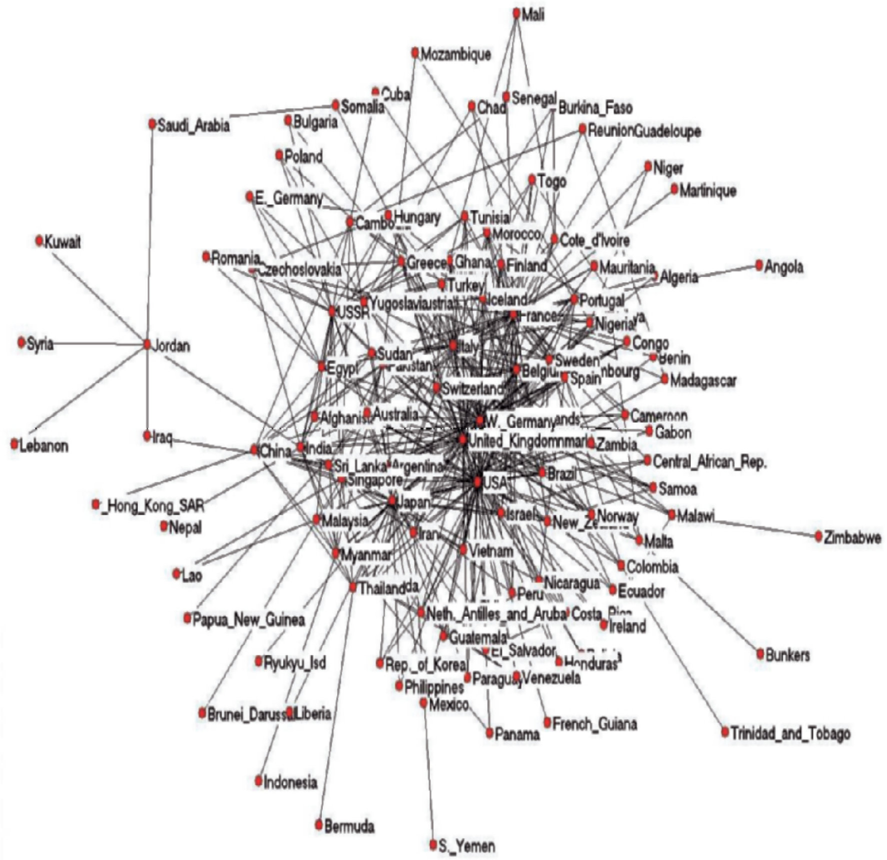

Figure 15.5 **Visual depiction of export network in 1965 (countries labeled).**

importance). The central region of the graph has also become more dense as the Hub countries seem to be trading more with one another and there appears to be more Hubs in 2000. Looking at Figure 15.5 versus the same network structure presented in Figure 15.7, it is not surprising that these central countries are among the world's richest: the United Kingdom, the United States, and West Germany are the three countries with the most degrees in 1965.

There are several other changes that are worthy of attention. Notice how China moves from an outer ring of trade in 1965 to the inner echelons of the network in 2000. In contrast, notice how Afghanistan's position in the international trade system declines as it moves from a semi-Hub location even more central than China to a remote corner of the graph by 2000.

In summary, these images alone do not confirm the existence of a Scale-Free Network, but they do show variations among countries that may suggest differences in trade-power as expressed by their macropositioning.[22] Note

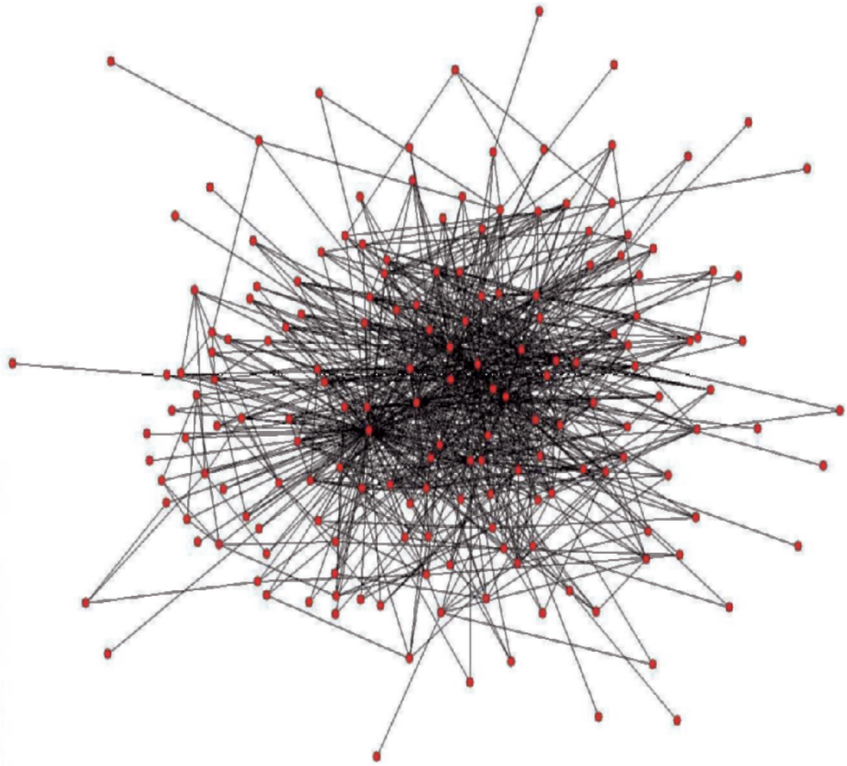

Figure 15.6 **Visual depiction of export network in 2000.**

[22] Power is used here in terms of Hirschman's conception of power, which is the ability of one country to coerce another (1980).

Figure 15.7 **Visual depiction of export network in 2000 (countries labeled).**

that the countries in the center – countries like the United Kingdom and the United States – are the ones which most trade relationships are dependent upon. Notice how the outer countries tend to have few relationships with other countries and are typically dependent upon only one or two countries.

15.2.2 Is the International System of Trade Scale-Free?

In order to determine whether the trade system conforms to a Scale-Free Network, we must inspect the distribution of degrees. In Figures 15.8 and 15.9, we display the distribution of degrees in 1965 and 2000, respectively.[23]

The x-axis represents the number of degrees of a nation and the y-axis represents the probability of a given country having that number of degrees.

[23] These charts were generated using Matlab. We also used Stata and Microsoft Excel for statistical work.

So in 2000, 2 out of 161 countries had 40 degrees exactly. Therefore, there is a 2/161 chance that if a country were selected at random, it would have 40 degrees. If we were to observe a Gaussian distribution, a Random Network

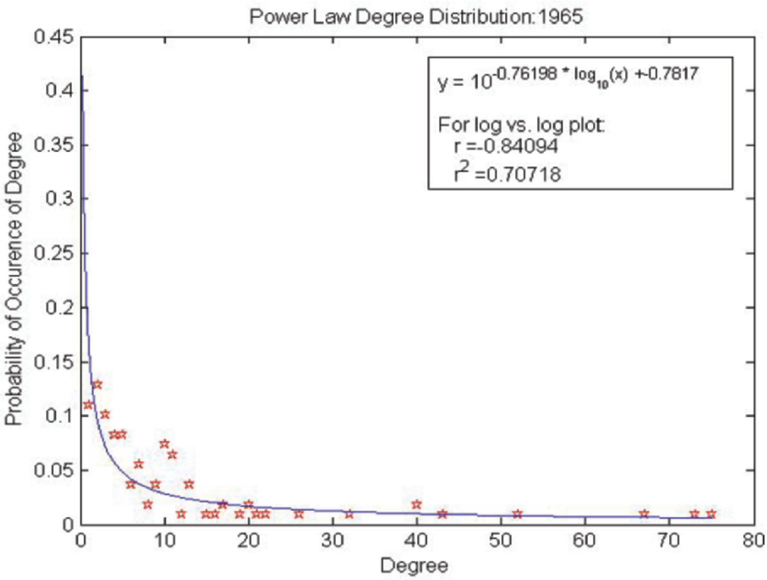

Figure 15.8 **Distribution of degrees in 1965.**

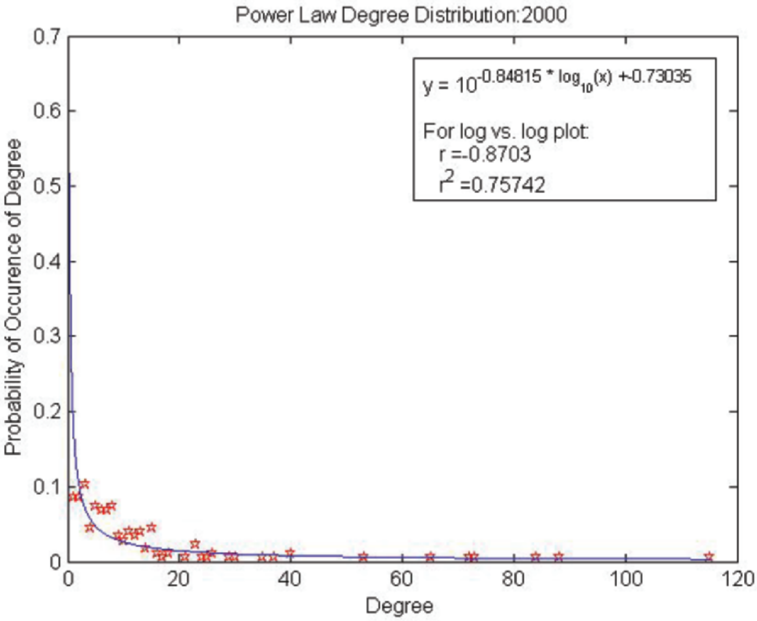

Figure 15.9 **Distribution of degrees in 2000.**

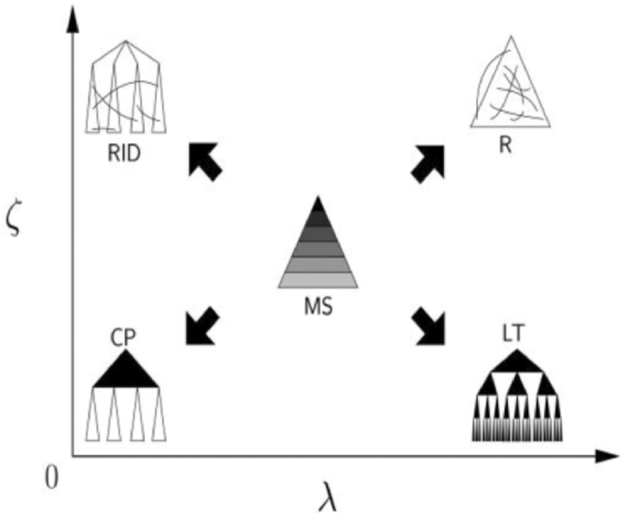

Figure 15.10 **Possible hierarchical structures. Source: Dodds et al. 2004: 12518.**

Would be in effect; if we were to observe a Power-Law distribution, a Scale-Free Network would be in place, with a definite hierarchy among nodes. We find that in both 1965 and 2000, the power-law distribution confirms that the macrotrade system conforms to a Scale-Free Network.

A Scale-Free Network suggests that the overall system is dependent upon some sort of hierarchy. There are several possible hierarchies outlined in the graph theory literature. Beyond Hubs and Spokes, Dodds, Watts, and Sabel have categorized five such possibilities for hierarchical network structures: *Random (R), Random Interdivisional (RID), Core-Periphery (CP), Local Team (LT), and Multiscalar (MS)* (2004).[24] These are presented in Figure 15.10.

The top two hierarchies are restricted to Random Networks. In a *Random Hierarchy*, links are distributed across a system so that flows and relationships need not necessarily follow a top-down structure. In a *Random Interdivisional Hierarchy*, there are apparent top-down relationships, but interactions take place across these cliques in a macromanner more so than a submacromanner. The bottom two hierarchies occur within Scale-Free Networks. In a

[24] Since Pool's days, MIT's Department of Political Science has played a relatively small role in social network analysis, but former department members are playing active roles in the domain nonetheless. For example, Charles Sabel was a professor at MIT from 1977 to 1995; according to his publications, however, he did not become involved in graph theory until joining the faculty at Columbia University. This lack of researchers within MIT department is particularly surprising given the fact that graph theory has emerged in departments across the Institute, and that the Department of Political Science has a strong history of multi-disciplinary collaboration.

Core-Periphery Hierarchy, links occur exclusively within clear-cut cliques in a very rigid and top-down structure. In such a hierarchy, a subservient node may only interact with the node above it. In a *Local Team Hierarchy*, the distributions are further mottled, as nodes of the same team can interact with one another, but must interact with a Hub node. Between the Random Network (typified solely by global interactions) and the Scale-Free Network (typified solely by clique global *and* clique interactions are equally implicit to the network structure. In a Multiscalar Hierarchy, link density (the frequency of links) decreases monotonically with depth. In the top grouping, such hierarchies share a multitude of relationships with one another, with nodes involved in both horizontal and vertical relationships, but by the bottom grouping, relationships are almost entirely vertical. In the image, the darker area implies thicker link density, or *homophily*, between the component nodes. Having already identified that the international system of trade is a Scale-Free Network, we know that the system hierarchy must either be Core-Periphery, Local Team, or Multiscalar. In order to determine which of these hierarchies is in place, we must examine the submacrogroupings of the system.

15.2.3 Exploring Submacrogroupings of the International Trade Network

Scale-Free Networks contain important subsystem groupings which can be used to determine the system's hierarchical structure. A Scale-Free Network has several subsystem groupings, and it is the structure and function of these submacrosystem groupings that have huge ramifications for the international system. If the subsystems are becoming separated and more distinct, as we would expect if regionalism or some other submacroform were on the rise (as Mansfield and Milner, 1999 suggests), we would observe cliques in which the distributions of relationships and the distribution of power increasingly centered on the Hub of the clique. Alternatively, if we were to observe the increasing cohesiveness of nations relative to one another and the emergence of an Egalitarian Network, or a flat world, as Thomas Friedman famously suggests, we would expect to see a transition to a Random Network where cliques and international economies do not matter as much (2005).[25] However, we clearly cannot fully understand the international system or its

[25] Hirst and Thompson discuss the difference between globalization and inter-nationalization, explaining that globalization occurs when a single unified global market is more prevalent than any national markets. Hirst and Thompson explain that the international system is actually one in which inter-national markets dominate the international arena (2002).

macrosystem without understanding the several possible submacrosystems already identified in the international relations literature.[26]

15.2.4 Submacrosystems in International Relations Literature

Submacrosystems come in many forms. Kaplan suggests supranational groupings may make the international order bipolar, or otherwise politically divided (1957); Huntington suggests that the international order is subdivided by cultures (Huntington, 1996); regionalists have explored cooperation among geographically-neighboring states (Schirm, 2002); international political economists frequently investigate trade blocs. In each of these cases, submacrosystems are defined (1) along political or military boundaries, (2) along social boundaries, (3) along geographic boundaries, or (4) along explicitly-defined trade boundaries. This taxonomy of submacrosystems explains all of the types of submacrosystems which form, but no individual gradient of this taxonomy explains all submacrosystems. For instance, if one seeks to capture submacrosystems by classifying countries according to their geographic boundaries or along their cultural (civilization) borders, one will inevitably be forced to neglect other taxonomies or classifications. Cuban international relations from the 1960s to the 1980s were shaped by the Soviet Union, even more so than by their Caribbean submacrosystem counterparts.

Such investigations amount to simplifying at the expense of our understanding of the international system, and such simplifications are common across submacroinvestigations. For instance, one can find research that compares the European Union (EU) and the North American Free Trade Agreement (Abbott, 2000), or research that examines political alliances (Kupchan, 1988), but one is unlikely to find research that compares Asian country relationships to the South African Customs Union, or even research on non-formalized trading communities, where the involved nations cooperate increasingly with one another without the benefits of an official trade alliance. As a result, our understanding of international interactions at the submacrolevel pale in comparison to our understanding of interactions at the micro and macrolevels. In this project, we seek to overcome this condition

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[26] The existence of submacroclusters may confirm Huntington's position that subinternational groupings of countries are the best way of conceiving of the macrosystem (Huntington, 1996). Alternatively, the existence of clusters in the international system may confirm those who believe the macrosystem is actually just a set of several regional systems, with the regions primarily dictated by geography (Schirm, 2002). Certainly, there are formal regional structures which countries join, forming explicit clusters. However, in order to determine the true conditions of the system and whether Huntington and the Regionalists are correct, we must identify the latent subsystems.

by observing submacrorelationships embedded within microrelationships.[27] By embedded relationships, we mean patterns that are defined by the behavior: in this case, multilateral patterns emerge from dyadic international trade relationships.

Why consider such embedded relationships at all? In Figure 15.11, a friendship network of children in a US school is shown (Newman, 2003; picture courtesy of James Moody). The light dots represent white children; the dark dots represent black children; the shaded dots represent children of other racial backgrounds. Notice that while children do divide themselves along racial lines, what emerge are four distinct clusters – or communities of children – suggesting that some other divide beyond race exists as well.[28]

As a thought exercise, imagine these dots as countries instead of school children. Each color would then represent exclusive participation in a certain

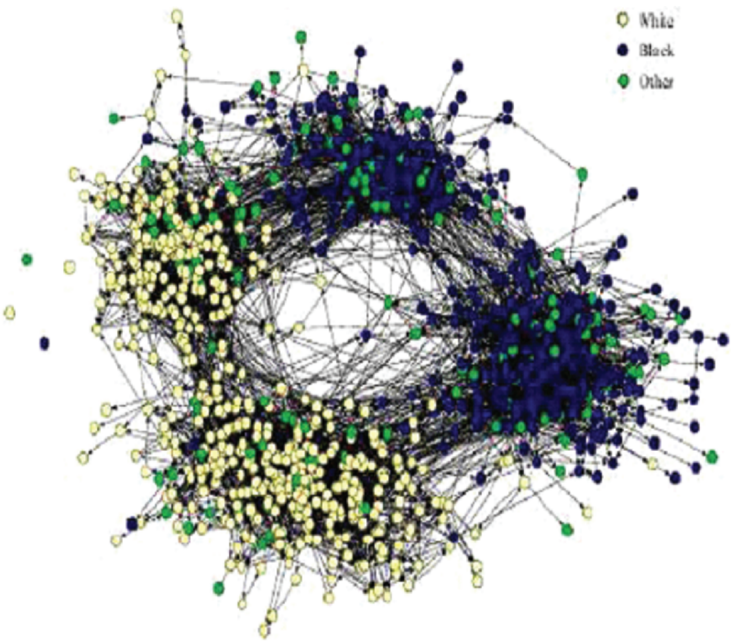

Figure 15.11 **Friendship relationships between children in a US school. Source: Newman, 2003, courtesy of James Moody.**

[27] In earlier drafts of this chapter, we described the latent cliques as "embedded." However, in *The Great Transformation*, Polanyi frequently refers to the economic system being embedded in the interactions of a larger international system, meaning that it is not autonomous. This concept of embeddedness has been adopted by many others, including Granovetter, Ruggie, and Evans (Block, 2001). To avoid confusion, from now on, we will use the term "latent" to describe non-formalized clusters in the international trade system.

[28] One may suspect that this divide is perhaps one of gender or class, but in actuality, it results from an age divide.

explicit trading bloc (such as NAFTA or the EU) as opposed to another trading bloc. However, the common divide within each of the trading groups would not be apparent if participation in a trading group were all that was being considered. Thus, the benefit of identifying each clique in the dataset is that it allows us to observe groupings that are not typically studied. For illustrative purposes, in Figure 15.12 we have provided one such latent submacroclique from 1984. Notice that the seven countries included come from different trade groups, different cultures, different political alliances, and different continents.[29] To be clear, the value of considering latent trade cliques is that they are determined exclusively in terms of trade interactions, without relying upon any prior assumptions about identities or classifications.

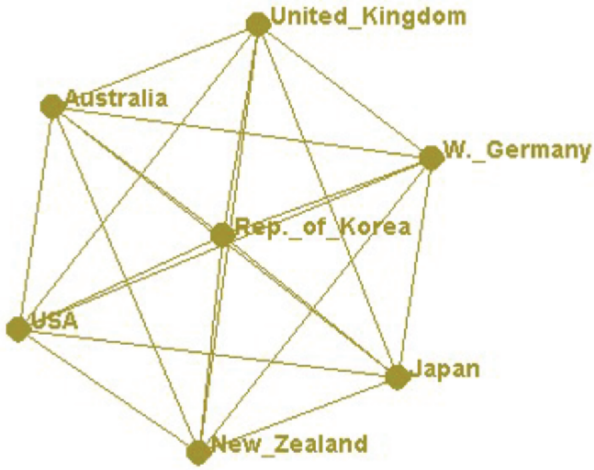

Figure 15.12 **A latent submacroclique in the international system.**

15.2.5 A Submacrograph Theoretic Approach

To identify these several latent submacrogroupings of countries, we shall take full advantages of recent developments in graph theory, especially utilizing advances in *community identification analysis*. Most networks typically have regions where the components are increasingly interconnected relative

[29] A cynic might point out that these countries all belong to the Organization for Economic Co-operation and Development (OECD). However, in 1984, South Korea was not a member of this group and would not join for another 12 years. However, perhaps being so intertwined with these richer countries did help South Korea achieve OECD status, further demonstrating the benefits of examining latent submacrocliques.

to the rest of the network, and these regions are known as *cliques*, or *clusters* (Palla et al., 2005).[30] For our purposes, such *cliques* can be considered as nonformalized submacrogroupings of countries.[31]

Scholars in graph theory have increasingly focused on uncovering latent clique structures within complex networks (Newman, 2004). There are several algorithms that have emerged for identifying these cliques.[32] Among them are *spectral-bisection*, the *Kernighan-Lin Algorithm* (both championed by computer scientists), and the *Bron-Kerbosch Algorithm* (especially useful for finding and defining sociological cliques) (Newman, 2004). In each of these algorithms, the number of latent cliques must be predetermined, and each component must belong to one – and only one – of the cliques. The *Girvan-Newman Algorithm* represents an improvement as it finds "natural" grouping among the components, whereby the user does not have to define how many cliques actually exist at the outset (Newman, 2004).

For studying the international trade system, there are many drawbacks to using any of these algorithms, even the superior *Girvan-Newman Algorithm*. Firstly, by requiring all countries to be classified in a clique, inaccurate groupings of loosely-related nations will be endemic in our analysis. Secondly, by limiting the number of groupings a country may be recognized within to one, these clustering algorithms do not show the full complexity of the international system. Consider the United States, for example, which is heavily involved in trade across the world. If we were to use the *Girvan-Newman Algorithm*, the United States could only be included in one submacrosystem. However, the United States plays an important role in several submacrosystems, interacting in otherwise secluded trading communities in Africa, as well as trading communities in South America, for example. An algorithm which allows us to recognize that a country may belong to more than one clique would be tremendously advantageous.

Palla, Derényi, Farkas, and Vicsek offer a solution in the form of an algorithm which helps the researcher identify components in a network that may belong to several different communities at once (2005).[33] Such an algorithm

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[30] Cliques are also known as clusters, communities, and groupings (Derényi et al., 2005).

[31] By a nonformalized grouping, we mean a grouping that is tied together by the fact that they trade with one another, not *necessarily* by geography, explicit trade bloc status, or culture.

[32] Rather than engage in a lengthy discourse about the mathematics behind each of these algorithms, we shall contain our discussion to the pros and the cons of each algorithm only with regard to our purposes. We recognize that the Palla et al., algorithm which we end up utilizing is the best for our purposes and not necessarily best for other purposes. For a brief introduction to community analysis, consult Newman, 2003 and Newman, 2004.

[33] Palla et al., are all biologists. It is comforting to note that other methodological techniques employed in international relations and biology are also shared. McClelland's concept of equilibrium comes from biology (identified by Goodman, 1965). More recently, evolutionary biologists have adopted methodologies in game theory for their purposes (Hauert and Doebeli, 2004).

provides us a way of identifying latent submacrosystems without limiting the participation of a country to a singular submacrosystem.[34] In Figure 15.13, from Palla et al., the image on the left shows how typical community identification analysis does not recognize overlaps. Such an image is the product of a divisive grouping algorithm, like the four previously identified. The image on the right shows overlapping cliques, with nodes that belong to more than one clique, as produced by Palla et al. Considering the manifest divides in the international system alone, such a structure may be more appropriate: France belongs to NATO and the EU while the United States is a member of both NAFTA and the OECD. The Palla et al., Algorithm offers us the best leverage for considering the submacrosystems of the international trade system.

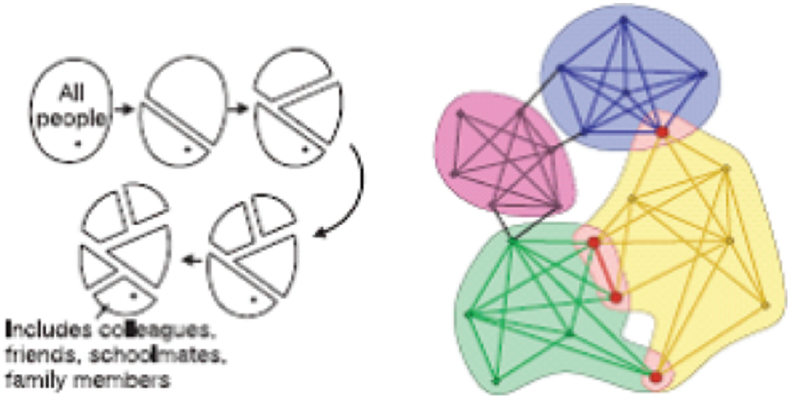

Figure 15.13 **Divisive cliques vs. overlapping cliques. Source: Palla et al., 2005.**

Recognizing that there are overlaps among latent trading communities, the Palla et al. Algorithm allows us to entirely reconsider the submacroconcept. Such community identification analysis should not be confused with typical clustering analysis found in traditional statistics. When one uses methods of clustering analysis found in traditional statistics, one is grouping based upon their relationships with one another rather than basing the observations based upon similar characteristics.[35] Such clustering analysis would be useful for creating a cluster of the richest countries in the world, for example. In contrast, community identification analysis group countries upon their similar attributes. In order not to further confuse the reader, we shall not use the term "cluster" to describe our submacrogroupings, but instead we shall call them either

[34] The algorithm was originally constructed to observe protein cliques in yeast to make predictions for the unknown functions of some proteins (Derényi et al. 2005).

[35] Newman observes that the algorithms used for clustering analysis and community identification analysis are similar, but distinct (2003).

cliques or communities, both acceptable substitutes in the graph theory literature (Newman, 2004; Palla et al., 2005).

The Palla et al. Algorithm is based upon an adaptation of an existing method for identifying latent cliques.[36] The existing method is known as the Clique Percolation Method (CPM). The CPM identifies cliques by scanning for k-cliques. A k-clique is one in which all nodes within the clique share a specified minimum number of edges minus one. More formally, k-cliques are "complete (fully connected) subgraphs of k vertices" (Derényi, Palla, and Vicsek, 2005: 160202-2). In Figure 15.14, a k-clique is presented where $k = 2$. Because it is the minimum number of edges, notice that despite the fact that two of the nodes in this figure actually have four edges, the rest of the nodes have three edges, making $k = 2$. Essentially, a CPM algorithm scans the data for each of these k-cliques starting at $k = 3$, then proceeding to $k = 4$, and so on. As a result, any clique requires at least 3 nodes. As the algorithm reaches the maximum k-clique, the percolation method instructs the algorithm to terminate.

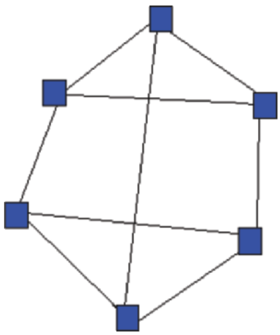

Figure 15.14 **A *k*-clique where *k* = 2.**

Ordinarily, once a typical algorithm identifies a node at one k-clique level, it does not group that node with any other clique at that level. The Palla et al. Algorithm differs from the previous algorithms in that a node may still be included in another clique. In other words, nodes are included across several cliques, even at a common k-clique level (Derényi et al., 2005; Palla et al., 2005). Palla et al., have graciously made their clique-identifying algorithm publicly available and free of charge, even providing a graphical user interface for convenience (2005).[37] The program which they create, known as CFinder, visually displays the latent cliques.

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[36] For those further interested in the mathematics behind the algorithms, first consult the Derényi et al., article in *Physical Review Letters*, 2005, before Palla et al., 2005, in *Nature*.

[37] For Palla et al.'s algorithm and clustering program, visit http://angel.elte.hu/clustering/ (accessed April 2006).

To locate and identify the submacrostructures, we again use export data from the UN Comtrade Database from 1962 to 2003. From this data we again identify dyadic relationships between countries, again only including major trade relationships.[38] Once the data is organized in terms of dyads, stored in a text file, and selected, we can run the calculations and compute the latent clusters using CFinder. CFinder not only allows us to identify relationships and display latent clusters, but it also provides graphs the clusters. However, CFinder does not incorporate spring embedding or any energy minimization function into its graphs, of making some of the visualizations very difficult to analyze without the help of Netdraw or Pajek.

15.2.6 Examining Submacrosystems to Identify the Macrosystem

Looking at the macrosystem, we ruled out the possibility of a Random or a Random Interdivisional Hierarchy existing across the entire network, as we found that the macrosystem is actually a Scale-Free Network. However, Random Hierarchies and Random Interdivisional Hierarchies do exist at the submacrolevel, as do Core-Periphery Hierarchies and Local Team Hierarchies. Networks can have a variety of hierarchies, and when a network has multiple hierarchies, it enters the Multiscalar region.

One should not simply accept the statement that all hierarchies are prevalent in the international trade system, however, as we have the means of demonstrating it. In order to determine the nature of the macrosystem, we have to examine the several international submacrosystems. Three types of cliques emerge from our analysis, displaying a range of *interdependence*. Rosencrance and Stein identify at least three different ways in which interdependence has been previously conceived in international relations:

> In its most general sense, interdependence suggests a relationship of interests such that if one nation's position changes, other states will be affected by that change. A second meaning, derived from economics, suggests that interdependence is present when there is an increased national "sensitivity" to external economic developments … The most stringent definition comes from Kenneth Waltz, who argues that interdependence entails a relationship that would be costly to break (Rosencrance and Stein, 1973: 2).

We adopt the most general notion of the term, that if one nation changes itself, other states will be affected by that change.[39] The amount that a nation will be affected by another nation depends upon the form of interdependence.

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[38] Major trade relationships are already defined and explained in the preceding sections.

[39] In reading the literature, we were struck by the number of authors who would discuss interdependence without defining the term.

In terms of latent cliques, interdependence ranges from cliques with one Hub and several Spokes to cliques with multiple Hubs and several Spokes to cliques with several countries of the same hierarchical type. In each case, if one nation changes itself, other states will be *differently* affected by that change.

15.2.6.1 Pure-Dependent Submacrosystems

The first clique formation we shall label a *Pure-Dependent Submacrosystem*. In this clique, a Hub country is crucial to tying the flow of international trade to the rest of the clique and therefore, these Spoke countries are solely dependent upon the Hub. Take, for example, a $k = 4$ latent clique from 2002, as shown in Figure 15.15. The other countries in the latent clique are functionally dependent upon the United States to connect to the larger trade network. Excluding the United States, the average clustering coefficient of the group is 0.6786, much higher than the United States' 0.4190 coefficient, with a low clustering coefficient suggesting diversity of partners, and in turn, increased interconnectivity with the international system.[40] As a result, power is heavily concentrated with the United States and if Hirschman is correct, we would expect to see the United States able to coerce these other countries if necessary, both economically and politically (1980).

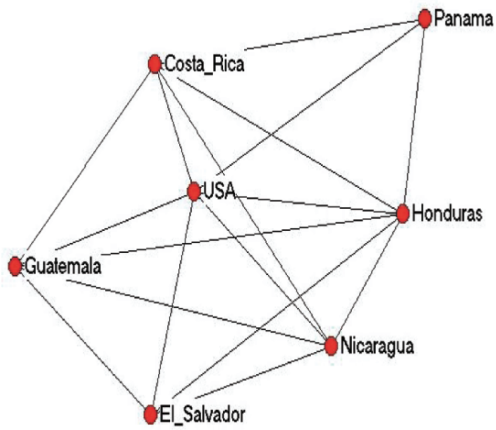

Figure 15.15 **A $k = 4$ latent clique from 2002 (countries labeled).**

[40] The clustering coefficient for a node is the likelihood that its partner nodes interact with one another. In terms of trade, imagine three countries: A, B, and C. If countries A and B trade, and countries B and C trade, the clustering coefficient shows the likelihood of a trade relationship existing between countries A and C.

Hirschman empirically demonstrates that large trading countries have a preference to interact with smaller trading countries (1980). Hirschman explains that given two countries, a strong one (Country A), and a weak one (Country B), Country A has an interest in monopolizing the trade of Country B, and Country B has an interest in "splitting its trade equally among as many countries as possible in order to escape too great a dependence on one or two great markets or supply sources" (Hirschman, 1980: 85–86). The logic for such a struggle is simple: trade dependencies give the dominant country the ability to affect the weak country, both in terms of economic coercion as well as social and political coercion. In addition to statistical analysis, Hirschman also offers a convincing case study in Nazi Germany. Hirschman observes that the Nazis used trade relations to first penetrate, and then dominate countries in several areas, especially in Southeast Europe.

Hirschman's work is focused upon dyadic relationships, but his theories can be extrapolated for the rest of the international system, offering other interesting insights. For instance, having a large trade deficit is not as detrimental for a Hub if other countries are becoming increasingly dependent upon that country, particularly if that Hub is a Hegemon. The Hub is gaining relatively to the other countries in the system, making it more integral to the stability of the system. If that country collapses, other countries which are dependent upon the Hub country are equally in trouble. This property is similar, but not identical, between the various hierarchical structures we identified earlier.[41] However, this Pure-Dependent clique formation most closely conforms to a Random Interdivisional Hierarchy, but it may also occur within a larger Local Team, Core-Periphery, or Multiscalar Hierarchy.

15.2.6.2 Identifying Gatekeepers

When a Random-Interdivisional Hierarchy or a Multiscalar Hierarchy is in place, a certain country may prove crucial to tying the horizontal flow of trade between two cliques. We define such countries as *Gatekeepers*, as they have the ability to regulate interactions between the submacrogroupings. In Figures 15.16 and 15.17, we see that a clique of primarily European countries and a clique of primarily Asian countries are principally connected through just a few Gatekeepers.

Gatekeepers can influence other nations by their positions not just in the macrosystem, but also by their positions between cliques. Gatekeepers need not only be Hub countries as we observed Pakistan serving as one of many Gatekeepers in 1982. In the 1980s, aid flows to Afghanistan from the Soviets and the West made Afghanistan play a Gatekeeper role in the international

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[41] We speculate that this property depends upon the vertical nature of the hierarchy, and we plan on examining this property at another time.

aid system. Such a role as the intermediary helped Afghanistan avoid capitulating to Soviet coercion as the Western clique fought to protect its sovereignty during the Soviet invasion of the 1980s.

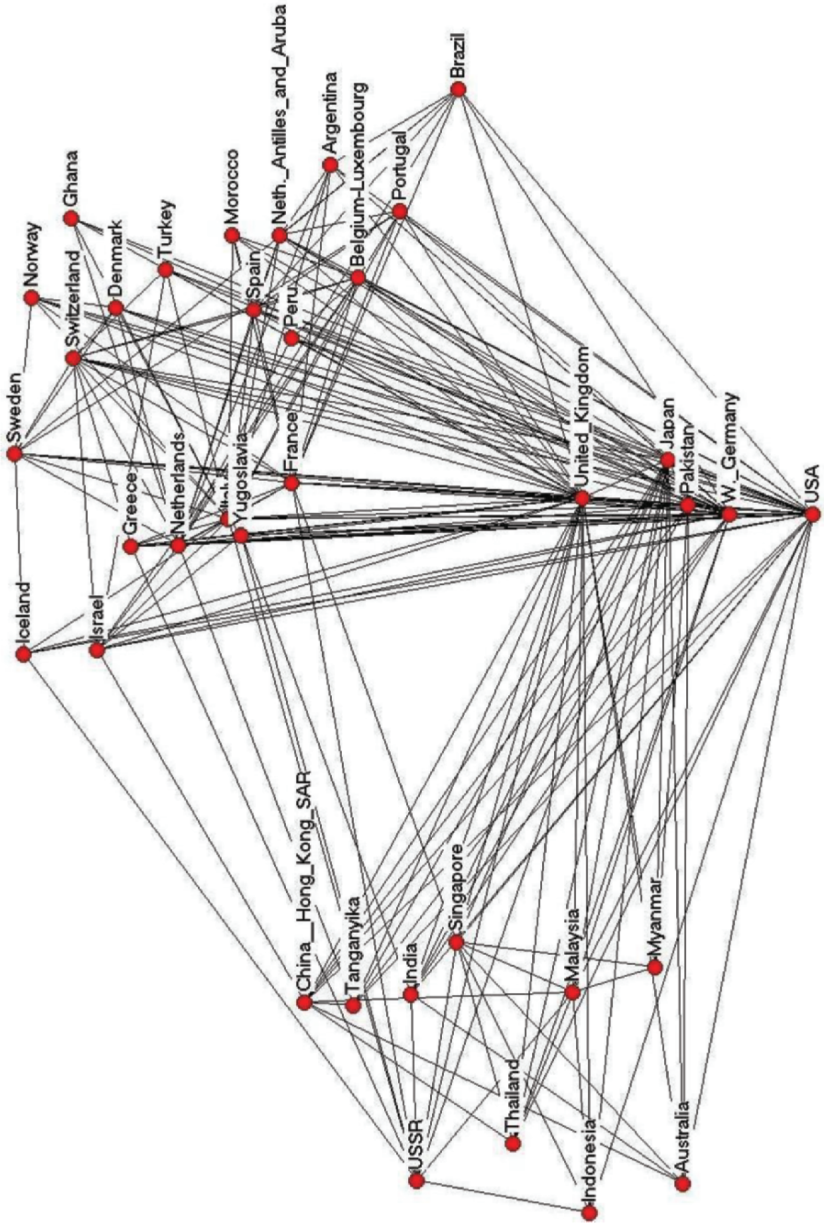

Figure 15.16 **Two *k* = 6 cliques and their connecting nodes (countries labeled).**

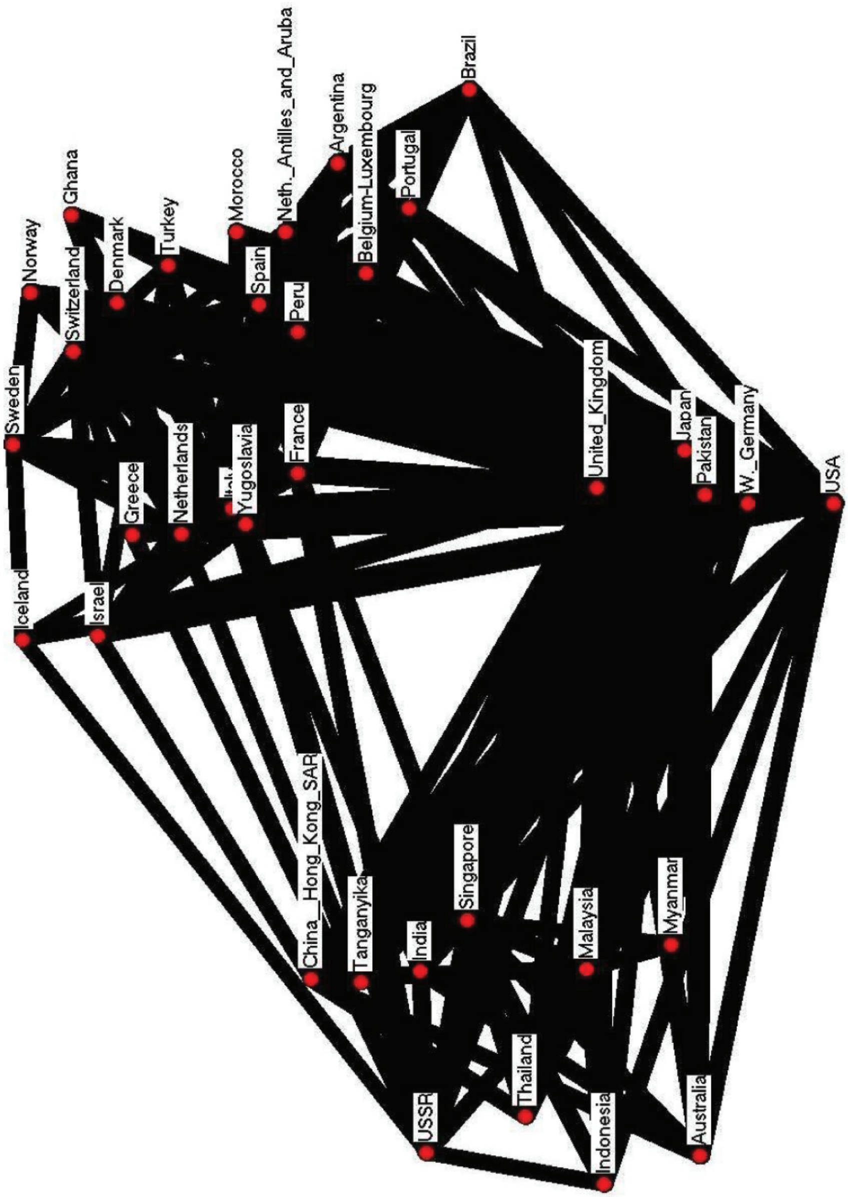

Figure 15.17 **Two *k* = 6 cliques and their connecting nodes, with weighted relationships (countries labeled). Notice that most of the trade flows through the bottom right group of countries.**

Further applying Hirschman's logic to submacrosystem dynamics, dominant countries not only have an incentive to minimize other Gatekeepers, but they should strive to become Gatekeepers themselves. If a country can fully control a submacrosystem and serve as the submacrosystem's only link between those Spokes and the rest of the international order, that Hub country will rise in relative and absolute power. For the United States, such was the logic of the Monroe Doctrine of the 1800s. Discovering those isolated cliques in order to connect them with the larger world trade system also drives trade expansionism today in much the same way as colonialism and mercantilism influenced country policies over the last 500 years.

Hubs would have an interest in breaking down other Hubs' monopoly power, or at the minimum, Hubs would want to see trade relationships develop among a rival country's Spokes and the international system. For example, it is beneficial to the Europeans that Japan, China, and South Korea are increasingly competing against one another while vying for better positions in the macrosystem, so long as one of these countries does not emerge on top and so long as these countries do not join forces in some supernational structure. If China emerges as the dominant country in East Asian trading circles, with subordinates of the caliber of Japan and South Korea, China would instantly enjoy greater position in the trade system.

15.2.6.3 Multi-Dependent Submacrosystem

Not surprisingly, we do find cliques with multiple Hubs. In these cliques, Spoke countries are not completely dependent upon a sole Hub and connect to the international system through an alternate route. As a result, if one Hub introduces a form of coercion on the Spoke, the Spoke has the ability to resist by turning to the other Hub, tempering the coercive ability of the original Hub. Within such a submacroclique, there is a system in effect, whereby each Spoke has a level of autonomy from its multiple Hub partners, and thus we classify such clique relationships as a *Multi-Dependent Submacrosystem*.

One such clique, a $k = 5$ clique from 1984 is presented in Figure 15.18. Notice how West Germany and the United States, each with high clustering coefficients and significant trade participation across the world, share the markets of Costa Rica, Guatemala and El Salvador. In such a condition, the Spoke countries are stronger because if one Hub country engages in coercion, the Spoke countries may turn to the other Hub country for assistance. However, compared to the Gatekeeper relationship, if one Hub country cannot push the other Hub country out of the submacrosystem, the two Hub countries are likely to increasingly cooperate, forming an oligopoly (Hirschman, 1980).

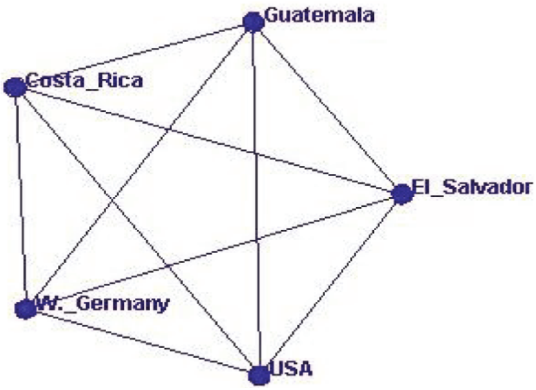

Figure 15.18 **A *k* = 5 latent clique from 1984 (countries labeled).**

15.2.6.4 Mutually-Dependent Submacrocliques

Rounding out the range of submacrocliques are latent cliques that are made up of countries which are mutually dependent upon one another. Most of the high value *k*-cliques are such communities, and they are usually solely comprised of Hub countries. The latent clique presented in Figure 15.19 is one such clique. This clique formation is an *Mutually-Dependent Submacrosystem*, whereby the resilience of the system is highly contingent upon each of the members of the community. These upper-level cliques are the closest approximations of Egalitarian Networks observed in the international trade system.

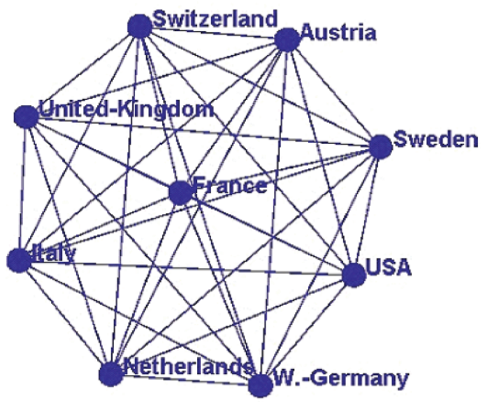

Figure 15.19. **A *k* = 9 latent clique from 1964 (countries labeled).**

In terms of hierarchical possibilities, such a clique displays high *homophily*, or high interconnection between its members. This clique is necessary for a Scale-Free Network, and it is necessary for Multiscalar, Local Team, and Core-Periphery Hierarchies. Such a small and exclusive latent clique would not be found in the Random or Random Interdivisional Hierarchies as it would not occur in a purely Random Network.[42]

Combined, this evidence suggests that a Multiscalar Hierarchy exists, as we do see elements of Random Interdivisional and Random Hierarchies, as well as elements of Core-Periphery and Local Team Hierarchies. Just as we would expect in a Multiscalar Hierarchy, we do observe some level of homophily, or horizontal trade, but we also observe a significant amount of vertical trade as well. As one moves vertically up the hierarchy, higher and higher levels of homophily are present.

15.3 Re-Examining the Macrosystem in the Context of the Submacrosystem

We shall now put the components together. Both our macro and submacroanalysis suggest that the macrosystem is governed by a network of Hubs heavily interacting with one another. Typically, the Hubs are European or Western, but in recent times, other countries such as India and China have joined the higher levels of trade. In Figure 15.20, we display the theoretical structure of the upper echelon, as justified by our macro and submacrolevel analyses. It is not surprising that such a structure resembles what we would expect in a Balance of Power System, with several Hubs of approximately equal trade capabilities.

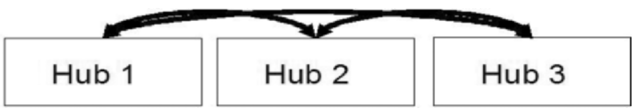

Figure 15.20 **The theoretical upper-echelon.**

In Figures 15.21 and 15.22, we present two theoretical double-level, Multiscalar hierarchies distinct from those of Dodds et al. In Figure 15.21, we offer an international system with only Pure-Dependent Submacrorelationships in the vertical frame. In Figure 15.22, we depict an international system laden with Multi-Dependent Relationships. The edge thickness in each figure represents the homophily: notice that the edges between the Hubs are thicker than the edges between the Hubs and Spokes.

[42] A clique like this one may occur in an Egalitarian Network if the population was limited to only these countries.

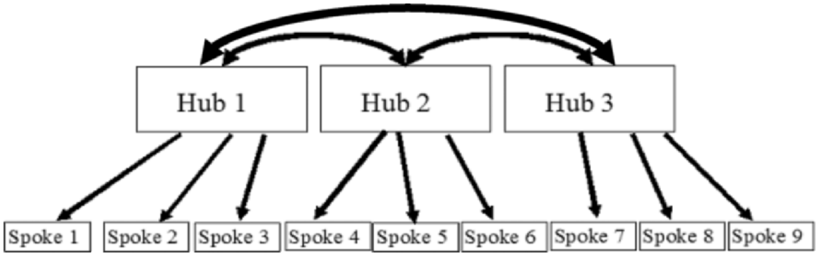

Figure 15.21 **The upper-echelon with spokes connected through Pure-Dependent Submacrorelationships.**

Also, in the real-world hierarchy, there are many levels, with intermediary components connecting countries in a far more complex pattern than what is presented below. We posit that the hierarchic international system of trade lies somewhere in between these two structures, with the modern-day trend approaching Figure 15.22 as the degrees of separation between nations reduces. We suspect this transition because in our analysis, we do see a drop in the average degree of separation, and in the real-world we do hear of greater involvement by Hubs in these so-called *emerging markets*.

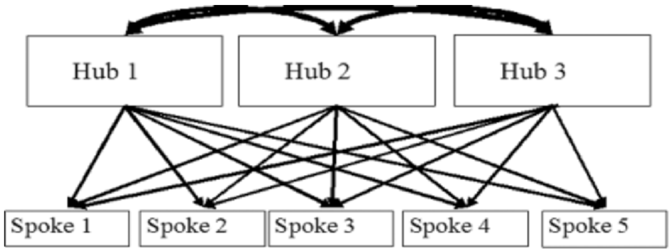

Figure 15.22 **The upper-echelon with spokes connected through Multi-Dependent Submacrorelationships.**

Reconsidering cascading failures, in either structure such contagion effects should tend to spread either horizontally or descend through the system. Additionally, due to the high homophily in the upper echelons of the trade hierarchy, the upper echelon members should be more or less resilient when faced with bottom-up disturbances, relative to the amount and depth of interconnections between the Hubs and the Spokes. In other words, if the economy of a small country collapses, we would not expect any large economies to collapse unless several other small country economies collapsed at once. However, if the economy of a large country collapses, we would expect the small country to suffer as well.

15.4 Conclusion

Graph theory is useful for understanding a system's overall structure, but it is also useful for understanding relative positions of elements within a system. In this chapter, we have utilized graph theory to explain stability and contagion, both of which are important aspects of sustainability. We find that the international system is predisposed towards horizontal and top-down contagion, but that it is remarkably resilient to contagion effects that rise from the bottom-up. In other words, the economic collapse of a small country is unlikely to adversely affect any large economy. We also find that certain countries in the international system have a greater ability to exercise coercion, not just from their absolute elements (such as military force or economy size), but also due to their relative elements (consider major power monopolization).

In this chapter, we have just scratched the surface of the possibilities of graph theory for better understanding conditions for sustainability of trade patterns. Similar to the system of international trade, many issues of sustainability are under girded by complex patterns of interactions between various stakeholders. Understanding these patterns can yield beneficial results across many domains. Furthermore, graph theory is still developing and growing as a field. As our understanding of the systems involved in sustainability develops, and as graph theory is developed, we expect to see new and exciting directions for research in sustainability due to graph theory. Graph theory can help us better understand these patterns and can help us craft better policies for the future.

References

Albert, R. and Barabási, A. (2002). Statistical mechanics of complex networks. *Review of Modern Physics*, 74(1), 47–97.

Abbott, F. M. (2000). NAFTA and the legalization of world politics: a case study. *International Organization*, 54(3), 519–547.

Barabási, A. L. and Albert, R. (1999). Emergence of scaling in random networks. *Science*, 286, pp. 509–512.

Beck, N., King, G., and Zeng, L. (2000). Improving quantitative studies of international conflict: a conjecture. *American Political Science Review*, 94(1), 21–35.

Beck, N., King, G., and Zeng, L. (2004). Theory and evidence in international conflict: a response to de Marchi, Gelpi, and Grynaviski. *American Political Science Review*, 98(2), 379–389.

Bennett, D. S. and Stam, A. C. (2000). Research design and estimator choices in the analyses of interstate dyads. *Journal of Conflict Resolution*, 44(5), 653–685.

Berton, P. (1969). International subsystems: a submacro approach to international studies. *International Studies Quarterly*, 13(4), 329–334.

Block, F. (2001). Introduction. (In K. Polanyi's *The great transformation: the political and economic origins of our time*. Boston: Beacon Press)

Bueno de Mesquita, B. and Lalman, D. (1988). Systemic and dyadic explanations of war. *World Politics*, 41, 1–20.

Denemark, R. A., Friedman, J., Gills, B. K., and Modelski, G. (2000). An introduction to world system history: toward a social science of long-term change. (In R. A. Denemark, J. Friedman, B. K. Gills, and G. Modelski (Eds.) *World system history*. New York: Routledge)

Derényi, I., Palla, G., and Vicsek, T. (2005). Clique percolation in random networks. *Physical Review Letters*, 94, 160202.

Dodds, P. S., Watts, D. J., and Sabel, C. F. (2003). Information exchange and the robustness of organizational networks. *Proceedings of the National Academy of Sciences*, 100(12), 12516–12521.

Dunne, J. A., Williams, R. J., and Martinez, N. D. (2002). Network structure and biodiversity loss in food webs: robustness increases with connectance. *Ecology Letters*, 5, 558–567.

Friedman, T. (2005). *The world is flat*. (New York: Farrar, Straus and Giroux)

Gilpin, R. (1981). *War and change in world politics*. (Cambridge, UK: Cambridge University Press)

Goodman, J. S. (1965) The concept of "system" in international relations theory. *Background*, 48(4), 257–268.

Hauert, C. and Doebeli, M. (2004). Spatial structure often inhibits the evolution of cooperation in the snowdrift game. *Nature*, 428(8), 643–646.

Hirschman, A. O. (1980). *National power and the structure of foreign trade.* (Los Angeles, CA: University of California Press)

Huntington, S. (1996). *The clash of civilizations and the remaking of world order.* (New York: Touchstone Press)

Kaplan, M. A. (1957). Systems theory. (In J. C. Charlesworth (Ed.), *Contemporary political analysis*. New York: The Free Press.)

Kaufman, S. J. (1997). The fragmentation and consolidation of international systems. *International Organization*, 51(2), 173–208.

Keohane, R. O. (1984). *After hegemony: cooperation and discord in the world economy.* (Princeton, N.J.: Princeton University Press)

Keohane, R. O. (1997). Problematic lucidity: Stephen Krasner's 'State power and the structure of international trade.' *World Politics*, 50(1), 150–170.

Krebs, R. R. (1999). Perverse institutionalism: NATO and the Greco-Turkish conflict. *International Organization*, 53(2), 343–377.

Kupchan, C. A. (1988). NATO and the Persian Gulf: examining intra-alliance behavior. *International Organization*, 42(2), 317–346.

Lebow, R. N. (1994). The long peace, the end of the cold war, and the failure of realism. *International Organization*, 48(2), 249–277.

Mansfield, E. D. and Milner, H. V. (1999). The new wave of regionalism. *International Organization*, 53(3), 589–627.

Maslov, S. and Sneppen, K. (2002). Specificity and stability in topology of protein networks. *Science*, 296, 910–913.

Marsden, P. V. (2002). Egocentric and sociocentric measures of network centrality. *Social Networks*, 24(4), 407–422.

McGrath, C. and Blythe, J. (2004). Do you see what I want you to see? The effects of motion and spatial layout on viewer's perception of graph structure. *Journal of Social Structure*, 5, Retrieved September 26, 2006, from http://www.cmu.edu/joss/content/articles/volume5/McGrathBlythe/

Newman, M. E. J. (2003). The structure and function of complex networks. *SIAM Review*, 45(2), 1–58.

Newman, M. E. J. (2004). Fast algorithm for detecting community structure in networks. *Physical Review Letters E*, 69, 066133.

Ortiz, C. (2005). Geographic information systems and geopolitics: a proof of concept information visualization in political science research. S.B. Thesis, Department of Political Science, MIT.

Palla, G., Derényi, I., Farkas, I. and Vicsek, T. (2005). Uncovering the overlapping structure in complex networks in nature and society. *Nature*, 35(9), 814–818.

Pool, I. de S. and Kochen, M. (1978). Contacts and influence. *Social Networks*, 1, pp. 1–51.

Rosencrance, R. and Stein, A. (1973). Interdependence: myth or reality. *World Politics*, 26(1), 1–27.

Schirm, S. A. (2002). *Globalization and the new regionalism*. (Malden, MA: Blackwell Publishers)

UNCTAD. (2006). *Handbook of trade statistics online*. Retrieved May 2006, from http://www.unctad.org/Templates/Page.asp?intItemID=1890&lang=1

Walt, S. M. (1985). Alliance formation and the balance of world power. *International Security*, 9(4), 3–43.

Waltz, K. (1954). *Man, the state, and war.* (New York: Columbia University Press)

Watts, D. J. (2003). *Six degrees: the science of a connected age*. (New York: W. W. Norton & Company)

Scale-Free Networks. (n.d.). Retrieved September 26, 2006, from www.wikipedia.org.

Chapter 16

SYNERGY FOR SUSTAINABILITY

Law, Science, and Computability

Wallace R. Baker

Introduction

At the most general level of analysis, concerns pertaining to sustainability includes the viability of (1) ecological configuration, (2) economic activity, (3) political behavior and governance, and (4) institutional performance. This chapter addresses key issues pertaining to law and implications for sustainability (Choucri, 1999: 149), and, by definition, to each of these domains as well.

Earlier in this book, we presented the overall GSSD design, including the segment on coordinated international initiatives for global accord. This segment is represented in the outer circle of the system. Implicit in the overall design is the assumption that there has been considerable progress in the international community's understanding of, and responses to global environmental problems and the challenges of sustainability which still fall short of solutions for most of the serious problems confronting us. A related assumption throughout the entire book is that advances in computer-related technologies facilitate our understanding of, and responses to, dilemmas of sustainability at local as well as global levels.

Context

Law, along with ethics, often a component part of law, not only plays an important role in coordinated international activities (the outer circle of the system), but is also mixed into all the other rings, often in important ways; for example, in the rings "From Activities and Conditions," "Sustainability Problems," and "Social Circle and Technical Solutions," laws and regulations apply to most, if not all of the subjects mentioned in these circles. This increase in understanding is in large part due to the realization that problems

N. Choucri et al. (eds.), Mapping Sustainability: Knowledge e-Networking and the Value Chain, 337–365.

of sustainable development can only be solved through application of knowledge from many fields in science, technology, biology, medicine, the social sciences and the law, including its ethical element. This chapter examines how law itself could become more effective by absorbing knowledge from other disciplines.

Focus

In this chapter we take a step back by adopting a broader perspective on the issues of law and legal and ethical precepts governing social interactions, for the purposes of exploring potentials for synergy in assessments and understandings. One purpose of this effort is to remind ourselves of some generic underlying issues related to providing order in complex social contexts – and recognizing the dilemmas posed by our increasing appreciation of the imperatives of complexity. A second is to explore some potential basis for "value added" derived from dual sources of insights: law and legal practice, on the one hand and science and computability, on the other. Most, if not all of the problems reflected in the Global System for Sustainable Development require knowledge from multiple disciplines – the natural sciences and the social sciences – and reflect current understandings of the sustainability domains and dimensions, the "outer circle" is about coordinated international actions, namely what we can do as an international community to manage the challenges generated by imperatives of sustainability.

Many of the illustrations (and anecdotes) introduced in this chapter draw upon legal discourse within advanced industrial societies; but it is important to remember that the issues central to this book – challenges of sustainability – are ubiquitous as well as generic. They cut across types of societies and levels of institutional development. And, most important of all: we must stress that the lines of inquiry pursued here is exploratory in nature. It is shaped by the overall logic of the previous chapters and the architecture of GSSD as an interactive agent interface between "users" on the one hand, and the rapidly growing "virtual community" generated by Internet, on the other.

16.1 Progress in Law

In the field of law there have been no Newtons, Lavoisiers, Darwins, Einsteins, or others who developed the quantum theory which governs the behavior of transistors and integrated circuits and is the basis of modern chemistry and biology (Hawking, 1988: 56). Scientific discoveries more recently, especially those in quantum mechanics, have triggered remarkable scientific progress which embodies new theories and paradigms which do not replace classical mechanics in physics but apply to the behavior of elementary particles. Notably, then, Bernard Cohen adds that some discoveries in science in the past are revolutions comparable to religious conversions or the acceptance by a new generation of concepts the disappearing older generation could not accept (Cohen, 1985: 468–472).[1]

A description of litigation 2000 years ago in Athens shows how little progress legal "science" has made in dispute resolution since that time.[2] Of course, in the evolutionary time scale 2000 years of the estimated 2 million years of man's existence is not much, so perhaps one should not be discouraged yet. But comparing progress in law with that in physics, chemistry, and the other natural sciences often makes one think that judges and lawyers have not done enough in 2000 years to improve the legal system.[3]

16.1.1 The Purposes and Nature of Law

Max Weber's view that "Law is an order, i.e. a set of ought ideas which are held in the minds of certain people" is instructive here (Rheinstein, 1969: lxvii).[4] Some of the purposes of law in Western countries are to:

- Limit arbitrary government and protect the individual from his government and through criminal laws from illegal activity of his fellow citizens to soften, if not eliminate, the law of the jungle where the strong eliminates the weak. Law is a supposedly civilizing force leading to

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[1] Cohen cites Max Planck's Scientific Autobiography, New York Philosophical Library, (1949), 33–34.

[2] Reading Greek Text, Part Five, Athenian Views of Justice, Section Sixteen "Private Justice: Trouble Down at the Farm," Cambridge: Cambridge University Press, Joint Association of Classical Teacher's Greek Course (1986). However, progress has been made in the last forty years through the substitution of conciliation, mediation, arbitration and alternative dispute resolution. There are fewer long costly trials in court now than in the past.

[3] Some dispute that the invention of the atomic bomb is progress, but there has been remarkable material progress after the industrial revolution and the more recent advances in science and technology, communications, and transmission of information. These developments are certainly due in great part to important discoveries in physics, chemistry, medical sciences and others, and progress in engineering which after World War II have fueled the accelerating globalization, especially in communication and intellectual technology.

[4] Rheinstein states that law-making and law-finding are formally rational insofar as "the legally relevant facts are determined in a process of logical interpretation of meaning and as fixed legal concepts are thus created and applied in the form of strictly abstract rules." Weber's interest centered on whether formal rationality of legal thought contributed to the rise of Capitalism or whether Capitalism contributed to the rise of logical rationality in legal thought.

the moral improvement of the species – or at least knock off the rough edges.[5]

- Guarantee political and economic freedom and to enforce rules of competition to benefit customers in free-enterprise economies.
- Provide for predictability by having a minimum of law and order through criminal and legal decisions to encourage hard work, invention, and wealth accumulation.
- Maintain social norms and values (on course).

In addition, of course, there is a fundamental purpose, namely to provide employment for a lawyer population (which has more than tripled since 1950 in the United States).[6]

Decision-makers, jurists, legislators, politicians, and civil servants also generate more and more laws and administrative regulations in Western countries on the theory that these are necessary and will please their constituents, who hope new laws will improve and reform society.[7]

For example, the United States got a fresh start in developing law governing a newly discovered country several centuries ago. It drew up its new constitution in the 18th century, a document intended to set the ground rules for present and future generations. The Constitution has been described as a triumph of "bounded rationality" with restricted but fundamental objectives – the preservation of freedom and an orderly society (Simon, 1994: 163).

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[5] By protecting the weak, rather than eliminating them, social costs rise for the rich and strong. Man seems to be the champion killer and the primary agent of extinction for animals, including himself, which reflects the survival of the fittest or self-destruction of the fittest.

[6] This factor was not added totally as a touch of humor, since once special groups grow up in a society or in government administrations – even those groups or organizations which initially served the public interest – they tend to militate for their own selfish goals and influence public opinion and secure legislation for their own benefit. A recent study tends to confirm that US lawyers themselves are responsible for promoting and perpetuating a system of adversarial and legalistic dispute resolution in costly court actions along with American political culture and governmental structure. See Kagan (1994).

[7] Irving Younger's May 15, 1980, Charles Evans Hughes Memorial Lecture, "Socrates, Law, and the Congress of the United States," delivered at the New York County Lawyer's Association, in which he criticizes complex laws not understood by the congressman who votes for them nor by the average citizen who is supposed to obey them, which are passed to solve insoluble problems [unpublished paper]. This results in mounting distrust of the law and a diminution of faith in government and democracy. Also see Clark (1992), 275–302. The author notes the growth in the amount of law, regulations, and case law published in the Federal Register between 1960 and 1985 was 270%, additional pages to West Regional Reporter were increased by 146%, Federal Reporters grew by 336%, and the full-time staff of 55 Federal Regulatory Agencies grew by 176%, and budget increased by 237%. J. Miller, in a comment made to this section, noted that the executive branch, by writing regulations, replaces the judge in common law as the decider of cases in an adversary system.

To extend the example, the court system in the United States provides some measure of predictability and protection. The Supreme Court usually follows its previous rulings but overturns decisions when it is time for change. Legislatures do the same work in their law-making, working with the seemingly chaotic behavior of great numbers of individuals in the state of nature pursuing their own interests through freedom of speech, formation of public opinion, and use of the political process. The legislatures take this raw material (input) and formulate general or specific rules which secure the sanction of the enforcement powers of the state. It does so through a variety of conversion rules mutually agreed upon.

But the role and organization of law itself (i.e. the "industry of law" and its knowledge-base) cannot be overlooked as we consider the presumed goals of law. Law as practiced in large law firms has become a global service industry helping countries with little or no modern law or legal traditions by introducing modalities of modern contractual systems to facilitate their induction into the global economy. Even in the U.S. lawyers, especially new firms or specialized firms, create law by developing legal devices and techniques on behalf of actual or potential clients – a bottom-up approach to the creation of law rather than the conventional top-down system (Powell, 1993: 423–452).[8] This form of innovation is akin to a "social technology" where robustness will be contingent on utility and precedence. Judges for 700 years have developed the Common Law as a by-product of litigation (Dawson, 1968).[9]

Thus, in the United States, the Constitution, the court system, and the legislative with other institutions in society organize the chaos of social interaction through a complex system of arrangements – which is itself organized more than it is chaotic or disorganized, made up of a "large number of parts that interact in a non-simple way." The whole is more than the sum of its parts, with special properties that are "retrieved" or called upon to facilitate transactions or interactions in any particular situation.

16.1.2 Advance in Legal Systems

It is true that law has "advanced," but "advance" is often difficult to define and generally quite slow. Often too, "advance" is culture- and context-specific. Hence it can be quite contentious. Further, it sometimes regresses, as in the Middle Ages compared to developments in Rome. The anecdotal evidence abounds. For example, proof by ordeal with fire in France, was accomplished

[8] This article demonstrates the entrepreneurial law-making role of corporate lawyers, who develop new legal devices such as the poison pill as a defense to a corporate take-over.

[9] For the historical and comparative study of the role of judges in the development of legal systems in England, Germany, and France. See Dawson (1968).

by forcing the accused to hold a red-hot iron. His hand was bandaged and sealed. If gangrene set in, guilt was proven. In the ordeal by cold water, the accused was bound and thrown into the water. If he sank, he was innocent. The "advance" that occurred next was adoption of the proof, the judicial duel (*"bataille"*), which first appeared in Burgundy in the year 501 and in the next century was adopted by the Francs. It was the most usual proof in the 13th century and lasted up though the 15th century as a privilege of the nobility in special cases of critical matters. This proof could occur at the beginning of the case where one party challenged the other to a duel within the premises of the court house. A party could provoke a duel with an unfavorable witness or a judge rendering an unfavorable judgment presumably to control perjury and a dishonest judgment (Laingui and Le Bigre, 1979: 26–27, 37). Saint Louis in 1260, to stop private wars between his nobles, instituted "la Quarantaine du Roi," a cooling-off period between belligerents during which negotiations began. He also prohibited the barbarous custom of proof by ordeals (Bordonove, 1984: 246).

The "advance" that followed was the use of torture, which was widely reported beginning in 13th century France for the purpose of securing "proof," i.e. confessions (Laingui and Le Bigre, 1979). This practice is still common in many parts of the world – in both developing and industrial countries. Governments at war often use torture to secure intelligence and law enforcement institutions of "law" often prefer confessions (even if false) and do not generally want to spend the time and the effort necessary to secure legal and more objective, independent, more reliable and civilized methods of proof but prefer efficiency and speed.

In law – at all levels of social orders, from local to global – both the notions of advance – could be defined as applications of more effective, less costly, and more legitimate (i.e. better) forms of justice in the formulation of "rules" and in the implementation of forms of justice. Progress in *content* of law, of course, need be viewed separately from improvements in applications and *instrumentalities* of law.

16.1.3 Contrasts to Advances in Science

In contrast to the natural sciences, the law seems to develop in more of a steady and gradual process that precludes "jumps" or sharp "breaks" with tradition. Law is essentially "system-preserving," sometimes too conservative, or it incorporates wrong or stupid rules that impede innovation and improvement in society. It can also be system-altering and can lead to important reforms in society. Nevertheless, one Swiss author, citing Thomas Kuhn's definition of a scientific paradigm – namely that in law there has been a series of paradigms which do not necessarily replace completely the preceding one, i.e. the dialectic paradigm corresponding to the process by which the Roman law developed and became the subject of research and systematic knowledge, i.e. developed an architecture; the physics – mathematical paradigm which inspired the development of natural law; the historical paradigm which focuses on the study of legal issues in various countries throughout history. The author also stated that there are many founding and renovating figures in legal science (Dufour, 1994: 142–167).[10] Therefore, probably the only revolutions in law have occurred when a country is conquered and the winner imposes its law – which still can take time to become effective.

The practice of law has provided robust foundations for legal and other institutions and their governing rules necessary for a modern state to function. In addition, one can recognize considerable progress by making a historical analysis of constitutions, governmental structures, financial institutions, commercial and industrial companies, stock markets, and the innumerable laws governing important institutions, some of which have outlived their usefulness.[11]

In a legal context, however, where contentions are involved (in contrast to legal services related to developments of frameworks for coordination, at national or international levels, for example), "satisfaction" may be difficult to obtain because in a lawsuit both parties think they should win, but one party generally loses, and quite often both parties can waste a lot of time, effort, and substantial sums of money for legal fees, in which case the only real winners are the lawyers. In an international context, issues increase in complexity.

In such cases, the position of the lawyer compared to his or her client provides added insight in social relations. Overall, it is usually better to be a lawyer than a client. The cash flow is generally in the right direction, and if the lawyer retains his independence, honesty, and professional ethics, he should be less dependent on the client than vice versa. In the past, taking into account that the legal profession has usually had a monopoly position, its members do not always deliver services to the client which added value in proportion to the fees paid – at least not equivalent to outcomes or results received by the clients in all situations. But when the "client" is humanity, and the litigant is a sovereign state or a multinational entity, the stakes expand commensurately.

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[10] The meaning of the word "science" in French is often used in a broader sense than in English, i.e. an organized body of knowledge. Law and Economics in France are referred to as Science. See Dufour (1994).

[11] The fact that there has always been substantial popular dissatisfaction with the law and lawyers indicates that evaluation and expectations may have been unrealistic, and perhaps even that expectation of "satisfaction" has not been met.

In cases where legal services are required to facilitate institutional developments, policy harmonization and the like, it is usually the client that defines broad goals and the range of desired outcomes, and the lawyer then seeks to identify the operational feasibility and implementation procedures. In such cases, the driving motivations are less contentious than they are designed as they are targeted towards "feasibility." One could say that the "precedent" may be an accumulation of past "feasibilities."

16.1.4 Dilemmas of Progress

In social contexts, we tend to think of "progress" rather than "advance," even though both concepts are closely related. The Information Revolution is having a profound effect on our daily lives. Digital libraries may soon be accessed by 20 million people at no cost. Gordon Moore said in 1965 the number of components on a micro chip doubled every year since 1959 and the trend would continue to 1975. Computers are better each year – faster, cheaper, and smaller. Software has increased in size and complexity even faster than Moore's prediction. Microsoft's Word originally had 27,000 lines of code. In 1995, it had about 2 million lines (Brand, 1995: 154).[12] Clearly, there is a dilemma in defining "what is meant by progress in human societies is not easy". Increasing success in meeting basic needs for food, shelter, and health is one kind of definition most people would agree upon (Simon, 1994: 183). But "progress" today in this sense certainly is not constant in developed countries for all levels of its population, and a number of developing countries are regressing rather than advancing. And this holds true for some of the developed states as well. Among the more empirically oriented methods of measuring "progress" is the Human Development Index (HDI) computed by the United Nations Development Program (UNDP, various years). This measure is a composite of three indicators of improvements in material well-being. Not surprisingly, the HDI reveals a wide variability in the conditions of countries, even though or perhaps because its individual components are so similar to each other.

A quite different view of "progress" is an average increase in "human happiness." With regard to the latter, because of rising aspiration levels, Herbert Simon doubts if much progress (most broadly defined) has been made on this score. He adds, "there is no reason to suppose that a modern industrial society is more conducive to human happiness than the simpler, if more austere, societies that preceded it."

Simon's contribution to this issue is insightful: he cites a third way of measuring progress – in terms of intentions rather than outcomes – moral

[12] An interview with Nathan Myhrvold, a physicist turned programmer, Director of Microsoft's Advance Technology Group.

progress – but judgment on this issue is not easy. It may be too slow to be noticeable, or mankind could be regressing. Humans have probably killed other human beings recently in wars and murders at a faster rate now than ever before. But the record noted earlier clearly shows a commensurate growth in environmental protection, in terms of increasing environmental legislation, within states.

One view commonly expressed traces the optimistic belief in the inevitability of progress. This idea of progress was well expressed by Condorcet in the Enlightenment and driven by the Industrial Revolution and Adam Smith economics, so people thought the world would become more perfect and increasingly rich and happier. Although many Europeans lost this optimism about progress due to Marxism, Keynesian economics, world wars, and less happy circumstances, the Americans have retained up to now a much more optimistic view in large part due to opportunities that existed in the United States with a large unexploited country with room for expansion.

This optimistic (or perhaps instrumental) faith in progress seems to be receding among segments of the U.S. population in recent times as a result of the Vietnam War, stagnation of the income of the poor and middle classes after the 1960s, reduction in employment in companies implying that developed countries do not need all the labor force to produce plenty of goods, more social stress resulting from more aggressive action by women and minorities to improve their position, racial tensions, no common national objectives like one often sees in wartime when the population is mobilized. There also appears to be a lack of inspired leadership (Lewis, 1995).

A related but different proposition is illustrated by one high Japanese government official, who believes that what he calls progressivism – the goal of a rapid increase and a fair distribution of material welfare – ended with the end of the Cold War, which some have described as the victory of capitalism in its ideological war with socialism. He agrees with Huntington's analysis that "civilization identity will be increasingly important in the future, and the world will be shaped in a large measure by the interaction among seven or eight civilizations. This reemergence of civilization consciousness is directly related to deep disillusionment with the ideology of progressivism (Sakakibara, 1995: 8–14).

Sustainable development has raised a whole new perspective on the issue of "progress" by embedding human survival in the viability of the natural as well as the social systems.

Measuring "advance" in law as well as advances in law for sustainable development – recognizing that it is an institution central to the fabric of society – is not an easy task either, unless volume is the only criterion. If this criterion were to be applied, then we would conclude that there has been enormous progress in developed and many developing countries. However, it is difficult to argue that a volume criterion alone is sufficient, as this could just as well reflect a regression in practice rather than progress. Indeed, the enormous proliferation of volume may well be a sign of "distress" in the advanced industrial countries. Perhaps we can think of "direction," i.e. moving in the right direction, given our definition of "progress" or "advance" along the issues noted earlier.

If the information revolution transforms how we live, it will surely transform how legal systems operate and how lawyers practice and could lead to profound changes in the very essence of law itself. For example, new tools rather than new doctrines have led to advances in physics (Dyson, 1995). The same could (or perhaps should) be true of law.[13] In Chapter 1 we noted the development of a wide range of coordinated international actions supporting sustainability – the outer circle of GSSD – that jointly reflect efforts to bring natural systems within the purview of legal systems or, alternatively, to expand the scope and reach of legal systems (for regulating interaction with social systems) to cover issues traditionally considered as part of "nature," rather than "society."

16.1.5 Law and the Internet

The Internet is a big part of the information revolution cited as progress in the previous section of this chapter. The purpose of this section is to rapidly review some examples of regulation of the Internet. It also will consider what new legal mechanisms the Internet has generated (Goldstein and Wu, 2006; Lessig, 1999).[14]

The major contentions relating the regulation of the Internet are: who should be responsible for regulating the operations of the Internet? Also, where, how much, and what should be regulated?

In the 1990s, some thought the Internet could not and should not be regulated. For them, cyberspace was a separate space in another world. As the years passed and governments and courts played their normal roles in the real world, it became obvious that the Internet was subject to regulation which, in some cases, resulted in removing information, like in China where information relating to democracy and Taiwan were withdrawn for political reasons.

Control and regulation of the Internet come from many sources. The U.S. government, through contracts with ICANN, has a predominant influence in fixing Internet policy. Other organizations actively engaged in proposing rules and/or regulating the Internet are: international organizations, the European Union, international conventions, technical arrangements with companies

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[13] Clearly there are extensive caveats and qualifications associated with this statement.

[14] The author has learned a great deal from this excellent book in preparing this part of this chapter.

relating to equipment and software, laws enacted by nation states and court decisions in each country.

One global regulation mechanism is ICANN, the Internet Corporation for Assigned Names and Numbers, an international public organization in the form of a corporation formed under the laws of the State of California. ICANN is a private not-for-profit company which administers the Internet formerly managed by the U.S. government. It has an international board of directors which the European Commission has claimed is subject to too much U.S. political interference since changes cannot be made in the domain name system without approval of the U.S. Department of Commerce. Countries like Iran and Brazil have argued that the domain name system should be managed by the United Nations or another global body.

ICANN has been defined as an internationally organized, non-profit corporation that has responsibility for Internet Protocol (IP) address space allocation, protocol identifier assignment, generic (gTLD) and country code (ccTLD) Top-Level Domain name system management, and root server system management functions. These services were originally performed under U.S. Government contract by the Internet Assigned Numbers Authority (IANA) and other entities. ICANN now performs the IANA function.

As a private–public partnership, ICANN is dedicated "to preserving the operational stability of the Internet; to promoting competition; to achieving broad representation of global Internet communities; and to developing policy appropriate to its mission through bottom-up, consensus-based processes" (ICANN, 2006).

ICANN is the place where different interests, often hostile, discuss and decide Internet policy. Disputes have included trademark and domain name conflicts and numerous disputes over domain names. It is an organization built on consent which has worked by reaching decisions by consensus but difficult political and ethical issues arise which underline its relative fragility. Although some claim it is not always a transparent organization it is thought to be the only organization able to avoid total commercialization of the Internet.[15]

Whether or not the United States will be able to maintain its control of ICANN functions or will want to in the future remains to be seen. The United States government itself was in no position to administer the Internet since the technology is complex and it preferred to delegate this work to the private sector for industry self regulation and bottom-up governance, since it had doubts that a bureaucratic international public sector entity could do the work efficiently and carry out policies it favored. It has made an effort to set up representation on the board of directors from the high-tech industry from

[15] See http://www.gouvernance-internet.com.fr/information/faq-icann.html

many countries and has an advisory board of governments with the intention of reaching decisions by discussion and consensus among experts.

Thus, ICANN has the outward appearance of being an international organization, yet remains in the private sector (non-profit), subject to the ultimate control of the U.S. Department of Commerce. However, this has angered the European Union and the U.S. agreed to delegate a primary role to the World Intellectual Property Organization (WIPO), a European-based international organization, in order to settle trademark and domain name disputes (Mueller, 2002).

In 2005, a U.S. Department of Commerce official announced it will "maintain its historic role in authorizing changes or modifications to the authoritative root zone file" (Wright, 2005). As a compromise the United States agreed to a new Internet Governance Forum in which governments will debate and make recommendations on Internet policy without having decision-making power. All of this illustrates the management challenges created by the Internet.

Although one cannot say the legal structure for ICANN, a public–private California corporation, is a new invention, the purpose and the activities of the entity are entirely new since the Internet is a unique new development never seen before.

The United Nations General Assembly recently adopted a "Draft Convention on Electronic Communications in International Contracts" (A/Res/60/21) which will remain open for signature for two years. This convention was prepared by the United Nations Commission on International Trade Law (UNCITRAL) who also prepared the Model Law on Electronic Commerce and Model Laws on Electronic Signatures. Nations adopt laws, sometimes based on UNCITRAL model laws, which attempt to regulate activities on the Internet. An example of such a law is the U.S. Can-Span Act of 2003 (Controlling the Assault of Non-Solicited Pornography and Marketing Act) which establishes requirements for those who send commercial e-mail and provides penalties to companies whose products are advertised in violation of the law.

A considerable number of cases have been brought in courts in various countries. Courts in France have punished violations of French legislation relating to collecting e-mail addresses and fraudulent publicity. In the United States and France, spammers have been punished for interfering with the treatment of data (Jahan, 2006: 19–21).

One of the most important cases was one brought in France when a French court re-issued a preliminary injunction ordering Yahoo!, an American company, to take all possible measures to dissuade and prevent the access in France of web pages in Yahoo!'s U.S.-based server which auctioned Nazi objects. Some in the United States saw this as a threat to free commerce and expression on the Internet. Yahoo! brought suit in the United States claiming the French court had no jurisdiction and its right to free speech guaranteed by the U.S. Constitution was threatened. Others claim the Internet "is a separate jurisdiction" and reject the right of nations to interfere with the free flow of information on the Internet which, they claim, is a "value imbedded in the present architecture of the Internet through geographic indeterminacy of Internet transmission." One commentator notes this "decision forces the technical elites to respect democratically chosen values and the rule of law" and "does not vitiate the responsibility and power of States to police activities within their territories" (Reidenberg, 2002: 261–280). French law prohibited "the public display of any uniform, insignia or emblem of Nazi organization or person responsible for crimes against humanity" (Reidenberg, 2002: 261–280).

The result in this case confirms that "no longer will technologists be able to ignore national policies based upon the purported architectural values of the Internet. The technical instrument of geographic determinacy will allow multiple policies and values to co-exist. At the same time, the constraints of international law and the technical capability to boycott rogue nations will protect against the implementation of repressive policies in a nation's Internet rules. States will regain their voice in the global network as participants in a pluralistic international democracy" (Reidenberg, 2002: 261–280).

A leading French scholar has also analyzed this case (Watt, 2003: 673–696). She points out that conflicts arising in case of electronic commerce require little more than technical adjustment of the rules or methods applicable in analogous real world situations. However, a "growing number of conflicts involve clashing fundamental values in the international arena [...] the violence of reactions which the Yahoo! decision generated on both sides of the Atlantic – it may be these conflicts implicate an additional dimension unparalleled outside the Internet."

The author concludes that enforcement of rules in each country is probably facilitated because the Internet runs on man-made software and subject to change. This should make enforcement of national rules easier. The regulating State can prevent given data from entering within its borders through the use of gateway software. But this, in turn, raises the question: who should bear the burden? One would think the regulatory State would be the logical choice. However, "real world inequalities" will probably mean that the French court was right to put the burden on Yahoo! because it had local assets in France and it was earning money in France from its advertising revenues. However, Yahoo! did not want to filter out the obnoxious material so the receiving State had more incentive to bear the burden of excluding the unwelcome data which should militate against overregulation. However, some receiving States may not have the resources to bear this burden.

To conclude this brief inquiry into the impact of law on the Internet and the effect the Internet has had on the law, one notes that there is a new type of global regulation through ICANN subject to U.S. control. The Yahoo! case teaches us that Internet technology need not dictate whether there is regulation or not. Each State's courts will likely follow its States rules. We have seen in the Yahoo! case that France's legislation prevailed in France and the violation of these rules was sanctioned by a French court that had jurisdiction over Yahoo! assets to insure enforcement of French rules.

Nations and individuals can effectively invoke the law and its sanctions to put cyber criminals in jail and to filter out undesired information in part, if not completely, to an important extent. While the Internet has and will lead to remarkable changes in the world application of the law, legal systems are more often than not effective. The techniques of applying the law are often different. Aside from regulation through the architecture and the software of systems, pressure or litigation is often effective if directed to Internet service providers and credit card businesses involved in Internet gambling and other illegal activities. Private enterprises need law enforcement help where their businesses can be invaded by fraudulent operators as was the case with E-Bay. Cisco, Yahoo! and Google have catered to the desires of China to restrict the flow of information believed to be contrary to its public interest, even though contrary to the unique but not universal values protected in the United States. Europe has, by its privacy requirements, forced Microsoft to respect European standards for its Dot-NET Passport, not just for Europe but for every client worldwide. Because Europe was such an important market (one-third of its business) and it was not practical to separate Europe from other markets, the European more restrictive rule was generalized by Microsoft throughout the world, causing all customers to bear the additional cost. European rules made global law.

Illegal activities, such as selling votes or selling drug paraphernalia, carried out on the Internet have been also sanctioned by removing rights to domain names which takes these activities off the Internet (Goldstein and Wu, 2006).

In conclusion, there is a vast number of ways to enforce various national laws relating to Internet activities. The law has adapted to regulating conduct on the Internet and to applying sanctions in imaginative, practical and effective ways.

The Internet, like the law, is an artificial complex adaptive system, a remarkable network of networks which promises to facilitate the spread of knowledge despite numerous barriers such as language and cultural differences. Law, in its many forms mentioned in this section, is a major force in shaping the nature of the Internet reflecting the values to be respected in each nation state.

16.1.6 Order Under Complexity

Complex systems are characterized by a hierarchy in a vertical structure or a more horizontal one "with sub-systems that in turn can have their own sub-systems." Such a system goes through an evolutionary process evolving faster than a non-hierarchical system would. It also has dynamic properties and can be organized into sub-systems in order to analyze their behavior. For example, one can distinguish "between the interaction among sub-systems ... and the interaction within sub-systems" (Simon, 1994: 195–229).[16] Complexity theory now provides a way of thinking using metaphors and concepts which have almost become generic since they are used in natural sciences as well as the social sciences. The fundamental concepts are anchored in positive and negative feedback loops, emergence, self-organization, among the most dominant, that serve as foundations for computability. In other words, the representation for such concepts requires computerization. Per Bak, a Danish scientist, wrote that "[a] general theory of complex systems must necessarily be abstract," i.e. unprecedented generality. There is convergence of chemistry, physics, biology, and engineering. If E.O. Wilson is correct, there is unity of knowledge (Wilson, 1998: 53–54, 85) of which this convergence is an illustration.

Two examples of complexity are illustrative of dominant properties. First is the case of sand in a sand pile. Add grains of sand to a sand pile on a table until its sides get steep and there is catastrophic collapse and much of the pile cascades to the floor. Nothing about the place where each grain of sand is added can tell you whether the pile will start to collapse. The necessary information is distributed throughout the pile. The added grain of sand (reductionism) will not describe what will happen to the whole pile (holism). The key point here is that of reaching the "tipping point."

Second is the case of symbols-in-a-pot. In a pot, there are numerous "symbol strings" floating. A simple symbol string is an ordered group of zeros and ones, like 011, 101011, 111000. Imagine these strings such as if part of one colliding string is 011 and if part of another is 100. Then the latter sequence is changed to 11010. The first string can be thought of as an "enzyme" that catalyzes the transformation of the second string. Assuming the pot has enough zeros and ones, a catalytic reaction can occur. This situation can be simulated on a computer with a given set of grammar rules which can result in an auto "catalytic set" which continually produces the same strings. Some think such a situation gives a crucial insight into life's

[16] In his chapter "The Architecture of Complexity," Simon has outlined the elements he believes make up a complex system, which the author has summarized or incorporated into this paragraph within quotation marks.

development from a primordial "soup pot" containing molecular strings of atoms (Talbot, 2001: 15–19).[17] The key point here is that of emergence.

An article in the French magazine *Revue internationale de théorie du droit et de sociologie* (L.G.D.J.), No. J4J6 (2000) concludes with a study stating that complexity is a paradigm for a legal system (Serge Diebolt). Other chapters in this study note that complexities should be plural because complex situations are often very different and analysis as a complex situation constitutes a heuristic quality to the analysis. It is also stated that it has taken a long time not to consider complexity as a difficulty or hurdle but as a useful way to see the world.

16.1.7 Ubiquity of Networks

Complex systems usually consist of networks with nodes that sometimes become hubs which are linked together. Networks are ubiquitous; they exist in governments, universities, neurons in brains, cities, Internet, multinational and business corporations which can have significant impact in many countries on economic development and civil society. Other networks include public private partnerships which privatize activities heretofore performed by governments such as managing prisons, financing and performing educational and other government's functions. Indeed, all social interactions involve networks (as well as networks of networks) ordered by legal instruments managed within the underlying legal order.

In the international context, there are no instruments that perform the exactly same functions as do constitutions in the national context. That is, after all, the difference between national sovereignty and international conditions. Internationally, norms, customs, and treaties provide analogous functions, however these are not accompanied by commensurate institutions and sanctions to enforce compliance. Practices and institutions for coordinated international action are noteworthy in both scale and scope. Some scholars believe that national governments can reform their own internal laws to extend them to effect some measure of global governance in absence of a world government (Aman, 2004). Others argue that some world governance is growing through contacts between persons operating within horizontal networks of government officials from different countries who sometimes form associations. In some case there is especially close cooperation in matters of intelligence. These networks also occur in other fields such as regulators with specialized expertise who meet in international conferences. There are also G-7, G-20 and other similar meetings. This is also true for judges, legislators, foreign ministers, and military leaders from a number of countries and those within international organizations, intergovernmental

[17] The examples are summarized from Talbot (2001).

executive agreements, the Basel Committee as well as other information and enforcement networks, not to mention international organizations like the OMC which are more akin to a vertical network (Slaughter, 2004).

And, as evidenced in various chapters throughout this book, our efforts to provide coherence in our understanding of evolving global complexities are daunting indeed. Interactions of vertical structures with more horizontal ones and the embedded and nested relationships within and across structures (and sub-systems) are inherently difficult to grasp (let alone model). At best, we have tried to provide some internally consistent intellectual order in current understanding of complex global dynamics in both social and natural environments.

16.1.8 Complexity and Computability

As defined by Herbert A. Simon, law can be regarded as an "artificial system," namely one that is "inextricably interwoven" with complexity. He examines economics, social planning, and designing, which he characterizes as "artificial" because "they are as they are only because of a system being molded, by goals and purposes to the environment in which it lives." If natural phenomena have an air of "necessity" about them in their subservience to natural law, artificial phenomena have an air of "contingency..." and depending upon what nature and qualities they are given by man (Simon, 1994: i–xi). In this context, law can be viewed as an "artificial system."

The "artificial world," as defined by Simon, has been greatly expanded recently by the forging of cyberspace, which has generated what is now known as "virtual reality" shaped by "a globally networked, computer sustained, computer accessed, and computer generated multidimensional, artificial, or "virtual" reality. In this reality, to which every computer is a window, seen or heard objects are neither physical nor necessarily representations of physical objects but are rather, in form, character, and action, made up of data, of pure information" (Benedikt, 1994: 119). In this connection, it is important to distinguish among computer *science*, computer *technology*, and domains and types of *applications.*[18] Parenthetically, we should note here that we are concerned with all three dimensions of "computability," particularly since the *Global System for Sustainable Development* provides an example of all three facets. In addition, we are concerned with identifying and reducing barriers to each of these three facets as they bear on transitions toward sustainable development.

[18] We are grateful to Professor Robert Silsbee for reminding us of the relevance of these distinctions.

16.2 Sustainability of Legal Systems

On efficiency grounds, law should effectively rule the minimum requirements to be enforced by society with sanctions. These minimum requirements become legally enforceable duties. Higher up the scale "duty leaves off and the challenge of excellence begins." There is much conflict as to where along the scale the invisible pointer should be set that marks the dividing line between duty and aspiration. Morality and ethics rule the higher-level ethical behavior, and there is in this upper portion of the scale more divergence of opinion (Fuller, 1964: 9–10). Nevertheless, unethical actions, even if they do not violate any laws, are often subject to the pressure of public opinion and the press.

On equity grounds is the realization that transcending all of the above is the underlying function of law: to reflect, protect, and represent the consensus in a society, its norms, aspirations, and regards for individuals and for the society as a whole (the "parts" and "whole" argument or consensus analogy in the context of complex adaptive systems). And, we know from empirical experience, social order can be maintained even in the absence of modern and formal instruments of law (Carbonnier, 1992: 37).

16.2.1 The Overload Issue

Does excessive legal infrastructure create too many laws and precedents? Is there an excessively complex society in the most developed countries which ultimately tends to collapse from its own weight from time to time as it becomes less and less efficient? How much is too much? Ancient Greece was well known for the litigiousness of its citizens before it declined.

In the 16th century, Montaigne, who was a distinguished judge before he became a writer, quoted a Roman in his 13th Essay: "For we have in France more laws than all the rest of the world together, and more than would be needed to rule all the world of Epicurus: As formerly we suffered from crimes, so now we suffer from laws (Tacitus)" (Montaigne, translated by Frame, 1958: 815).

Even within a highly developed legal system when traditional systems of securing justice are long, expensive, and inefficient, short-cuts grow up to replace them (Baker and Fontbressin, 1992–1993).[19] These short-cuts tend to serve an adaptive function and reduce prospects of "ossification." Conversely,

[19] The Alternative Dispute Resolution movement, which has seen impressive growth in the last 20 years in the United States, militates for more private arbitration, mediation, conciliation, etc. through institutions and procedures outside the overcrowded court system. The need for resolving disputes often spurs new, more efficient and flexible systems for settling disputes, such as the system of equity in English legal history.

it has been argued that too many laws reflect a pathological condition in which increasing laws lead to an increase in lawyers and more claims, frivolous litigation, new regulations, bureaucracy, and resistance to simplifying and lightening the burden of the law and more tension in society (Carbonnier, 1992: 7).

16.2.2 Corporate Perspective

In the corporate community, the growth of law has been viewed as follows:

> In the 70's we learned how to do things right, then, in the 90s, we are going to learn what to stop doing! My thesis is that legal work, as it has been classified in times past, has grown exponentially. That there is 10 times as much legal work to be done in 1990 than there was to be done in 1980. We need also to be better able to explain it to our skeptical CEO's and financial officers in defense of our ever-growing legal budgets (Weise, 1992: 5–1, 5–2, 5–3).

The question that follows is this: why is there 10 times as much legal work in this expansionist era? And Weise answers as follows:

> In the last decade, we have seen criminalization of government procurement, the securities industry, the banking industry, environmental matters and occupational safety … Our corporate clients get indicted, they need their own lawyers and the legal standards for caring for their well-being increase. More lawyers have to do more things with a higher standard of care.

As the law schools pump out more lawyers, they have found work in previously unmined causes like unjust termination, discrimination, invasions of privacy, denial of sales commissions, occupational safety, and negligent hiring – at the expense of corporate America. The simple fact is that the cost of legal services to U.S. corporations is fast becoming unaffordable.[20]

In the United States at least, there is a view that it is not changing client demands that have caused the growth of large law firms but the race among young lawyers to win the promotion to partnership tournament to be the root cause of the exponential growth of the large law firms. In other words, big law firms have had a built in "growth engine" (Galanter, 1991).

While promoting order, it is clear that in many societies – industrial as well as developing – the legal system has aspects that do not serve the poor,

[20] *The Wall Street Journal* European Edition, October 6, 1994, p. 1 reported that Motorola, beginning in 1992, ran up a $15.2 million legal bill defending itself against a pollution case arising from dumping commercial solvents on the ground for over three decades near Phoenix, Arizona, which had as many as 700,000 potential plaintiffs.

the general welfare, and sometimes only favor narrow private interests (Trubek, 1984: 575–622; Unger, 1983).[21]

16.2.3 Public Policy Perspective

Richard Epstein, in his April 2004 article "The Optimal Complexity of Legal Rules" (Epstein, 2004), believes the government should have strong coercive powers only within well-defined spheres to achieve its primary objectives – the maintenance of order and infrastructure that make voluntary transactions possible. He notes that a legal system must deal with the lack of knowledge (cognitive limitations) of ordinary people but also curb excesses of individual self-interest. However, he warns that the motives and cognitive powers of individuals working for the government are not themselves above question. He believes that the simpler rules of thumb that characterized natural law often do a better job in overcoming the cognitive and motivational weaknesses than the more complicated administrative expertise which much modern law provides. For him, the optimal strategy involves the fragmentation of government power and the limitation of public discretion. "Three types of rules that help achieve this result are rules of absolute priority, rules that judge conduct by outcomes, not inputs, and rules that use simple ratio formulas to allocate benefits and burdens."

After citing Hobbes, Locke, Hume, Adam Smith, Madison, and Hayek for their vision of the world, he asks the question "What is the optimal complexity of law within this framework? The answer depends upon the greatest obstacles toward the achievement of a stable political order. "Here the modern preoccupation with behavioral economics and cooperative limitations tends to find the weak link in human behavior in the ability to integrate information and to calculate the odds of future events. Expected utility calculations are a mirage for all concerned" (Kahneman and Tversky, 1982). Epstein goes on to cite Madison's concern "Who guards the guardians?" and comment that we need institutions that can stand abuse in bad times just as they promote effective government in good times. This makes the grand objective not to minimize the level of complexity but in the United States has led to the fragmentation of power "that consciously reduces short-term efficiency in order to counteract the corrupt motivations of political actors." This fragmentation occurred by the separation of powers between the

[21] The legal system that has evolved in the United States has in the last decades of the 20th Century been subjected to severe criticism by a group of scholars referred to as Critical Legal Studies Movement who claim that the legal system, which is more resistant to change than rapidly innovative, is skewed in favor of the rich against the poor, that although legal principles may seem objective, in fact, the poor do not secure the benefits from the legal system that they should.

legislative, executive, and judicial to insure that no individual or small group controlled all functions of government. Epstein adds other limits to power, such as the system of checks and balances, elaborate electoral rules designed to slow down election of public officials, the electoral college and finally the system of federalism which divides power between the Nation and the States.

16.2.4 The Value Added Dimension

In many ways trans-disciplinary contributions to law tend to be underestimated. There is hidden "value-added" whose potential is yet to be fully realized. As a result, trans-disciplinary studies have been incorporated in curricula at leading law schools. Economists and specialists in other disciplines have become members of law faculties and done important work. (Coase, 1992). Does Brian Arthur's emphasis on "law of increasing returns" in new economic theory have an effect on law in society? This theory has been used to explain Microsoft's success by setting a standard with its software which does not follow the law of diminishing returns (Cassidy, 1998).

History, including the history of the law, has long been a field of study which illuminates and explains the existence of many legal institutions and rules. Justice Holmes, probably the most influential legal scholar in the United States and a Justice on the Supreme Court, stated that "The life of the law has not been logic: it has been experience" (Holmes, 1920: 238–239). The equivalent of "experiments" in the natural sciences is found in law and the social sciences in trying out legal rules and institutions in real life to ascertain if they function well. It is legal history and the study of comparative law that records the results of these "experiments" (Atias, 1994: 129–144).[22]

A legal distinguished scholar has "thought that certain developments in science (physics) can help us discover a deeper and richer insight into the pervasive and profound role law plays in shaping our society ..." (Tribe, 1989: 574). Simon also argues that cybernetics constitutes "if not a theory, at least a point of view that has been proving fruitful over a wide range of applications in seeking out common properties among diverse kinds of complex systems."

Significant studies in linguistics have been accomplished by computer which could also be relevant to the legal profession.[23] And, clearly, sometimes

[22] Atias denies there are revolutions in law – only continuity – and notes that "experiments" in law sometimes are confirmed by public opinion polls and the study of comparative law. Could it be said that discovery practice in the United States has some elements of an "experiment" before going to trial?

[23] See publications by David G. Hayes described in an article in August 1995 *New York Times* by Wolfgang Saxon.

interdisciplinary knowledge helps natural scientists. According to his own account, Einstein developed his critical powers by reading philosophy and had discussions with his friends of Hume's and Ernst Mach's writings (Whitrow, 1970: 36). Other scholars are working to increase understanding about the relationship between biology, human behavior, and law and to develop new ways to facilitate the integration of biological theories in law, economics, and public policy.

More recently, economics has incorporated knowledge of psychology to create a new area of research behavioral economics, which explains why we "procrastinate, buy, borrow, and grab chocolate on the spur of the moment" (Lamtest, 2006). The addition of skills and knowledge of physics helped lead to the revolutionary discovery of the double helix. The recent discovery of important laws of scaling in biology was accomplished by Geoffrey West of the Santa Fe Institute, a physicist working with a leading biologist. So combining deep knowledge in separate fields has yielded remarkable results. Crick, a physicist working with Watson, a biochemist, led to the most important Nobel Prize winning discovery of the double helix.

One of the most important additions to law school curricula is courses on negotiation (Fisher and Ury, 1981) and the study of alternative dispute resolution. Although lawyers have long negotiated settlements in disputes, it was not generally thought to be a subject that was teachable or constituted a body of knowledge worthy of special attention. Alternative dispute resolution has grown up because of the increase in litigation and its rising cost. It includes arbitration, mini-trials (a quick, informal non-binding procedure designed to facilitate a settlement), mediation, and conciliation. These techniques have themselves drawn on knowledge from other fields such as psychology. Although the development of these different dispute resolution options has not proven to have helped reduce the case load in courts it has certainly provided additional paths for resolving the growing number of conflicts.[24]

16.3 Potentials for Synergy via Computability

What is to be gained for sustainability by exploring potentials for synergy between legal thinking and practice, on the one hand, and artificial intelligence (AI) and "computability" on the other? What are the sources and what are the potential benefits?[25]

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[24] This statement is drawn from a conversation with Frank A.E. Sander.

[25] The costs of such efforts are more readily identifiable: They would be conventionally seen as a diversion from the benefits of continued specialization, and as a source of "fragmentation" of knowledge, insight, and wisdom.

At issue here is the argument that synergy between innovative computational applications and the legal systems add value to each. This argument expresses a new and increasingly important view among legal specialists (Rissland, 1990). In this connection Rissland distinguishes "expert systems," which are special purpose computer programs in narrow problem areas used to model certain rule-based aspects of law. Constitutional law, she believes, has concepts too vague for an expert system. Drawing on Marvin Minsky's definition of Artificial Intelligence, "the science of making machines do things that would require intelligence if done by man," and describing its realm as playing chess, solving calculus problems, making mathematical discoveries, understanding short stories, learning new concepts, interpreting visual scenes, diagnosing diseases, and reasoning by analogy with the limiting factor that "common sense" reasoning or perception such as language understanding are by far the most difficult for formal representation of artificial intelligence (Minksy, 1966: 1958–1959).

In an article written about 25 years ago, Minsky described a program employing reasoning by analogy – a system of reasoning commonly used by lawyers (Minsky, 1966). The process of modeling laws, Rissland adds, has helped programmers uncover problems in the laws "such as undefined legal predicates and loopholes" (Minsky, 1966: 1967) and in this connection distinguishes among a number of modes of reasoning:

(1) Reasoning with Rules (Rand Corporation's Center for Civil Justice and the Legal Decision Making System [LDS], which computes the settlement value of a case).
(2) Precedent-Based Reasoning with Cases and Hypotheticals (Kevin Ashley's HYPO model, where certain aspects of case-based reasoning are used). This system evaluates trade secret problems by comparing them and contrasting them with cases from its knowledge-base. It generates legal arguments citing past cases as justification for legal conclusions about who should win. HYPO's arguments present competing adversarial views of the problem and it poses hypotheticals to alter the balance of the evaluation.
(3) Reasoning with both Rules and Cases.

More recently, Aikenhead notes the shortcomings of a rule-based system (a positivist jurisprudential model) because the open texture of rules makes possible different interpretations, especially when facts change. He also thinks the case-based system, founded on thinking by legal realists that the law is based on experience embodied in case law, fails to capture all that is law. He then concludes that of key importance to law is the justification of legal decisions and the discursive theory of law (law as a process of argument between parties) provide a better way to the community's acceptance of a decision reached through a process of argumentation. Rules and cases are of course elements used in the construction of arguments but are not stand-alone arguments. Models have been developed based on the nature of legal argument but in addition to other complications the discursive model requires reference to policies, principles, and values in support of arguments, i.e. reference to meta-standards which need to be incorporated in the model. But this in turn has problems: what is an acceptable meta-level argument, how do you determine which meta-argument supports a particular argument and what happens when meta-arguments conflict? (Aikenhead, 2006).

In this context, we can begin to see what some potential gains from synergy might be. The types of reasoning noted above are clearly the kind of intellectual activity accomplished by legal services operating within legal codes. The next step will be to determine to what extent they, even though imperfect, can be useful to the practicing lawyer, the legislator, or the client.

By the same token, it may well be that there is a special role for law as an "open discipline" capable of borrowing knowledge from closely related and relevant other fields. Therefore, this process of expanding and deepening inter- and cross-disciplinary work is a most fertile avenue for producing progress in the law, even though it may complicate the attempt to model legal decision-making.

In addition, the study of laws of other countries and comparing solutions and institutions has provided interesting insight which can be of practical application. This process is particularly important for progress in the law for countries without a strong legal system.

It is possible that the most important recent progress in the legal system has been made in perfecting negotiating techniques and alternative dispute resolution procedures to short-cut or otherwise avoid court cases. Consideration of the modes of legal reasoning and legal modeling mentioned above could facilitate negotiation and settlement techniques before a court decision becomes necessary. The importance of this development should be measured against the seemingly constant increase of litigation in many developed countries. The extent legal experts presently use these above tools is only a beginning which will hopefully increase in the future to improve the efficiency of the law's service to society.

As noted, law is produced and applied through (society constructed) complex adaptive systems of social interactions which in participatory societies are supposed to evolve and change without violent destructive disruption or revolution. But as in the past, if *any* system becomes too complicated, overloaded with outdated laws, does not recognize and provide answers to new problems and if new generations fail to take the actions necessary to make the system work better than their ancestors did, it may decay, collapse, and disappear. Wars can also help destroy a civilization with a legal system. History provides a good record of civilizations that did not survive (Tainter, 1988).

Keeping in mind that metaphor and analogy may be helpful –but can also be misleading – legal analysts may obtain some sense of potential “value-added” for enhancing their own pursuits by exploring the implications of analytical innovations in the study of complex systems. It might very well be that some useful insights might emerge. However, some basic skills in “computability” are needed, or to put it differently, at least an elementary form of literacy.

Certainly, we do not suggest to partially or wholly replace the system of justice by efficient adaptive computer programs filled with problem-solving capabilities and legal precedents. That would be both unrealistic and highly irresponsible. But “computability” may facilitate the efficiency of information processing, at the very minimum.

For example, litigants could “submit” their complaints and have an objective decision in ten minutes if the program were perfectly prepared. Just think how much money, time, and effort could be saved in an economy without lawyers and judges, especially if there was an interactive interface to simulate human intervention.[26] Even if litigants found it unacceptable to submit their dispute to a software program for decision, such a system might be helpful instead of a mini-trial or if a potential plaintiff wished to secure an advisory opinion prior to filing of a lawsuit.

If one can draw any conclusions about the success or failure of legal systems in transforming chaos, violence, and unpredictability into more ordinary, even benign, rules governing society, one could say that it has been a crucial element in the economic growth of Western societies, providing basic rules and enough stability to facilitate the production of significant wealth. In industrial countries some ask if it is not reaching the breaking point as court systems become overloaded with cases (reflecting more and more of a demand for justice). This could indicate the system is functioning by providing a substitute for physical violence, the more ancient and more efficient mode of dispute resolution.[27]

The increasing “demand” for justice also reflects more willingness by citizens to enforce their rights in court which have heretofore been ignored – presumably a positive factor in measuring improvement in a society. The question here is how that justice is in fact “supplied.” In many ways, the issues raised in Chapter 14 on e-governance touch upon the suppositions above.

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[26] You would not have to “kill all the lawyers,” as Shakespeare suggested – they would just become obsolete.

[27] Perhaps not more efficient if reciprocal killings lead to family wars, regional wars, and world wars which cannot really be characterized as an efficient method of dispute resolution, since it is costly in lives and property. Even if a lawsuit is inefficient, slow, and costly, there may be a benefit in that the adversaries secure time to cool off and settle the dispute after time passes and circumstances change.

16.4 Synergy for a "World That Could Be"[28]

This chapter briefly considered ways in which one might view the legal and ethical system as a reflection of the complexities of society as well as of efforts to manage the complexities. The legal system as well as the underlying social orders can be seen as constituting complex systems to which mathematical, scientific, or computational tools of analysis could be utilized in the hope of introducing analytical rigor in order to clarify contradictions, tensions, and "irreconcilable" factors and, potentially, to lead to efficiency. This view would be applicable to both the more and the less contentious legal contexts.

In this connection, we have argued that innovative analogies which might be relevant and possibly instrumental to improve insights in the legal system may be found in computation-dependent domains of knowledge. Computer science and modeling, for example, could provide better computational analysis and better strategic decisions as to where the law should be going in the future. In medicine, recent use of scanning devices and computer analysis have greatly enhanced diagnosis efficiency and reliability. If doctors were able to use computers that could help diagnose the 12,000 known diseases perhaps most of the preventable medical errors which are estimated to lead to the death of 44,000 to 98,000 people annually in the United States could be avoided (Economist, 2005). Common law lawyers have a somewhat similar problem in being sure they have found all the legal precedents relevant to the problem involved.

Clearly, the adoption of computational representation and new modes of analysis must never replace the human mind, human knowledge and experience. But advances in providing and organizing all the information needed and in analytical reasoning, computation capabilities, and electronic technologies cannot be ignored. Is there a potential basis for the proverbial "win-win" combinations? We think yes.

We have argued in this chapter that the quest for sustainability could be enhanced through the pursuit of a distinctive form of synergy, namely between the theory and practice of law, on the one hand, and the advances and applications of computational methods, on the other. In this connection, we argued that legal analysts, scholars, and practitioners could gain in creativity and in practice by understanding and then utilizing the logic and even the potential applicability of methods relevant to advances in the natural and social sciences, and the uses of models associated with advances in information technology, for example.

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[28] Initially coined by the late Professor Robert C. North, of Stanford University, the "World that Could Be" is a phrase that reflects both vision and possibility.

The search for synergy is predicated on the premise that those entrusted with preserving the rule and the role of law in modern societies need also explore the impacts of such “progress” for sustainable development. Central to sustainability is enhancing the resilience of legal systems and their adaptability to rapidly changing socio-economic and technological conditions worldwide. This may even mean reevaluating old truths and value systems embedded in the procedures that may have been instrumental and effective in the past but may not be optimal at present, and perhaps even more burdensome in the longer run. The concept of sustainable development has added new perspectives to law and ethics that must be taken into account, such as intergenerational ethical considerations which should leave a better world to our offspring than was delivered to us. Human activity has become a danger to survival through misdirected harmful scientific and technical advances, unwanted climate change, pollution which damages health and other environmental threats. This militates for careful analysis and action before a dangerous situation becomes irreversible.

Reaching a consensus among the nations on the importance and the nature of the environmental problems that require solutions has been impossible up to the present. Politicians, governments, and citizens have failed for many reasons which include powerful private interests. There is great difficulty in understanding highly complex problems. Most human beings remain unconcerned by potential long term problems confirmed by experts, probably because people are genetically programmed to react only to immediate threats and to ignore long term threats which they hope will disappear. Behavioral economists have found that people act irrationally by overly discounting the future.

Many believe the Kyoto Convention will not be able to deliver much relating to climate change. In 2005, an Alternative Climate Pact was announced between the United States, China, India, Australia, Japan, and South Korea, representing about one half the world’s population and about 40% if the CO_2 emissions. By contrast, everyone agrees that more will need to be done to manage the challenges of climate change.

In this connection, then, the pressing objective for the international community as a whole, indeed a “desirable-trajectory,” may perhaps best be viewed as one of increased understanding enhancing social resilience, adaptability to necessary changes, and, above all, sustainability in conceptions and applicability of law, order, and institutions of justice. In other words, the challenge of synergy is one of facilitating “the world that could be” in order to prosper and survive. If the world is diligent, urgency will arise, leading to a mobilization of citizens’ demands, and their articulation in public contexts, to drive politicians to forge solutions before irreversibility sets in and move the world toward a sustainable trajectory.

References

Aikenhead, M. (2006). A discourse on law and artificial intelligence. *Law Technology Journal*, 5(1). Retrieved August, 2005, from http://www.law.warwick.ac.uk/ltj/5-1c.html

Aman, A. (2004). *The democracy deficit taming globalization through law reform*. (New York: New York University Press)

Atias, C. (1994). Legal experiments: are there any crucial experiments? *Théorie du droit et de la science, L'Armatan*, PUF.

Baker, W. R. (1999). Law, chaos, and complexity: can progress in the law be accelerated? revised edition, *The International Lawyer*, Nomos Verlags Gesellschaft, Baden Baden.

Baker, W. R. and de Fontbressin, P. (1992–1993). The French référé procedure – a legal miracle? *The University of Miami Yearbook of International Law*: 2.

Benedikt, M. (1994). Cyberspace: some proposals. (In *Cyberspace*: First Steps. Cambridge, MA: MIT Press)

Bordonove, G. (1984). Les rois qui ont fait la France, les capétiens, Saint Louis. Collection Marabout University, Editions Pygmalion/Gerald Watelet, Paris.

Brand, S. S. (1995). For $100 you get software that costs $100 million to make. *Wired Magazine*.

Carbonnier, J. (1992). *Flexible droit, pour une sociologie du droit sans rigueur. seventh edition* (L.G.D.J. Paris)

Cassidy, J. (1998). The force of an idea. *The New Yorker:* January 12.

Choucri, N. (1999). The political logic of sustainability. (In E. Becker and T. Jahn (Eds.) *Sustainability and the social sciences, a cross-disciplinary approach to integrating environmental considerations into theoretical reorientation*. London: Zed Books)

Clark, R. C. (1992). Why so many lawyers? Are they good or bad? *Fordham Law Review*: 61.

Coase, R. H. (1992). The institutional structure of production, *Occasional papers from the law school.* University of Chicago, No. 28, Nobel Prize Lecture. (Buffalo, New York: Hein and Company)

Cohen, B. (1985). *Revolution in science*. (Cambridge, MA: The Belknap Press of Harvard University Press)

Dawson, J. P. (1968). *The Oracles of the law*. (Ann Arbor, MI: The University of Michigan Law School)

Diebolt, S. (2000). Ubiquity of networks. *Revue internationale de théorie du droit et de sociologie* (L.G.D.J.), No. J4J6.

Dufour, A. (1994). The scientific paradigm in modern legal thought. *Théorie du Droit et Science, Léviathan*, PUF.

Dyson, F. (1995). Introduction: the scientist as a rebel, nature's imagination. (In J. Cornwell II (Ed.) *A debate on the future of science*. Oxford: Oxford University Press)

Economist, The. (2005). Technology Quarterly. *The Economist*, December 10: 35.

Epstein, R. A. (2004). Optimal complexity of legal rules. *Chicago Working Paper Series Index*. Retrieved 2004, from http://www.law.uchicago.edu/lawecon/index.htm

Fisher, R. and Ury, W. (1981). *Getting to the yes.* (Boston: Houghton Mifflin Company)

Fuller, L. L. (1964). *Morality and the law. revised edition*. (New Haven: Yale University Press)

Galanter, M. and Palay, T. (1991). Tournament of lawyers. (In *The transformation of the big law firm*. Chicago: University of Chicago Press)

Goldstein, J. and Wu, T. (2006). Who controls the Internet? (In *Illusions of a borderless world*. Oxford: Oxford University Press)

Hawking, S. (1988). *A Brief History of Time*. (New York: Bantam Books)

Holmes, O. W. (1920). *Collected legal papers*. (New York: Harcourt, Brace & Company)

Jahan, G. (2006). Le rapport du congrès sur le Can-Spam Act: bilan de la loi américaine contre les spam (The report of congress on the Can-Spam Act: the effect of the American law against spamming). *Gazette du Palais*, Paris: 16–20 April.

Kagan, R. A. (1994). Do lawyers cause adversarial legalism? A preliminary inquiry. Law, and social inquiry, *Journal of the American Bar Foundation*: 19(1).

Kahneman, D. and Tversky, S. P. (1982). *Judgment under uncertainty: heurists and biases*. (Cambridge: Cambridge University Press)

Kuhn, T. S. (1970). *The structure of scientific revolutions, second edition*. (Chicago: University of Chicago Press)

Laingui, A. and Le Bigre, A. (1979). Histoire du droit penal II, la procédure criminelle. *Synthèse Cujas 4, 6, 8 rue de la Maison Blanche*, Paris.

Lamtest, C. (2006). The marketplace of perception. *Harvard Magazine*, March–April: 49–50.

Lessig, L. (1999). *Code and other laws of cyberspace*. (New York: Basic Books)

Lewis, A. (1995). *What ails America?* Talk given at Edgartown, Massachusetts.

Minsky, M. (1966). *Artificial intelligence in information*. A Scientific American Book.

Montaigne, M. (1958). The complete essays of Montaigne, 13th Essay, *Of experience*. Translated by Donald M. Frame. (Stanford, CA: Stanford University Press)

Mueller, M. (2002). Ruling the root. (Cambridge, MA: MIT Press)

Muir Watt, H. (2003). Yahoo! cyber-collision of cultures: who regulates? *Michigan Journal of International Law*, 24(3).

Powell, M. J. (1993). Professional innovation, corporate lawyers and private law making. *Law and Social Inquiry American Bar Association*, 18(3).

Reidenberg, J. R. (2002). Yahoo! and democracy on the Internet. *Jurimetrics*, 42.

Rheinstein, M. (1969). Introduction to Max Weber. *On law and economy in society*. The 20th Century Legal Philosophy Series. (Cambridge, MA: Harvard University Press)

Rissland, E. L. (1990). Artificial intelligence and the law: stepping stones to a model of legal reasoning. *The Yale Law Journal*, 99(8).

Sakakibara, E. (1995). The end of progressivism. *Foreign Affairs*, September/October.

Slaughter, A. M. (2004). *A new world order*. (Princeton, NJ: Princeton University Press)

Simon, H. A. (1994). *The sciences of the artificial*. (Cambridge, MA: MIT Press)

Tainter, J. A. (1988). The collapse of complex societies. (Cambridge: Cambridge University Press)

Talbot, S. (2001). The lure of complexity. Context #6, *The Nature Institute*. Retrieved September 27, 2006, from http://natureinstitute.org/pub/ic/ic6/complexity.htm

Tribe, L. (1989). Laws, geometry and the curvature of constitutional space. *The Record of the Association of the Bar of the City of New York*: Cardoyo Lecture.

Trubek, D. M. (1984). Where the action is. *Critical Legal Studies and Empiricism*, *Stanford Law Review*

Unger, R. M. (1983). *The critical legal studies movement*. (Cambridge, MA: Harvard University Press)

U.S. principals on Internet's domain names and addressing system. Retrieved August 19, 2005, from http://www.ntia.doc.gov/ntiahome/domainename/USDNSprincipals_06302005.htm

Weise, R. H. (1992). Representing the corporate client/designs for quality. (In *Full client utilization*. New Jersey: Prentice Hall and Business)

Whitrow, G. J. (Ed.). (1970). Einstein: the man and his achievement. (In *Einstein: early years*. Reprinted by R. Karplus in *Physics and man*. New York: W.A. Benjamin Inc.)

Wilson, E. O. (1998). *Consilience - the unity of knowledge*. (New York: Alfred Knopf)

Wright, T. (2005). E.U. and U.S. clash over control of the net. *International Herald Tribune*: September 20.

Younger, I. (1980). Society, law and the Congress of the United States. Charles Even Hughes memorial lectures (unpublished paper).

Chapter 17

FINANCIAL RISKS AND CLIMATE CHANGE

Infrastructure Finance Risks

Craig Hart

Introduction

The quest for sustainable development and the threat of climate change have largely been addressed to date by environmental groups and national governments. The private sector is increasingly becoming engaged in the climate change discussion as climate risks and required responses are becoming better understood. The purpose of this chapter is to contribute to the mission of Part III of this book, namely to address new areas of research in the area of global social and environmental change by examining one aspect of the role of the financial system in addressing the challenges associated with climate change. Until recently, both academic and policy circles, nationally and internationally, have largely ignored the critical role the financial system must play in addressing climate change.

The focus of this chapter is on how the financial system, principally the banking system, views the risks associated with financing infrastructure in light of climate change, and to assess the degree of their current understanding of climate change. Based upon this assessment and further informed by the science of climate change, this chapter proposes a new way of framing the risks associated with infrastructure finance in light of climate change.

17.1 Climate Change and Risk

Within the scientific community, it has been recognized for some time that climate change will adversely affect infrastructure (see, e.g. Revelle, 1983). However, traditional infrastructure finance analysis has assumed that the natural environment poses risks that can be identified, allocated and managed by conventional means. While the scale and scope of changes in the

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natural environment was understood to pose significant risks to infrastructure projects, the range of risk was believed to be sufficiently well defined within an acceptable range so that large-scale infrastructure projects could be financed without further consideration to long-term climate trends in making investment and risk management decisions. Given the recent observed weather patterns exhibiting increased volatility and the availability of climate models capable of characterizing long-term climate trends, it is now imperative to take into account the evidence from climate science and to re-evaluate traditional infrastructure finance risk assessment frameworks.

Some of the most important traditional risk categories usually considered in infrastructure finance risk evaluation frameworks do not adequately identify existing and new risks exacerbated by climate change, and thus will not provide adequate visibility within the traditional infrastructure finance framework to analyze these risks. For example, in the traditional framework, the concept of force majeure is used to analyze a broad set of risks: acts of nature (such as flood, fire, earthquake), acts of man (riots, war), impersonal acts (financial system collapse), and acts of government (general strife). Given the increasing importance of climate events, the force majeure category as a catchall or residual category of risk provides inadequate visibility to climate-related risks.

Given this and other omissions, this chapter reevaluates the traditional infrastructure finance risk framework by (a) identifying new categories of risk in order to explicitly accommodate risks posed by a changing climate, and (b) providing specific examples of how climate change affects financial risks. The results provide the basis for a new financial risk assessment framework referred to in this chapter as the "Climate Risk Assessment Framework." We use the results of surveys administered to banks and insurance companies by the Carbon Disclosure Project to develop and validate the Climate Risk Assessment Framework. In doing so, we examine a segment of the financial industry's perceptions of risks in infrastructure finance associated with climate change.

17.2 Climate Risk Framework

17.2.1 Climate Risk Assessment Framework

The Climate Risk Assessment Framework presented in Table 17.1 was developed based on an analysis of the risks posed by climate change. This analysis relied largely on: (i) evidence from climate science research and literature covering various aspects of climate change, (ii) a review of the responses of banks in the Carbon Disclosure Project, and (iii) an understanding of how various parts of the financial system operate. On this basis, we derived a proposed synthesis of how various segments of risks interact with each other (Hart, 2006).

Table 17.1 **Climate risk assessment framework.**

Risk	Examples of Increase in Risk
Supply Risk	New technology rare materials/energy Weather disruption of supply chains Carbon credits
Market Risk	Climate affects short/long term demand/market Changing consumer attitude and preference Reputation risk for emissions/environment
Technology Risk	Accelerate new carbon neutral technology More complex carbon neutral technology More costly technology/infrastructure
Engineering Risk	Changing environmental conditions Increasing complexity of challenges Increasing scale of climate protection projects
Infrastructure Risk	Damage to transmission and distribution Grid connection of new technologies Natural support for infrastructure Uncertain government commitment to support
Environmental Regulatory Risk	Cost recovery for carbon neutral technology Cost recovery for climate-related events Taxation Regulation (including competitive effects) Litigation or liability Increasing complexity of regulation Uncertain or fragmented regulation Increased disclosure obligations
Political Risk	Deadlock/uncertainty Unrest/Violence Expropriation Protectionism Incomplete institutional arrangements
Legal Risk	Increased chance of breach of contracts Increased use of defenses to perform contracts Decreased flexibility once committed to law
Force Majeure Risk	Increased chance of severe climate events Reduced insurance coverage for climate events Increased chance of financial erosion/collapse

(*Continued*)

Table 17.1 (*Continued*)

Operating Risk: Cost	Climate events increase operations costs Complex technology increase O&M
Operating Risk: Management Capacity	Reduced capacity estimate risk and plan Increased demands on technical capacity Climate demand more management resource Climate reduce ability to pursue strategic plan Reduced capacity to undertake prevention
Capital Markets Finance Risk	Credit, default, collateral impairment Financial asset values Accounting/financial disclosure Innovation causes capital obsolescence Market disruption/volatility Scale/transaction cost
Participant Risk	Financial stability/creditworthiness Inadequate administrative or technical capacity
Governance Risk	No party best positioned, willing, or capable to accept and mitigate climate risk

Based on analysis in Hart (2006).

The Climate Risk Assessment Framework is intended to help provide a systematic method for analyzing climate risk in the context of financing and developing infrastructure. It has applications for practitioners in the infrastructure development field and for policy analysis. For financial planning and investment, the Climate Risk Assessment Framework is intended to give greater visibility to the effects of climate on financial risk in order to better identify, and where possible, mitigate these risks. For purposes of policy analysis, the Climate Risk Assessment Framework suggests various transmission mechanisms through which climate risks may potentially impair the capacity of the private sector to adapt infrastructure. These risks should be studied further and considered in policy analysis.

17.3 Climate Risk Interactions

Clearly, the interactions among risks are important. A static view of risk would be incomplete and likely to underestimate the complexity and magnitude of climate risks. Figure 17.1 presents an overview of the interactions among climate risks based on a review and synthesis of the relevant literature presented in Hart (2006). This figure is not intended to represent a dynamic model, empirically derived causal analysis, or inferences based on statistical inquiry. Figure 17.1 is developed, and presented here, largely for purposes of synthesis. Note that participant and governance risks are not

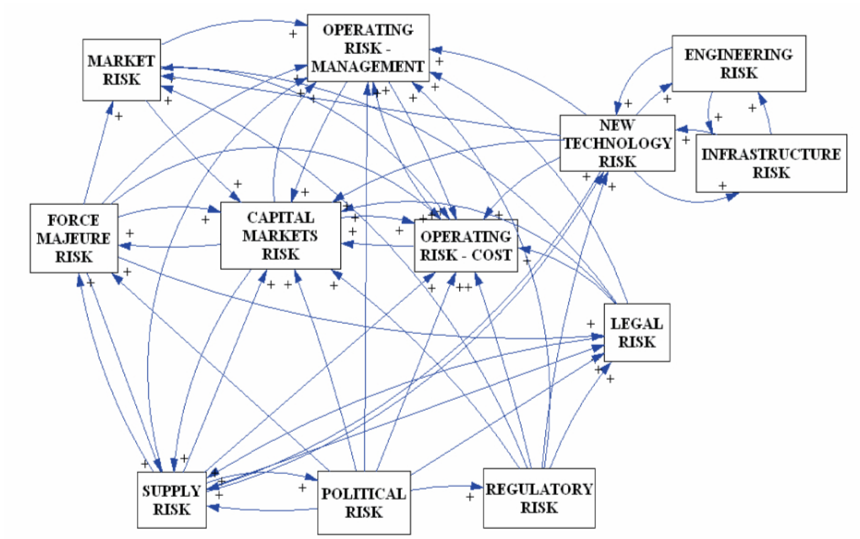

Figure 17.1 **Representation of potential climate risk interactions.**

explicitly introduced in Figure 17.1 because all other risks contribute to them, directly or indirectly.

As presented, Figure 17.1 is dominated by positive feedback, or reinforcing influences, thus suggesting that the various types of risk increase with climate change. Multiple interactions occur between many of the risks, with secondary and tertiary effects, and the patterns become complex. Missing from this figure are the potential countervailing or balancing relations. They are missing because the literature does not address them.

At this point, it is useful to illustrate the potential interactions by describing the relationships centering on one particular risk. Supply risk is selected for this illustration. Further analysis of supply risk and other risks are discussed in Hart (2006).

Supply risk interacts with other risks, such as force majeure, legal, political and capital markets risks. Supply risk and force majeure events interact to create a positive feedback loop: an increase in the risk of a major catastrophic event (a force majeure risk) potentially increases supply risk. Supply risk also increases force majeure risk because increasing costs of materials increase replacement costs following major catastrophic events. Supply risk and technology risk interact, as introduction of new technologies may rapidly shift demand towards new materials, and inadequate supply of materials can increase the risk associated with new technologies. If the response to climate change involves introduction of new technologies, the supply risk interactions with the technology risks cluster (technology, engineering, and infrastructure risks) will become increasingly important. Supply risk increases legal risk because tightening commodity markets increase the leverage of producers, thereby increasing risks of contract breach and renegotiation. Legal risk also potentially increases the likelihood that a company will be unable to obtain supply, particularly if suppliers perceive an increased risk of default by customers. Thus, there is a positive feedback loop between supply and legal risk. Supply risk and political risks also interact. In the case of oil, increases in political risks in producing regions often increase supply risk if markets perceive these risks could potentially interfere with production or transportation of oil. Tighter oil markets have provided producing countries with greater leverage to make political or economic demands. Thus, in the case of oil, there is a positive feedback loop between political risk and supply risk. Finally, supply risk affects capital markets, operating cost, and management capacity risks. For a particular company experiencing difficulty in obtaining reliable supply of inputs, capital markets can respond negatively with respect to a company's value and ability to raise financing. On a systemic level, increased volatility of prices or disruption of supplies of oil or other key commodities that co-vary with financial markets could increase the volatility of, or depress, capital markets. To the extent that commodities are increasingly linked to financial instruments that are traded on markets, capital markets risks can also affect the price of underlying commodities and the financial condition of companies that trade in commodities-linked instruments. Thus, there is a positive feedback loop between capital markets risks and supply risk.

Several risks can be isolated as representing critical nodes or system pressure points. These are important because they serve as performance indicators, or system failure points. Capital markets, operating costs, and management capacity interact with every other risk. Regulatory, supply, market, and technology risks also interact with many other risks with each other.

17.4 Identification of Climate Risks in the Carbon Disclsoure Project

Responses by banks, insurance companies, and energy and utilities firms surveyed by the Carbon Disclosure Project were one source of evidence used to develop and, to the extent possible, seek to explore the utility (even the validity) of the Climate Risk Assessment Framework (Hart, 2006). This section summarizes the identification of climate risks in the Carbon Disclosure Project responses submitted by the banking industry.

17.4.1 Overview of the Carbon Disclosure Project

At the time of writing, the Carbon Disclosure Project had completed three annual surveys of *Financial Times 500* companies in various industries. Overall response rates were 47%, 59%, and 71% for each of the three times that the survey has been conducted. In the third survey, 50% of the companies were located in North America, 30% in Europe, and the remainder in Asia, Latin America and the Middle East. The third survey included 69 banks, 84% of which submitted responses or information, twenty-seven utilities, 100% of which provided submissions, and thirty insurance and reinsurance companies, 67% submitted responses (Innovest, 2005).

For this chapter, one hundred and ninety-eight submissions were reviewed from three years of Carbon Disclosure Project surveys in the energy, utilities, insurance and banking industries. All insurance companies surveyed in the Carbon Disclosure Project recognized climate change as a potential risk to their property and casualty businesses. Almost all banks that responded recognized climate change as a risk to their lending businesses. Utilities and energy industry respondents similarly recognized climate change as significant to their business, in some cases presenting opportunities, but in most cases identifying significant increases in risk.

Lending banks, a subset of Carbon Disclosure Project companies, are of particular interest because of their role as lenders to infrastructure projects. The Carbon Disclosure Project surveyed 69 lending banks, excluding financial advisory services and investment banks, of which 47 banks responded by answering the survey or providing information in one or more years. Responses from these 47 banks were coded and tabulated with respect to their identification of specific risks associated with climate change. Most of the responses were coded from the banks' responses to the first question in the survey: "Do you believe climate change, the policy responses to climate change and/or adaptation to climate change represent commercial risks and/or opportunities for your company?" However, submissions were read in their entirety and answers were coded from any part of the document or supplemental materials provided by survey respondents.

To be coded affirmatively for a particular risk, a bank must explicitly identify or discuss the particular risk as a risk in one of its submissions for any of the three Carbon Disclosure Project surveys. In the case of operating risks, responses were either counted towards "Operating Risk – Cost" where a cost element was stated, or "Operating Risk – Management Capacity" where a management element was stated or the specific reason for identifying operating risk was not stated. When banks identified both a cost and management element, both risks were credited. Because this interpretation of banks' responses is subject to error, it may be more accurate to aggregate both subcategories of risk. Aggregating both subcategories as "Operating Risk" produces a total of twenty-four responses, the fourth most commonly cited risk, with over 50% of respondent banks identifying it.

In some cases, the coding policy may have led to an underestimate of the banks' perception of climate risk. There is evidence from bank responses that the banking industry understands the magnitude of risk presented by climate change, however, if bank responses were general in nature, it could not be counted affirmatively toward any risk.

17.4.2 Survey Results

The results of this review of the Carbon Disclosure Project are presented in two forms: explicitly tabulated entries, and general statements that are difficult to classify or tabulate. Table 17.2 sets forth the tabulation of bank responses counted towards specific risks. If a bank identified by name, described, or identified an example of, a category of climate risk, it was counted as having identified that category of risk.

Table 17.2 **Carbon disclosure project banks identification of risks.**

Climate Risks	Number of Responses	Responses (% of total)
Capital Markets Risk	27	57%
Environmental Regulation Risk	25	53%
Force Majeure	25	53%
Operating Risk – Cost + Management	24	51%
Operating Risk – Cost	15	32%
Market Risk	13	28%
Operating Risk – Management	12	26%
Supply Risk	12	26%
Infrastructure Risk	4	9%
Political Risk	3	6%
Technology Risk	3	6%
Legal Risk	2	4%
Engineering Risk	0	0%
Participant Risk	0	0%
Governance Risk	0	0%

Based on Hart (2006). Responses are from 47 replies of 69 banks surveyed.

An important question is whether the importance of risk identified in the framework is consistent with the banks' responses to the Carbon Disclosure Project survey. The banks' responses to the Carbon Disclosure Project survey identified risk clusters that are consistent with those noted here as critical nodes. The banks focused primarily on capital markets, regulatory, force majeure, operating, market and supply risks.

Of those surveyed, 27 banks identified capital markets risks as a potential risk magnified by climate change. Capital markets risks were the most frequently cited risk of climate change, identified by 27 banks. Within the capital markets risk category, 24 banks identified credit risk, default risk and impairment of collateral as important capital markets risks.

Following capital markets risks, regulatory and force majeure risks were the second most commonly cited risks of climate change. Twenty-five banks identified increasing environmental regulatory risk and increasing risk of force majeure events as effects of climate change. Banks identifying regulatory risks associated with climate change commonly cited the costs of regulatory measures to control carbon emissions and potential liability arising from legal actions.

Of the 25 banks that identified force majeure as a risk of climate change, 21 banks identified the potential for increased climate events, and 16 banks expressed concern that climate change could lead to curtailment of insurance coverage. Significantly, all insurance companies that submitted responses to the Carbon Disclosure Project survey recognized climate change to increase the potential for force majeure events, causing an increase in risk to their property and casualty businesses.

Fifteen banks in the Carbon Disclosure Project identified operating cost risk as a potential area of increased risk as a result of climate change. Many of the responses specifically mentioned increasing costs of energy as a source of risk. Management capacity risk was identified by twelve banks in the Carbon Disclosure Project as a potential area of increased risk as a result of climate change. The most common comment concerned the decreased capacity for management to properly assess risk and to plan.

As noted above, due to difficulties in distinguishing between operating cost and management capacity risk, these two categories should also be analyzed as an aggregate category – “Operating Risk.” On an aggregate basis, a total of 24 banks identified operating risk as increasing due to climate change. As an aggregate risk, operating risk becomes the fourth most commonly cited risk, with over 50% of respondent banks identifying it.

Twelve banks responding to the Carbon Disclosure Project survey cited potential supply problems as a risk posed by climate change. Most of these responses related to increasing cost of energy and electricity. One bank identified vulnerability due to dependence on imported petroleum as a supply risk issue.

Thirteen banks participating in the Carbon Disclosure Project identified increasing market risk as a potential result of climate change. Twelve of these banks specifically indicated that a company’s reputation might be adversely affected by being linked with carbon emissions or environmental damage. Four of the thirteen banks indicated that climate change could influence consumer preferences or changes in demand. Notably, only four banks identified infrastructure risk, only three banks identified technology risk, and no banks identified engineering risk. The comparatively few responses mentioning technology-related risks may reflect the fact that banks' responses focused on the more immediate or familiar risks associated with their business or a failure to recognize that climate change will exert important pressures on technological development. Technology risk is a traditional risk and its importance has been recently reaffirmed by rating agencies in connection with IGCC technology (Foster, 2005a, b). Only three banks identified political risk as a concern. One possible explanation is that banks equated political risk with regulatory risk, the most commonly cited risk, and the coding of the surveys conflated these risks.

Legal risk was identified by two banks, and participant and governance risks were not identified by any banks. We know from experience that these risks are important. A possible explanation is that the omission of these risks may reflect that they are viewed as secondary to loan default and preservation of collateral. Table 17.3 shows bank responses that were too general in nature to classify within any one particular risk category and were therefore not counted toward any of the above risks.

Table 17.3 **Carbon disclosure project banks' general impacts.**

Climate Change Impact	Carbon Disclosure Project Banks
Agriculture	ANZ, Barclays, HSBC, Credit Agricole, Scotiabank, CIBC, Standard Chartered, Toronto-Dominion, WestPac
Biodiversity	BBVA, SocGen, WestPac
Loss of Operating Capabilities	Bank of Montreal
Relocation of Business	HSBC
Business Interruption Commercial Risks	CIBC, Toronto-Dominion
Shifts in Weather	Dexia
Affects on Industry	Standard Chartered
Coastal Zone Business	Wachovia
"Impact on all aspects of modern life"	HSBC
"One of the most serious problems facing humanity"	Mitsubishi

Based on Hart (2006).

17.4.3 Learning by Banks

There is evidence that the banks' understanding of climate change improved during the period of the Carbon Disclosure Project. In some cases, this learning was dramatic. Several banks responded in the first or second years of the survey that climate change had no effect on their businesses or indicated that they had not studied the issue. In subsequent responses, these banks indicated that they had changed their earlier view and subsequently provided detailed responses comparable with other survey participants (see Bank of America and Bank of Ireland responses).

17.5 Conclusion

A survey of the banks' disclosures suggests that the financial community recognizes the critical risks identified in the Climate Risk Assessment Framework. However, the financial community's understanding of climate risk is not uniform as suggested by the range of responses to the Carbon Disclosure Project survey. Further, the financial community still lacks a common framework for systematically analyzing climate risks. The Climate Risk Assessment Framework is intended to provide a tool for analyzing investment decisions and potential government policies for supporting the development of infrastructure in light of climate change. It provides a foundation for further development and modification by individual banks in order to identify and provide greater visibility to financial risks affected by climate change.

References

Foster Associates. (2005a). S&P report concludes that coal-gasification technology holds potential financial risks, as well as environmental rewards. *Foster Electric Report*, 403.

Foster Associates. (2005b). S&P outlines challenges IGCC technology will have to overcome to be a viable power supply option. *Foster Electric Report*, 422.

Hart, C. (2006). The private sector's capacity to manage climate risks and finance carbon neutral energy infrastructure. Ph.D. Dissertation, September, 2006. Cambridge, Massachusetts; Massachusetts Institute of Technology.

Innovest Strategic Value Advisors. (2005). *Carbon Disclosure Project 2005*. (London, UK: Carbon Disclosure Project)

Revelle, R.R. (1983). Probable future changes in sea level resulting from increased atmospheric carbon dioxide. In *Changing Climate*. (Washington, D.C.: National Academy Press)

Chapter 18

GLOBAL AGENDA! VERSION 1.0

Toward Interactive Gaming and Simulation of World Politics

Christi Electris and Dinsha Mistree

Introduction

In this chapter, we report on *Global Agenda!* – a simulation game designed to explore the complex nature of interactions among actors in a global landscape. There is a long tradition of using simulations and games as tools for teaching and training in international relations, ranging from tools for military strategists and policy makers to games designed to educate students in high school and college to games designed for entertainment. Probably the earliest example of using games for developing military and strategy skills is the Chinese game of *Go*. According to legend, *Go* was used as a teaching tool under the Emperor Yao more than 4,000 years ago.

These days, military and strategy games remain popular. Games such as *Civilization*, *Age of Empires*, and *Risk*, have broad appeal, as evidenced by their success in the gaming market. These popular games, however, are based on highly stylized and unrealistic representations of actors, actions, and ranges of outcomes. For instance in the games mentioned above, the player usually wins by conquering the rest of the world. History tells us that it is not so easy to conquer the world, and a more accurate game should levy appropriate consequences on a "Veni, Vidi, Vici"-minded player.

In the more scholarly frame, initiatives such as the GLOBUS project, CASCON, as well as the earlier pioneering Inter-Nation Simulation in the Field of International Relations, were all attempts to model and simulate interactions in world politics, but they all preceded the possibility and potential power of web-based modalities. The same is true for the purely computational system dynamics model of the world oil market, namely the MIT International Petroleum Exchange (IPE) Model developed in response to the first world oil crisis, and designed to explore the implications of alternative policies and strategies postured on future prices, patterns of vulnerabilities,

N. Choucri et al. (eds.), Mapping Sustainability: Knowledge e-Networking and the Value Chain, 379–394.

and strategic configurations (Choucri, 1981). In addition, a range of simulation models in international relations have also been developing, with scholars attempting to model different aspects of the world and the interactions of different factors and agents.[1] Few such efforts are easily accessible for teaching purposes, or geared primarily for exploring issues central to international relations as, for example, tradeoffs, or long term consequences of short term decisions.

Also unlike previous simulations, the *Global Agenda!* initiative addresses interactions and potential tradeoffs across two sets of interdependent systems. These are the *natural system*, which is governed by environmental conditions, and the *social system*, including interactions among individuals, which are embedded in states, and conducted in an international system. These two interdependent systems are encompassed within a global system.[2] We want the player to consider the full set of costs and benefits associated with every decision across the global system. In the next section, we shall discuss other skills we expect the player to develop from *Global Agenda!*.

18.1 Game Lessons and Layout

Games are educational in the sense that they shape current understandings as well as the future beliefs and behaviors of their players. To this end, there are several key concepts that we hope to impart to the player as basic lessons in world politics. These concepts include the following:

- *Action–Reaction* – Invariably, actions motivate reactions. A player must recognize how certain decisions will trigger both good and bad results.
- *Feedback* – Actions may manifest themselves in terms of feedback dynamics, which may be positive or negative.
- *Delayed Impacts* – Most often than not, short-term decisions have both short-term and long-term consequences. The player cannot make myopic decisions.

[1] Some examples of such models are *International Futures*, the *World3 Model*, and the initial *Limits to Growth* model of the Club of Rome. A reframing and update of the original *Limits* logic and modeling demonstrates that there are indeed “Limits to Growth,” and that as a society, we need to make policy choices in order to avoid the so-called “overshoot and collapse” phenomena. None of the *Limits*-derived models consider the state explicitly as a key actor, state-based. The policy think-tank, the Center for Strategic and International Studies (CSIS), has also developed *Seven Futures*, a simulation tool that aims to inform policy makers of seven plausible future states of the world, and the policy implications and possible solutions. See the list of references to find further information on these models.

[2] Hence the title of the game.

- *Tradeoffs* – Decisions always entail tradeoffs. The player must think about the risks and benefits in order to make the most informed decisions.
- *Uncertainty* – Decisions are always made with some degree of uncertainty – one must make decisions based upon incomplete and inaccurate information.
- *Human–Nature Interactions* – All strategic moves affect the environment, directly or indirectly. So too may environmental factors influence the socio-political, or even the economic context for strategic moves.
- *Internal–External Linkages* – Foreign policy moves can have domestic impacts, and internal factors can constrain international action.

These concepts will be packaged in an exciting and enjoyable game. The current format of *Global Agenda!* is a single-player game. A player may choose one of many different international roles: for example, the player could be the President of the United States, the Secretary General of the United Nations, the President of Colombia, or the Prime Minister of Israel.[3] We envision this initiative as a vision of a complex world. It is a world where crises and instabilities arise, oftentimes unexpectedly. It is a world in which many of the past sources of insecurity and uncertainty persist and their destabilizing effects remain, but these sources have recently been augmented by a new set of instabilities and uncertainties which have developed through recent world events and whose characteristic features are still not fully appreciated. In *Global Agenda!*, we depict a coherent view of these new realities and challenges of the 21st century while still emphasizing the uncertain conditions in which policies must often be devised. *Global Agenda!* is therefore about the challenge of steering a country or organization (via its leader) through a maze of domestic and foreign challenges, all of which shape international conditions.

18.1.1 Hotspots

The challenges that the player addresses are *Hotspots*. Formally defined, Hotspots are disturbances to established orders that, with little provocation, could deteriorate into major crises. Not all Hotspots inevitably become major crises, but as they are all some form of crisis, they all force leaders to act in a mode of crisis-management.

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[3] In time, we hope to let the player choose between leading countries, both large and small, as well as choosing between heading several different international institutions. However, in this chapter, we shall only discuss the game in terms of a player who can lead a country, footnoting where international institutions would require a different game-structure. Also, the examples above are illustrative, and not exhaustive.

In the game, there are two different kinds of Hotspots. First, there are Hotspots that are entirely human-generated, which fall into the domain of strategic and political challenges. Hotspots that involve conflict or political instability are examples. Second, there are Hotspots that are produced by nature, and fall into the domain of environmental disasters. Such crises include hurricanes, floods, and other natural disasters. The effects of a Hotspot may overlap between the social and natural systems. In other words, Hotspots produced in one system may affect elements in the other. For instance, a conflict inevitably brings some reduction of environmental properties in the same way a poorly-handled natural disaster response may bring about higher crime rates. Hotspots in one system may even contribute to the triggering of Hotspots in the other system.[4]

To stress the constraints of time, the player will only be allowed to address a certain number of Hotspots in any given turn. Currently, we are designing the game to be played in about thirty minutes in real time, with six turns taking place over the course of the game. In each turn, there may be fifteen or twenty Hotspots a player can to choose to address, but the player will only be allowed to choose the most salient Hotspots and address them.

Among the many dilemmas facing each player are: how to manage responses to those Hotspots that he/she considers salient; how to take into account the implications of those Hotspots that are not selected to be on the country's agenda should they re-emerge or trigger other Hotspots; and, how to balance the several competing pressures while still seeking to adopt a winning posture.

18.1.2 Winning and Losing

In other games, winning and losing is easily defined: the player either succeeds in conquering the world and wins, or the player fails and loses. In *Global Agenda!* winning and losing cannot be so clear-cut. To start, winning and losing must stress the lessons we want the player to learn. If we want the player to learn about tradeoffs among social and environmental systems, it does no good to simply assess the player based upon internal popularity or economic strength. We must take into consideration several key variables. Also, winning must be measured in terms of both short-term performance, *as well as* long-term performance, which we call security.

The traditional way of thinking about security is in military terms, namely, the security of the state, its borders, and its ability to defend itself

[4] All Hotspots will include an element of randomness in their triggering. In other words, certain conditions may make a Hotspot more likely, but the player is not destined to encounter any specific crises. To be clear, the player will always receive several Hotspots, but these Hotspots will always be different.

against military incursion. However, many actual countries are vulnerable to a range of threats to the security of their societies that cannot readily be recognized by the conventional calculus. Accordingly, a more comprehensive logic of security must include at least three distinct components:

- *External Security (ExS)* – namely defense of the borders, i.e. security against military or related threats from outside its own territorial boundaries.
- *Internal Security (IS)* – security of the institutions of governance against internal socio-economic or political threats within the bounds of the state.
- *Environmental Security (EnS)* – viability of basic life-supporting properties from the natural environment, encompassing the social order.[5]

From a theoretical perspective, a state is secure to the extent – *and only to the extent* – that all three of these conditions of security are in place, and that the state is secure in both the short-term, as well as the long-term.[6] To this end, if any of three critical variables drop by 15 percent or more of their original values, either at the end of the player's reign, or 20 years down the line (assuming a consistent trajectory), the player is judged to have lost.[7] If the critical variables do not fall below this threshold, the player wins. These critical variables are International Approval, Domestic Approval, and the State of the Environment. Dynamically affecting these variables are a whole assortment of other variables and measures, including (but not limited to), Economic Conditions, Infrastructure, and Public Health. The equations which govern the relationships between these several variables are currently being empirically formulated by using real-world data of countries over the past years, combined with techniques in econometrics and statistics.[8] Using identified real-world relationships is one of the many ways in which we hope to reduce biases and personal prejudices from *Global Agenda!*

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[5] Based on this definition, which was originally presented in Choucri (2002), we need to stress that each of the variables consist of a wide range of composite variables, reflecting different manifestations of the underlying empirical realities, and different variants of the core concepts.

[6] Measuring winning in terms of state security works when the player chooses to lead a country, but when a player chooses to lead an international institution, winning will have to be reconceived. Perhaps we will consider global stability and security (in terms of both social and environmental components).

[7] Basically the way in which long-term consequences are measured is that no more Hotspots are triggered after the player stops, but the underlying game equations run for another several years.

[8] Constructing these country-models has proven to be one of the most demanding aspects of the game.

18.1.3 Reducing Bias

A player must manage several different Hotspots to successfully complete the game. For the player to successfully learn, the game-maker must construct the game by being as objective as possible. As with any work in political science, we must be cognizant of how our own biases, prejudices and pre-conceived notions may shape the game. We take several steps to ensure objectivity.

The most direct way in which we address biases is by using real-world data and real-world observations. The game essentially consists of two elements: the country-models and the Hotspots. The country-models are the equations which govern the conditions of the country: how a rise in the economy affects the player's popularity, for instance. Other game-makers invent these country-models oftentimes employing little more than their own personal beliefs, and with good reason: these equations are tremendously complex to construct. Fortunately, we have a large amount of data for every country we are constructing, and we create country-models based upon what we have observed in the past. For the country-models, we do look for similar types of countries in order to discern various relationships between variables, but for every country, we calibrate the model using that country's historical past.

The process of constructing Hotspots is a little more difficult. Following a major theme of *Global Agenda!* our Hotspots are rooted in real-world instances of crises which have taken place. Unfortunately, with any crisis we can only observe the consequences of the policy actions that were historically chosen at that point in time. We have no way of determining the consequences of policy actions that were not selected. To get around this challenge, we employ two strategies. First, we observe other similar Hotspots. For natural disasters, this is easy: we can look at the consequences of several natural disasters in a given type of country and we can extrapolate that various policy actions will engender various responses. In terms of human-caused Hotspots, this process is less fruitful. For starters, even within similar Hotspot types (such as conflicts), there are so many different elements, causes, and consequences that must be considered. For example, despite some similar principles, the India–Pakistan standoff is profoundly different from the Catholic–Protestant situation in Ireland, or the China–US–Taiwan tension today. The consequences of actions in each of these situations will similarly differ as well.

To partially alleviate this condition of bias, we introduce elements of randomness. Certain actions may be taken to increase the likelihood of success, but in any Hotspot decision, there will always be a chance of failure. For example, a hostage-rescue only has a certain chance of success; a sure-fire peace negotiation may just as likely fail. Some element of randomness also dictates the initial detrimental effects of a Hotspot: an earthquake may knock out between two and twenty percent of a state's infrastructure, for instance.

18.2 Game Progression

A player begins by either choosing to view an introductory sequence, or by choosing to directly enter the game. Following the introductory sequence or the selection of the second option, the player is asked what country he or she would like to lead.[9] This decision is not a blind choice: before selecting which country to lead, the player is offered descriptions of each country, with pre-existing country indicators clearly shown. These pre-existing country indicators are once again based upon real-world data: if the player chooses to lead the United States, the player's initial Gross Domestic Product (GDP) will be equivalent to the United States' most recent GDP estimates.

18.2.1 The Office

After the player chooses a country, the player is introduced to the Office. If a player chooses to lead China, the player would be introduced to the Chinese Prime Minister's Office, shown at the center of Figure 18.1.

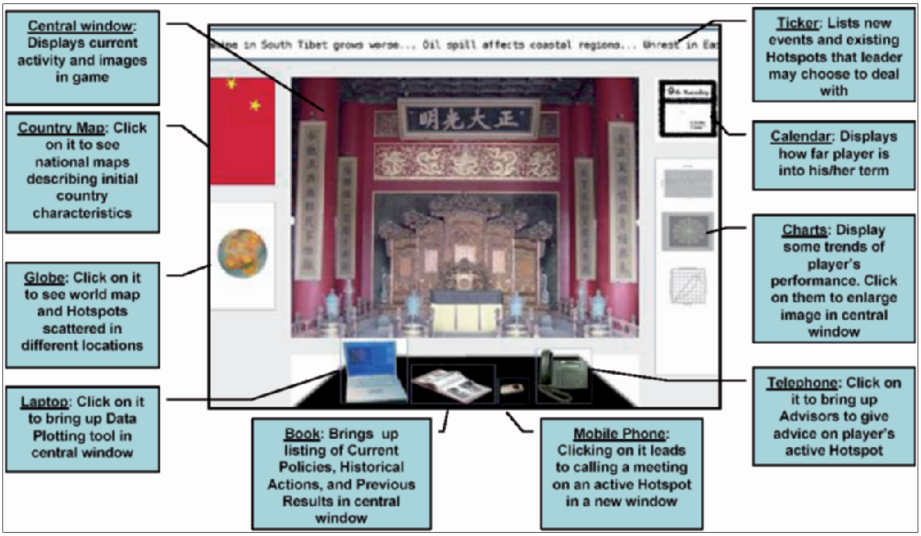

Figure 18.1 **Screen view of Chinese Prime Minister's Office.**

[9] Again, in time the player will be able to select international institutions as well.

There are several notable features of the player's Office. On the right of the screen is a Calendar, keeping track of the time until the player's game ends. Below the Calendar are several Charts, showing key measures of the country's well-being. These key measures are known as *Barometers*, and the player is expected to consult these measures when responding to Hotspots. When responding to Hotspots, the player may also wish to consult with various advisors. By clicking on the Telephone on the right of the desk, the player is taken to another window where advice can be solicited from various military experts, economic experts, and other experts. Next to the Telephone is a Mobile Phone. Clicking on the Mobile Phone brings the player to the Crisis Management Room. The Crisis Management Room is where Hotspots are addressed and where the player can see the options for alleviating each Hotspot. Also on the desk is a Book, where the player may review previous decisions and the consequences of these decisions, and a Laptop, where the player can observe more Barometers while comparing his or her performance to real-life trends.

Above the desk and to the left are a flag and a globe. By clicking on the globe, the player can observe a map showing the breakout of various Hotspots. In Figure 18.2, an example map is shown, with several Hotspots occurring across the world. Clicking on any of the Hotspots again leads the player to the Crisis Management Room, with the correspondingly selected Hotspot featured.

Figure 18.2 **Hotspots displayed across the global landscape.**

The flag is always of the country which the player is leading. Clicking on this flag brings maps and visually-friendly information about his or her country. Finally, across the top of the Office runs a Ticker, where short descriptions of the Hotspots scroll across the screen. Clicking on the ticker also leads the player to the Crisis Management Room.

18.2.2 Types of Hotspots

During the course of the game, Hotspots arise. Several Hotspots greet the player as he or she enters the game. Such *Background Hotspots* are randomly included at the advent of the game. *Randomly-Generated Hotspots* are not necessarily triggered by any barometers, but arise on their own. An example of a *Randomly-Generated Hotspot* would include a natural disaster or a conflict between two allies. Other Hotspots are triggered by certain barometer conditions, and these are *Barometer-Generated Hotspots*. While there is always some level of randomness in whether one of these Barometer-Generated crises will be triggered, these Hotspots are largely the result of the player's responses to previous Hotspots. For instance, a precipitous drop in the economic strength of a nation may trigger riots, producing another crisis. In Table 18.1, we summarize these types of Hotspots, with examples.

Table 18-1. **Description of Hotspot emergence on global landscape.**

Hotspot Type	Appearance Criteria	Example
Type 1: Background (Pre-existing issues)	Several Hotspots exist before the game begins.	A pre-existing conflict
Type 2: Randomly-Generated	Hotspots occur during the game due to random conditions.	Natural disasters
Type 3: Barometer-Generated	These Hotspots are triggered by the conditions of the barometers.	Drop in economy causes riots

When seeking to manage or respond to Hotspots in game play, the player can refer to the barometers, the advisors, and the game history to obtain information that can be useful for selecting a policy response. When the player finishes dealing with a Hotspot, he or she can look at the short-term or immediate results and decide whether more action is necessary. At the end of the game, the player is told what would happen in the future, assuming constant policies and conditions over a longer time period. Walking through a Hotspot may help the reader better understand the mechanics of the game.

18.2.3 Hotspot Example: Responding to Invasion of an Ally

The player is notified of the Hotspot across the Ticker on the main screen of the Office. In this example, the player is presented with a Hotspot. The player responds to the Hotspot by entering the Crisis Management Room, either by clicking on the Ticker or on the Mobile Phone. There, the player sees a specific dilemma associated with the general Hotspot. In our case, an ally in a distant part of the world has been invaded. This invasion has caused an immediate reduction in infrastructure of the allied country, has undermined the player's interests in the region, and will soon cause a reduction in other important variables if the correct policy actions are not selected.

In the Crisis Management Room, the player is presented with a general description of the Hotspot, including possible historical effects, an image of the event, a list of the choices the player can select in response to the Hotspot, and a link to the player's advisors.

After reading the description of the specific crisis, the player may want advice. This is given through the advisors, who are available in the Advisor Screen. There, the player can receive advice from any of several different advisors, with each advisor seeking to advance certain priorities. In this example, a military advisor suggests bringing in troops to repel the invaders, while an economist urges the player to select limited military engagement to protect business interests.

When the player has gathered all the information he or she wants, the player can respond to the crisis at hand. The player does so by selecting a response in the Crisis Management Room.[10] In this example, the player will need to decide how to respond to this crisis – an invasion of an ally's country – in a manner that best solves the problem in relation to the state of country.

With the invasion, the player may select any of the following actions:

1. Do nothing.
2. Negotiate with invaders – allow them to control ally so long as they maintain strong ties with your country.
3. Negotiate with invaders – offer very little and demand peace.
4. Limited military action – send a small number of troops to assist ally.
5. Large-scale military action – commit a large number of troops to repel the invasion.

Assume the player chooses Action 1, effectively ignoring the problem. The Game Engine then calculates the negative effects of the invasion in terms of signals sent by not supporting one's ally and in terms of sacrificing control in the region, once again relying upon some element of randomness. In addition to being dependent upon the parameters given by the Hotspot and the element of randomness, the success of handling the situation is also dependent upon the state of the player's own country. In this case, if the magnitude of military spending is above a certain threshold, your country's soldiers will be able to aid your ally in repelling the invasion. Otherwise, the extent

[10] Currently, the player may only choose one response per Hotspot Event. In the future, we want to allow the player to select multiple options.

of damage will be greater, and public opinion of the player will decrease. To fully illustrate the example, let's assume that the player chooses Action 4, but that the invasion is too great for the military to contain (determined partly by the size of military expenditures and partly by randomness) and that the Hotspot continues to persist through the second game-time iteration.

The player is immediately informed of the military's inability to repel the invasion, as well as the outcomes of any other Hotspots the player addressed in the previous turn. In the Office, the player can choose to observe the ramifications of the action selected. For example, the player could view a graph of the measure of regional control. With the continuation of the Hotspot, the player's military regional control would continue to fall, as the inability to counter the invasion causes further destruction from the initial conditions. To be clear, if a Hotspot is not appropriately handled, it will again emerge in the next time iteration, triggering another sub-crisis related to the Hotspot.

To return to our example, following the failure of the military, international approval has dropped. Again, the player can read about how this invasion is projected to affect his or her own country, the player can once again consult advisors, and the player can see the initial changes on the barometers. To alleviate this new crisis, the player is offered with the following choices:

1. Remove troops from country and region.
2. Seek international military support.
3. Negotiate with invaders – allow them to control ally so long as they maintain strong ties with your country.
4. Continue limited military action.
5. Counter with a large-scale military action.

This time, the player chooses to cede the ally to the invaders in exchange for strong ties. Again, the Game Engine will assess the player's choice, and look at the internal parameters for the invasion. The player can then witness the effects of his or her choice. In this case, the invaders may choose to accept or reject the conditions the player has set forth (randomly determined). If the invaders accept the player's terms, then international approval may drop while domestic approval rises.[11] If the invaders reject the player's terms, the Hotspot would persist, and international approval, domestic approval, and regional control would drop.

If the Game Engine concludes that conditions are no longer favorable for the invasion-scenario to persist, the Hotspot will end in the sense that it will not arise in the next game-time iteration. Following the game-time iteration,

[11] We have intentionally made this example simplistic; in the game itself, the invaders may initially agree to the conditions of the negotiations, but depending upon other conditions (as well as an element of chance) they might not honor them.

the player will be sent back to the Office and will continue playing the game. However, if the player's choices do not make the necessary changes to end the Hotspot, it will continue, each turn presenting a new scenario in need of the player's response. The Hotspot will continue until the player has made the choices necessary to move the game model out of the state that triggered the invasion, or until the end of the game. At the end of the game, the player is informed as to whether he or she won the game, as the Game Engine inspects whether any of the key variables – Domestic Popularity, International Popularity, or State of the Environment – has dropped below the given threshold of a 15 percent decrease. At the crux of this game is the Game Engine. In the next section, we discuss the computational details of constructing *Global Agenda!*, including the Game Engine.

18.3 Behind the Scenes

Not specifically observed by the player, but critical for the operation of *Global Agenda!* are two important components: the Hotspot Library and the Game Engine. In this section, we discuss some features of the game design, exploring the nuts and bolts that give life to *Global Agenda!*

18.3.1 The Modular Principle

Computationally, *Global Agenda!* consists of four components. These are the User Component, the User Space Component, the Content Space Component, and the Computational Space Component. From a design perspective, *Global Agenda!* is modular in the sense that these different components of the game can be updated or entirely modified without overhauling the entire system. This important property enables us to improve and revise parts of the game without having to overhaul all aspects of the game. In Figure 18.3, we display the elements of each component.

In the previous sections, we have discussed the aspects of the User Component and the User Space Component; here we shall discuss the development of two major parts of the Computational Space Component and the Content Space Component: the Hotspot Library and the Game Engine.

18.3.2 The Hotspot Library

During any given game, the player will interact with only a select few Hotspots selected from the Hotspot Library. There is a consistent Hotspot

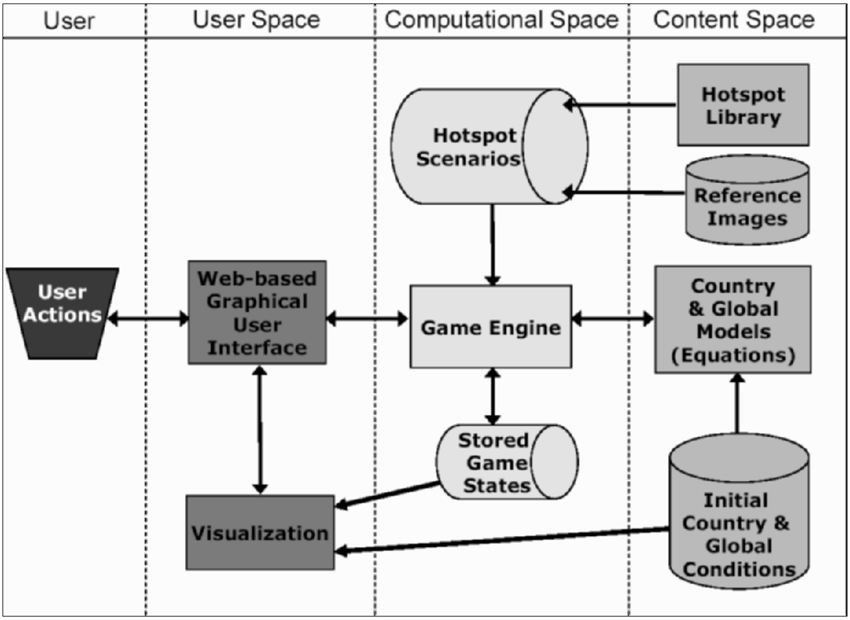

Figure 18.3 **Modular computational game elements.**

Template that is applied across-the-board to all Hotspots. Within this template, the content-provider or author of the Hotspot is asked to give the Hotspot a title and a brief description. The content-provider must identify which country is addressing the Hotspot, and must distinguish to what degree is the Hotspot transferable. By transferable, we mean that certain Hotspots are more salient or less salient to certain countries, and should be treated as such.[12]

The content-provider must also identify Events that may occur in the Hotspot, the trigger conditions for the Hotspot and for the Events, and the consequences of an activation of the Events and the Hotspot. A Hotspot is actually a whole set of sub-crises, which we call Events. A player receives one Event per turn. In the invasion example, the two Events that arose from the Invasion-of-an-Ally Hotspot were the invasion itself in the first turn, and a worsening of the situation in the second turn due to the player's military's inability to the repel the invasion. The Hotspot could have invoked other Events, such as the triggering of invasions against other allies or a war against another major power who may be supporting the invader.

[12] For instance, a flood is not likely to happen in a country that is a desert, and therefore a player should not encounter a Domestic Flood Hotspot if he or she is playing as a country located in such a terrain. Similarly, a Hotspot that describes tensions in the Middle East is drastically different from different country perspectives. Players who wish to lead the United States and Syria may each be confronted with a Middle East Hotspot, but the challenges of the Hotspot and the appropriate actions of the Hotspot are country-dependent.

Just as important as identifying what conditions activate a Hotspot or an Event is identifying the policy actions a player may take, and the ramifications of these policy actions. In each Hotspot, the content-provider should provide at least four different policy actions, and should identify the consequences of each action. The content-providers are aware that *Global Agenda!* is designed to teach students about tradeoffs, and here is where costs and benefits are built into the game.

Finally, the content-provider must provide messages for the user, advisor opinions, and relevant images. Content-providers must provide sources for their situation assessments, and there must be a valid and defendable logic for each of the consequences of the policy actions. Upon completion, each Hotspot is reviewed, critiqued, and revised by several members of the game design group before being included in the Hotspot Library.[13]

18.3.3 Computational Logic of the Game Engine

The Game Engine is the part of the computer program that handles all the requests and actions coming from the user through the Graphical User Interface (GUI), incorporating the relevant changes into the country–models, and recording the game progression. According to the condition of the country (as determined by the country model), the Game Engine will also evaluate which Hotspots are triggered.

Unlike several other projects which use off-the-shelf components for their purposes, the entire Game Engine has been constructed by our research group.[14] For illustrative purposes, we now turn to one element of the Game Engine: how Hotspots are computationally handled. Figure 18.4 consists of a diagram representing the underpinning logic for this part of the Game Engine.

To walk through the diagram (starting clockwise from the top-left and emboldened box), the Game Engine first identifies all Hotspots relevant to the country that the player selects. The Game Engine then tests the Activation Conditions of the Hotspots and Events. If a Barometer-Generated Hotspot or Barometer-Generated Event is activated, certain initial effects directly affect the player. For instance, at the outset of the Invasion Hotspot, the regional control is automatically initially reduced by a controlled-random

[13] All Hotspots are stored as XML documents for easy assimilation with the Game Engine, which has been written in Java.

[14] The logic for the different elements of the Game Engine is complicated, elaborate, and technical: in short, not the type of gritty material we want to discuss in this conceptual paper. After the game is further developed, we have every intention of making all Game Engine documentation available (including the code).

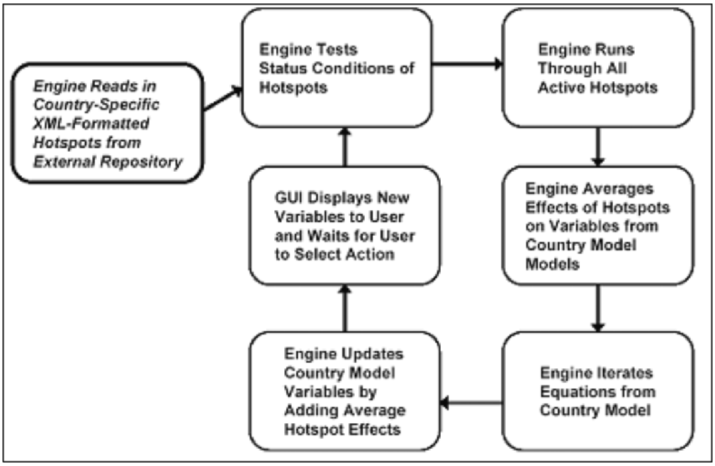

Figure 18.4 **Diagram of computational logic of the game engine.**

percentage. Once the player chooses a certain policy action, the Game Engine computes the effects on the countries by changing the country model variables. In the next game-time iteration, the next set of Hotspots and Events are triggered.

At the end of the game, the Game Engine iterates through this cycle twenty times without introducing any new Hotspots. These iterations, which capture long-term performance, combined with the player's immediate results, measure the player's level of success.

18.4 Conclusion and Future Steps

Unlike any other product that exists today, *Global Agenda!* stands as an experiment in both gaming and simulation. We predict that *Global Agenda!* will evolve over time to become a unique way of understanding, exploring, simulating and creating alternative reactions and representations of global politics.

In this chapter, we have described the basic approach to *Global Agenda!*, and we have described the current state of the game and its logic. However, in order to fulfill the vision set forth, considerable development must be undertaken. For instance, we are currently working towards representing the diaspora of stakeholders in world politics by making several single-user games, but in the future we hope to convert *Global Agenda!* into a multiplayer game, with different players representing these stakeholders in the same cyber-world. Capturing and representing the tradeoffs associated with such international interactions will also hopefully contribute to the players' overall understanding of the dynamics at hand.

We are also considering how to effectively add actions that are not directly Hotspot-related. Many forms of international relations are conducted without the presence of crisis situations.[15] Finally, we note once more that this chapter is based on the experiences of Version 1.0. We anticipate considerable revisions as we review our progress so far and plans for next steps.

References

Almond, G. A., and Powell, B. H. Jr. (1966). *Comparative politics: a developmental approach.* (Boston: Little Brown)

Bloomfield, L. P., and Moulton, A. (1997). *Managing international conflict: from theory to policy.* (New York: St. Martin's Press)

Bremer, S. A. (Ed.) (1987). *The Globus Model: computer simulation of worldwide political and economic developments*. (Boulder, CO: Westview Press)

Choucri, N. (2002). Migration and security: some key linkages. *Journal of International Affairs*, 56(1), 98–121.

Choucri, N. with Ross, D. S. and the collaboration of Pollins. (1981). *International energy futures: petroleum prices, power, and payments.* (Cambridge, MA: MIT Press)

Hughes, B. B. *International futures model*. Retrieved September 26, 2006, from http://ifsmodel.org/index.html

Meadows, D. H. (1972). *The limits to growth: a report for the Club of Rome's project on the predicament of mankind*. (New York: Universe)

North, R. C. (1990). *War, peace, survival: global politics and conceptual synthesis*. (Boulder, CO: Westview Press)

Peterson, E. *Seven futures*. Retrieved September 26, 2006, from http://7futures.csis.org/ discover/ index.cfm

[15] For instance trade, treaties, and many forms of aid are all commonly formed in the course of day-to-day international politics. Conceptually, we have to choose which interactions to include and the consequences for each of these actions. Computationally, we shall probably make these commands similar to Hotspot decisions.

Chapter 19

BASIC VERSUS COMPLEX LOGIC IN INTERNATIONAL RELATIONS

Taking Stock via Comparative Inquiry

Nazli Choucri and Charlotte Mathieu

Introduction[1]

Purpose and Process

The purpose of this chapter is to take stock of recent developments in the study of international relations – in the context of the broader social sciences – and to highlight the apparent differences between the basic, traditional assumptions and perspectives, on the one hand, and the more complex, emerging logic and fundamental departures from tradition, on the other. Our purpose here is less to engage in a philosophical critique or a methodological assessment than it is to provide a systematic comparison of two very different perspectives, the basic and the complex. However, tempting it might be to consider the latter as evidence of paradigm shift, the challenge at hand is to engage in an intellectual exercise as a useful reminder of underlying currents and currencies (Kuhn, 1970). In this connection, the essays in Lakatos and Musgrave (1970) are especially relevant in addressing these issues.

Tempting as it might also be to posit potentials for a scientific revolution – even more daunting a leap when applied to fields of inquiry that do not conform

[1] This chapter is based on a paper prepared earlier for a workshop at the Santa Fe Institute. We would like to thank Peter Brecke, George Cowan, Zhiyuan Cui, Marcus W. Feldman, Murray Gell-Mann, Peter M. Haas, Loren King, Uday Mehta, the late Robert C. North, Brian Pollins, Jerome Rothenberg, Robert M. Solow, and Jan Sundgren for comments, criticisms, and clarifications. We are especially grateful to Hayward R. Alker Jr., and Claudio Cioffi-Revilla for their methodological critiques and assessments of alternative approaches to, and perspectives upon, modes of scientific inquiry, the development of knowledge, and the advantages and disadvantages of alternatives epistemological foundations of critique.

N. Choucri et al. (eds.), Mapping Sustainability: Knowledge e-Networking and the Value Chain, 395–406.

to the letter of pure science – we seek only to take a systematic a first-order comparison of building blocks of international relations theory by highlighting basic versus more complex formulations.

Proceeding systematically, we begin by defining the method used in the analysis. Then we undertake a systematic comparison of key propositions. On this basis, we draw some underlying inferences, pointing perhaps to some (interim) conclusions. Our intent is to be as transparent as possible, so as to enable others to replicate, criticize, improve, reject, or reconstruct our method. At most, we seek to be indicative rather than exhaustive. Appendix D presents examples of the literatures that support these dual perspectives and the observations that illustrate their key features.

Guiding Proposition

This chapter is based on the proposition that the differences between basic perspectives in international relations manifested in various traditional approaches, and those that are more complex, manifested in emerging logics, are significant in content and implications. They signal indications of intellectual shifts-in-the-making, rather than common cleavages among established approaches. Clearly, only time will tell. For practical purposes, we consider basic logic to represent mainstream perspectives in the study of international relations, including the debt tone-classical economics and to the post-behavioral positions. The advanced or complex logic refers to identifiable departures from tradition, including a focus on transformation and change rather than on systems-in-equilibrium.

At this point, four short caveats are in order: first, given that the differences between basic and complex may be contentious in itself, and that it may not be as stark as implied here, it is essential to render some precision to the distinctions upon which the remainder of this chapter rests. This imperative is important in theoretical as well as methodological terms.

Second, given that the scholarly literature is not likely to conform to this distinction – one study may be grounded in tradition, and reflect mainstream assumptions and, at the same time, take into account the formulation of complex or emerging logics – it is useful to focus on the illustrative propositions rather than engage in a comparison of individual studies in their entirety.

Third, given that our interest is in stock-taking, we focus on core building blocs in propositional terms in order to signal significant differences rather than to discuss the features of specific works.

Fourth, our purpose is to clarify the current state of the art, rather than to engage in intellectual contention.

Context and Definition

Basic Logic

Basic logic refers to traditional modes of scholarly pursuits that reflect the simple form of positivism and its linear assumptions. In the field of international relations, dominant theories converge around various forms of realism and neo-realism, as well as liberalism and neo-liberalism. Challenges posed by other perspectives, notably constructivism, depart from the common debt to the rationality assumptions of neo-classical economics, structural macroeconomics, and positive political economy. The significance of the departures, however, remains to be determined.

All of designations above (and the attendant observations) are broad and general, to be sure. They are noted here primarily for concept-recognition purposes, and for contextualizing propositional comparisons.

Complex Logic

Complex logic refers to the focus on non-linear and interactive processes, notably those shaping change and adaptation in, and of, systems – at any level of analysis. In international relations, lateral pressure theory, a fundamental departure from tradition, is indebted to the new science of complexity (Anderson, Arrow and Pines, 1988; Choucri and North, 1975; Choucri, North, and Yamakage, 1992). In business and management, system dynamics and dynamical analysis reject the core neoclassical simulation tradition, putting forth and an alternative, yet internally consistent perspective. By contrast, ecological economics reframes select neo-classical fundamentals 'from within' disciplinary norms (Costanza, 1991).

Once more, these observations are general at best. They are highlighted largely to provide the context for competing propositions in the study of international relations.

Parallel Tracks

This stock-taking initiative is structured as a parallel set of propositions in order to facilitate comparisons across the two perspectives examined. The overall structure consists of propositions pertaining to (a) core assumptions, (b) political and economic processes, and (c) conceptions of sovereignty and security. The propositions are grouped accordingly, and then numbered sequentially from 1 to 10.

These issues are addressed sequentially. This comparative inquiry is suggestive not exhaustive, it is comprehensive not inclusive, and it represents the authors' views of the representative literatures.[2] Appendix D identifies some illustrative cases of basic logic in international relations, as well as those signaling more complex emerging logic. In each case, the parallel structure is used as an organizational device – addressing basic assumptions, political and economic processes, and matters of sovereignty and security.

19.1 Core Assumptions

By definition, core assumptions consist of the most fundamental of building blocks of all rigorous scholarly inquiry. Here we focus on assumptions pertaining to (1) epistemological foundations, (2) nature of system and system behavior, (3) agents and actors, and (4) temporality and time horizon.

(1) Epistemological Foundations

BASIC LOGIC	COMPLEX LOGIC
1.1 Based on 19th century mechanistic view of the world, in terms of structure and determinism; focus on equilibrium and stability	**1.1** Based on biological view of the world in terms of structure and evolution; focus on adaptation and re-organization
1.1.1 Positivistic orientation to inform content to knowledge-based claims; knowledge derived from statistical analysis and measurement rules	**1.1.1** Diverse orientations to knowledge-based claims; knowledge derived from application of different modes of rigorous inquiry (statistical and non-statistical)
1.2 Formal separation of natural and social systems; isolating social systems from natural environments (i.e. society extracted "out of" nature	**1.2** Formal integration of natural and social systems; focusing on interconnections and interdependence, and placing social system in the context of the natural systems
1.2.1 Focus on separation leads to search for regularities or laws of human behavior independent of laws of physical or natural systems; natural systems held constant	**1.2.1** Focus on interconnection leads to search for laws of living systems and rules that shape and constrain interactions of, and in, social and human systems
1.2.2 Dominance of social system in relation to all living things	**1.2.2** Salience of hierarchies and relationships, as well as linkages of wholes and parts

[2] It is also essential to highlight that the very nature of international relations as a field of inquiry – and by extension, its empirical referent – is viewed in various ways and that different scholars address the boundary issues differently. Recognizing this essential point, nonetheless, the approach we undertake, comparing 'basic' and 'complex' logics, places each within their respective frames of reference.

1.3 Emphasis on linear logic and focus on uni-directional relationships	**1.3** Emphasis on feedback dynamics and focus on multidirectional relationship
1.3.1 Basic system structure is additive (and linear); leading to simplified modes of analysis	**1.3.1** Basic system structure is non-additive (and non-linear), leading to challenging modes of analysis

(2) System Behavior

BASIC LOGIC	COMPLEX LOGIC
2.1 Systems are closed; behavior is subject to equilibrium assumptions	**2.1** Systems are open; behavior is subject to both internal and external disequilibria
2.1.1 Systems tend towards equilibrium; equilibrium seeking is both a norm and an operational assumption	**2.1.1** Systems tend towards different equilibria; no assumption of equilibrium seeking behavior
2.2 Presumption of efficiency of history; societies are identifiable entities	**2.2** Time and process dependence; variability and potential indeterminate outcomes for past and future histories; societies coalesce and reconstitute
2.2.1 Equilibrium eliminates identifiably of time-related effects; representation of abstract time dependence	**2.2.1** Explicit representation of time dependence; specification of time functions
2.2.2 Analytical and methodological foci are on initial conditions and final outcomes; emphasis on comparative statistics	**2.2.2** Analytical and methodological foci include initial conditions, intervening processes, alternative paths and outcomes; emphasis on comparative dynamics
2.3 Externalities in social processes are marginal to outcomes; internalizing externalities can improve socio-economic conditions	**2.3** Externalities are system-driving and endogenized into social process; social systems can reorganize and adjust to these drivers
2.4 Assumptions about generic behavior seldom acknowledge or articulate the root sources	**2.4** Assumptions about generic behavior are embedded in linkage assumptions and micro-macrorelations
2.5 Scarcity is a basic socio-economic condition at all levels of analysis	**2.5** Scarcity is situation specific and empirically defined at all levels of analysis

(3) Agents and Actors

BASIC LOGIC	COMPLEX LOGIC
3.1 Actors and agents are viewed as atomistic entities	**3.1** Actors and agents are reflective beings; they share common understandings and are shaped by inter-subjective meanings
3.2 Actors are rational and assumptions of rationality dominates	**3.2** Actors are subject to bounded rationality; bounded rationality dominates

3.3 Preferences are exogenous and given by assumption; idiosyncrasies are ruled out	**3.3** Preferences are endogenous in socio-economic contexts; idiosyncracies are possible
3.4 Clear distinction between actors interests and values; only interests have motivational significance; values collapse into interests	**3.4** No clear distinctions between interest and values; contents may differ; potential interacations between interests and values
3.5 Aggregation mechanism of human preferences and behavior is defined by utility maximization	**3.5** Aggregation mechanisms for preferences and behavior also include bargaining and negotiation that alter preferences and behavior
3.6 Actors are devoid of institutional contstraints and contexts; instiutional rules and regulations are not relevant to behavior and actions	**3.6** Actors are embedded in, and partially constituted, by institutional contexts; institutional results are important in framing behavior and action

(4) Temporality and Time Horizon

BASIC LOGIC	**COMPLEX LOGIC**
4.1 Short-term perspective dominates	**4.1** Long-term perspective dominates
4.1.1 Temporality issues are ignored	**4.1.1** Temporality issues include backward and forward extensions
4.1.2 Focus can be intra-generational at best	**4.1.2** Focus extends to inter-generational frames
4.2 Time is a variable only used for accounting	**4.2** Time is a variable endowed with substantive meaning
4.3 Time is defined and interpreted in chronological terms, with even and stable intervals	**4.3** Time is defined and interpreted in contextual terms, with potentially varying and uneven intervals
4.4 Discounting is the only method for taking into account temporal factors in valuation, and for consideration of agent preferences	**4.4** Discounting is of limited value however useful; other assumptions and methods are used in addition to traditional ones

19.2 Political and Economic Processes

At this point, we turn to the segment in the comparative analysis of basic versus complex logic. We assume that all of the preceding propositions hold and remain operative from one section to the other. Comparisons of political and economic processes span assumptions, represented as propositions, focusing on (5) characteristics of political economy, (6) key elements of knowledge and technology, (7) essence of decision-making, and (8) salient features of institutions. Clearly, the factors labeled (5)–(8) do not fully cover all domains of political and economic processes, however, we identify some of the most notable.

(5) Political Economy

BASIC LOGIC	COMPLEX LOGIC
5.1 Political and economic processes are neutral with respect to their natural environments	**5.1** Political and economic processes are embedded in, and interact with, natural environments
5.2 Politics, economics, and social processes are independent of each other	**5.2** Politics, economics, and social processes are interdependent and interactive
5.2.1 Politics and political processes are exogenous to socio-economic processes, and are fixed in the short run	**5.2.1** Politics and political processes are endogenous to socio-economics processes, and vary over time
5.3 Diminishing returns to scale dominate	**5.3** Increasing returns to scale are possible
5.4 Key economic elements consist of quantities and prices	**5.4** Key economic elements extend to patterns and possibilities, adaptation, and reorganization
5.5 Substitution possibilities focus on inputs in production processes	**5.5** Substitution possibilities focus also on products, processes, and sources of value-added
5.6 Growth and development are synonymous, both defined in terms of increases in net national product	**5.6** Growth and development are different; growth refers to expansion in size and scale; development refers to transformations
5.6.1 Development and sustainable development are defined as synonyms, both refer to expansion of net national output	**5.6.1** Sustainable development refers specifically to transformations meeting the needs of present and future generations preserving nature's resilience and the integrity and security of social systems

(6) Knowledge and Technology

BASIC LOGIC	COMPLEX LOGIC
6.1 Knowledge and technology are exogenous to economic and social processes	**6.1** Knowledge and technology are endogenous to economic and social processes
6.2 Knowledge and technology are defined in undifferentiated and bundled terms	**6.2** Knowledge and technology are defined in differentiated and unbundled terms
6.2.1 Technology refers to applications of science in mechanical terms	**6.2.1** Technology refers to application of knowledge and skills in organizational and mechanical terms

6.3 Structure of relevant system consists of the economy, centered on the production function (land, labor, capital), with technology as a residual	**6.3** Structure of relevant system consist of interconnected societal attributes, centered state profile (population, resources, technology), with technology endogenous
6.4 Knowledge intensity is an implicit element signaled by (residual) technology in the production function	**6.4** Knowledge intensity is an explicit element signaled by the explicit element of technology in the state profile
6.5 Technological choices are devoid of institutional or organizational factors	**6.5** Technology choices are shaped by institutional and organizational factors

(7) Decision-Making

BASIC LOGIC	**COMPLEX LOGIC**
7.1 Decision is a response to a specific problem, designed for specific impacts with no reference to system-wide effects	**7.1** Decision is a response to a specific problem, designed for specific impacts, and recognizes unintended system-wide effects
7.1.1 Decision and policy reflect forms of disjoined instrumentalism; i.e. each solution is targeted to a specific problem	**7.1.1** Decision and policy reflect holistic perspective and attention to system-wide effects; i.e. a solution to one problem often creates new problems
7.2 Solutions strategies are equilibrium seeking	**7.2** Solution strategies are path dependent**,** with contingent and variable equilibriums
7.3 Decisions and policy are exogenous to institutional processes	**7.3** Decisions and policy are endogenous to institutional processes
7.4 Short-term focus is coupled with, and reinforces, linear logic	**7.4** Long-term focus is coupled with, and reinforces, non-linear feedback logic

(8) Institutions

BASIC LOGIC	**COMPLEX LOGIC**
8.1 Institutions are exogenous to social systems	**8.1** Institutions are endogenous to social systems
8.1.1 Institutions are autonomous entities	**8.1.1** Institutions are not autonomous entities
8.2 Institutions are fixed	**8.2** Institutions are not fixed
8.2.1 Institutions are not adaptive or responsive	**8.2.1** Institutions are adaptive as well as responsive
8.3 Institutions coordinate behavior and lower transaction costs	**8.3** Institutions coordinate behavior and lower transaction; they also generate their own routinization costs
8.3.1 Institutions take preferences of actors and agents as given and fixed	**8.3.1** Institutions influence and structure the preferences of actors and agents

8.4 Rules and regulations are exogenous, inputs frame institutional properties and behavior	**8.4** Rules and regulations are endogenous, sensitive to institutional properties and behavior

19.3 Sovereignty and Security

The third segment of this comparative inquiry addresses sovereignty and security. These elements are fundamental to the nature of the state and its position in the international system. The sovereign state is the only entity enfranchised to speak on behalf of individuals in international relations, and its sovereignty is considered as much a right as a definitional necessity for survival. Preserving security is thus a corollary of state sovereignty. All of the assumptions and propositions reviewed above continue to hold, as we address (9) sovereignty and security (10) from basic as well as complex perspectives.

(9) Sovereignty

BASIC LOGIC	COMPLEX LOGIC
9.1 Sovereignty is a legal percept; the defining feature of statehood	**9.1** Sovereignty is a legal precept; one of the defining features of statehood
9.1.1 Sovereignty is invariant and does not change over time	**9.1.1** Sovereignty is variant and can change over time
9.1.2 Sovereignty is a legal and normative attribute	**9.1.2** Sovereignty is an empirical attribute
9.2 Sovereignty is bundled into an integrated, holistic concept	**9.2** Sovereignty is unbundled into a differentiated and multidimensional concept
9.3 Sovereignty is defined in territorial terms, framed by the physical boundaries of the state	**9.3** Sovereignty is not defined in territorial terms alone, and may extend beyond territorial bounds
9.3.1 Boundaries are recognized and are fixed	**9.3.1** Boundaries are recognized and are changeable
9.3.2 Boundaries are not permeable; state control of access is effective and absolute	**9.3.2** Boundaries are permeable; state control of access control is not effective or absolute
9.4 Sovereign rights and obligations are delimited by territorial boundaries	**9.4** Sovereign rights and obligations transcend and are not limited to state boundaries
9.5 Sovereignty is absolute; with no constraints	**9.5** Sovereignty is not absolute; with potential internal and external constraints

(10) Security

BASIC LOGIC	COMPLEX LOGIC
10.1 Security is a state-centric concept	**10.1** Security is not defined only as state-centric concept
10.2 Security is unidimensional, defined in the singular term of military capacity and protection against territorial incursion	**10.2** Security is multidimensional, defined to include military capacity, regime stability, and ecological viability
10.3 Security is strictly a social system issue, defined as protection from threats due to actions of other states	**10.3** Security is a social and environmental issue, defined as protection from threats to life-supporting properties as well as from threats due to actions of other entities
10.4 Threats to security are due to actions of other states	**10.4** Threats to security are due to actions of states and/or non-state groups, as well as to environmental vulnerabilities.
10.5 Security is bundled and is an integrated concept	**10.5** Sovereignty is unbundled as a multi-dimensional concept
10.6 Global security is derivative; it is a function of behavior among states that create disturbances or disruptions in socio-political systems	**10.6** Global security is fundamental; it is a function of the scale and scope of human activities (including states) that create disturbances or disruptions in socio-political and natural systems

This display of propositions, reflecting basic and complex approaches to sovereignty and security, concludes our comparison of two different perspectives in the study of international relations. The traditional view continues to dominate, but the complex view draws attention to new issues and to a more nuanced understanding of world politics. As noted at the onset, our analysis is illustrative at best. It is designed to highlight some competing propositions in contemporary international relations theory.

19.4 End Note

This chapter is a stock-taking initiative. It is not a theory-building effort. It is not an exercise to support or refute basic or complex logic. Our concern is with the nature of the fault lines separating traditional theory in international relations and the emerging logic. In some parts of our inquiry, the contrast between basic and complex perspectives is drawn perhaps more sharply than necessary. It is not our intent to create cleavages where none exist, but rather to highlight differences in ideas and assumptions when they can meaningfully be identified as such.

In this chapter we considered the question: "What do its members share that accounts for the relative fullness of their professional communication and the relative unanimity of their professional judgments?" (Kuhn, 1970: 182). The matter of *what* has been examined by undertaking a comparison across ten criteria, clustered in three sets of propositions, helping order to provide a baseline of central tendencies for *group commitments* in traditional international relations theory (basic logic) and versus those indicative of emerging theory and theory development (complex logic). It may be too soon to determine if the differences are sufficiently significant, if traditional theory will persist, or if the complex logic will provide an alternative perspective rather than supersede the norm more completely.

We demonstrate that the departures from traditional views are so explicit as to enable propositional parallel processing, so to speak. However, consistent with Kuhn's powerful insights – and the Introduction in this chapter – we draw conclude this comparative inquiry by highlighting three inferences that are derived directly from the parallel proposition structure.

First, highlighting key features of complex logics may well be an important task in its own right – as it is our view. Second, despite some fundamental differences, we do observe potentials for selective compatibility among various ideas across the theoretical fault lines of basic versus complex or emerging logics, rather than only of strict contention between them. Third, the development of interdisciplinary perspectives and attendant methodologies represent a significant shift in modes of social inquiry, most notably in relation to interactions of social and natural environments.

Given the challenges associated with knowledge development in any domain of human activity, an important next step is to improve our understanding of *emergence* as it pertains to social systems and interconnections with natural systems. Considerable advances have been made in underlying emergence in complex systems as applied to *organisms;* our understanding of emergence is primitive when applied to *organizations*. This is especially the case as we consider interactions among social and natural systems. Clearly we have put forth our own interpretation of basic and complex logic. We hope that others will determine the validity and utility of the comparisons and explain in the full nature of prevailing understandings of international relations. We also hope that others will help derive the implications most relevant for the scholarly enterprise and for policy-making purposes.

References

Anderson, P. W., Arrow, K. J., and Pines, D. (Eds.) (1988). *The economy as an evolving complex system*. (New York: Addison-Wesley Publishing Company)

Choucri, N., and North, R. C. (1975). *Nations in conflict: national growth and international violence*. (San Francisco: Freeman and Co.)

Choucri, N., North, R. C., and S. Yamakage. (1992). *The challenge of Japan: before World War II & after*. (London: Routledge Press).

Constanza, R. (Ed.) (1991). *Ecological economics: the science and management of sustainability*. (New York: Columbia University Press)

Kuhn, T. S. (1970). *The structure of scientific revolution. second edition*. (Chicago, II: The University of Chicago Press)

Lakatos, I. and Musgrave, A. (Eds.) (1970). *Criticism and the growth of knowledge.* (Cambridge: Cambridge University Press)

Chapter 20

CONCLUSION: MAPPING SUSTAINABILITY, KNOWLEDGE e-NETWORKING, AND THE VALUE CHAIN

Synthesis, Insights, and Evidence

Nazli Choucri

20.1 In Retrospect

20.1.1 The Context

Recall that, in Chapter 1, we define sustainable development as the *process of meeting the needs of current and future generations without undermining the resilience of the life-supporting properties of nature and the integrity and security of social systems.* Extending this definition, we then identify fundamental processes pertaining to ecological systems, economic activities, modes of governance, and institutional performance. More specifically, we argue for *ecological* systems to demonstrate balance and resilience; economic activity to exhibit efficiency and equity; *governance* to show participation and responsiveness; and *institutions* to demonstrate adaptation and feedback. We further stipulate that to become sustainable, a social system must exhibit a certain degree of viability along each of these processes. In short, if – and only if – prevailing trends point toward these conditions will a social system dispose toward sustainability.

Given these definitions and related stipulations, this book addresses three sets of intellectual challenges encountered in the course of seeking to enhance our understanding of sustainable development and contribute to the management of transitions toward sustainability. The first challenge is to provide a conceptual mapping of sustainable development as a knowledge domain, and to do so in ways that facilitate knowledge e-networking among interested individuals, institutions, and agencies, both nationally and internationally. The second is to extend the value chain of knowledge and

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e-networking, and to do so by providing new venues for knowledge development, provision, and diffusion. The third is to explore the value of new approaches to improve our understanding of the sustainable development *problematique*. In the Preface, we referred to these challenges as (i) *mapping and e-networking*, (ii) *the value chain*, and (iii) *new explorations in theory and methods*. Our efforts to address these challenges are designed to contribute to the expansion of knowledge, as well as to new applications in support of transitions toward sustainability.

This book is in three parts. Most of the chapters are based on research completed, the results obtained, and the evaluations undertaken. Others are clearly exploratory, and are motivated by earlier investigations that led to a new ways of 'thinking' and new methods of 'doing.' What keeps all the pieces together is the focus on sustainable development as a knowledge domain, the quest for improved modes of inquiry, and the attendant implications for theory and policy.

20.1.2 Central Themes

As a book of the *Alliance on Global Sustainability* series, the research initiatives reported in this book – the efforts and the results – pertain to theory and method, on the one hand, as well as policy, and performance on the other. In essence, the core of this book is located at the *intersection* of these four elements – all pertaining to sustainable development.

The *theory* aspect consists of delineating the broad domain of sustainable development, and then identifying its characteristic features as currently understood. In so doing, it is imperative to identify the criteria used to guide the definition and to determine the delineation strategy.

The *method* segment is multifaceted in the sense that different methodologies are relevant to different aspects of the theoretical issues at hand. In this connection, an essential feature of all methods used – as well as of all aspects of method – is the quest for innovative approaches and improved uses applications of knowledge e-networking. Of specific interest is the charting of new computational measures for facilitating representation, development, provision, sharing, and distribution of knowledge through cyber venues.

The *policy* aspect is multifaceted as well, with a specific focus on e-barriers to knowledge bearing on sustainable development. The reality of the inequalities in access to and uses of knowledge and e-knowledge is widely recognized, as are the constraints imposed by this reality. A fundamental policy challenge consists of devising a set of solution strategies to reduce significant e-barriers.

The *performance* challenge is closely coupled to matters of practice. It is based on the combined directives from theory, methods, and policy. For example, the practical implications of reducing e-barriers to knowledge networking consist of designing workflow processes customized to realities-on-the-ground, and then implementing these processes in a distributed collaborative framework worldwide.

20.1.3 Approach and Analysis

At this point, we review the concepts guiding this initiative by referring to the title of the book, namely, *Mapping Sustainability: Knowledge e-Networking and the Value Chain* – and briefly address each of the individual elements.

As noted at the onset, *Webster's New Collegiate Dictionary* defines the verb *to map* as meaning "to make a survey," and defines "a network" as "an interconnected or interrelated chain, group, or system" (1976). Accordingly, *Mapping Sustainability* means to survey the area of sustainable development and, on this basis, to derive a detailed view of its characteristic features. The product of this effort is a set of common organizing principles for depicting sustainable development as a knowledge domain.

Part I addresses the mapping challenge. Few have gone to such detail in terms of identifying the facets of sustainable development; fewer still have designed and implemented an ontology of sustainability as comprehensive as that structured in the *Global System for Sustainable Development* (GSSD). We recognize that this representation is driven by our theoretical orientation and that others may develop a different view of the issues at hand. For purposes of transparency, therefore, Part I presents the conceptual foundations, computational aspects, and implementation strategies of GSSD, as well as GSSD's specific contributions to the practice of knowledge e-networking. The theoretical task is to generate a structured ontology of sustainable development as a knowledge domain. This task involves identifying the core concepts and disaggregating the general notions into their constituent elements

As a concept- and content-based approach, *Mapping Sustainability* seeks to generate a baseline of current understandings. We fully appreciate that the nature of such understanding changes over time, and that representation of concepts and of contents must also evolve with time. The contribution of *Mapping* is to develop the ontology for the domain of sustainable development one that can be improved and corrected with better insight and with more evidence, contributing to richer understandings and a growing measure of wisdom.

The ontology provides an internally consistent representation of the characteristics of human activities, as well as of the dominant problems that arise from these activities and a range of solutions to them – in scientific, and technical, as well as social and regulatory terms. It is our hope that this ontology provides the initial conditions for future initiatives in the development and representation of sustainable development as a knowledge domain.

Turning to the first element of the subtitle of this book, *knowledge e-networking*, the challenge is to provide the operational mechanisms for engaging in cyber-based interaction and communication around a knowledge domain of shared interest. This initiative consists of computational as well as operational features. Computationally, this means translating the theoretical understandings into computational terms for enabling knowledge representation, provision, and retrieval. Operationally, this means developing and implementing a set of human–machine rules specifically for computational purposes.

Accordingly, Part II is devoted to the computational and operational aspects of this overall initiative. We examine some behind-the-scene dilemmas and then show how GSSD has performed to date. On this basis, we then suggest ways in which the entire system can be improved so that performance can be enhanced. Accordingly, the chapters of Part II not only present recent developments pertaining to the design and application of GSSD, but they also explore e-networking practices and processes to enable more effective performance in collaborative knowledge provision, sharing, and distribution.

The second elements of the subtitle pertain to the *value chain*, defined as the sequence of moves that enhances the overall gains associated with the activity or initiative. In this context, *extending the value chain* means identifying and enhancing gains associated with knowledge and e-networking. More specifically, our goal is to improve the entire value chain surrounding computer-based collaboration for knowledge provision and for enhancing the utility of e-networking itself.

The diverse ways of engaging in *new exploration and innovations* must be considered in the context of the gains associated with modes of designing and creating new knowledge to facilitate transitions toward sustainability. All of this must take into account the complexities associated with states and firms, from local to global levels. Ultimately, the value chain in global knowledge e-networking is about innovations in strategic uses of cyberspace for developing, providing, sharing, and organizing knowledge for sustainability.

Part III thus explores the potential gains due to applications of new perspectives and methodologies for enhancing our knowledge about sustainable development. The chapters in this section are loosely related, but they focus on issues central to the overall initiative at hand. These consist of addressing legal and financial institutional challenges, providing venues for new methods of exploring global politics, and clarifying the structure of concepts and assumptions underlying contending perspectives in the study and practice of international relations.

We now turn to each of the three parts of *Mapping Sustainability*, briefly note highlights from each of the individual chapters, in terms of theory, methods, and results.

20.2 Mapping Sustainability

Part I focuses on theoretical as well as computational issues central to knowledge representation, organization, and provision. Given that the process of engaging in transitions to sustainability is itself a moving target, the challenge is to capture the elements that are most relevant, and to discard the others. It is no longer possible to consider sustainability of individual entities, states, or groups without taking into account the broader configuration of natural and social systems within which all entities are embedded.

Accordingly, in Chapter 1, we highlight some of the most important facets of the entire global system as currently understood, particularly focusing on critical features of the globalization process. These facets frame the *terms of reference*, within which we engage in *Mapping Sustainability*. More specifically, Chapter 1 puts forth the conceptual framework of the mapping initiative. The framework also serves as the basic architecture for thinking about, searching for, and retrieving knowledge bearing on sustainability. Central to this effort is designing ways of transcending critical e-barriers to knowledge, and of implementing e-knowledge networking on a global scale.

Chapter 2 shows how the results of *mapping sustainability* are used to generate the ontology to for organizing the substantive materials – the knowledge content – distributed throughout a global e-networking system concerned with sustainable development. In this chapter, we also identify and six sets of e-barriers that impede access to knowledge about sustainable development. Our proposed solutions to these e-barriers, as well as their implementation, constitute the core of Parts 1 and 2 of this book.

To review briefly: the first set of e-barriers revolves around the conceptual ambiguities of the knowledge domain itself, namely sustainable development, compounded by multiplicity of views, conflicts and contentions, as well as cleavages due to differences in language, culture, and socio-economic conditions. The second is due to the explosion of information about sustainability that giving rise to access problems and difficulties in identifying the materials of interest. The third set of e-barriers consists of the powerful infrastructure constraints that impede basic access to the Internet, exacerbating the ability of people in various parts of the world to obtain knowledge pertaining to sustainable development. The fourth is defined by the very reality of the Internet – a largely English-speaking venue in a world that is non-English speaking. The fifth set consists of the resulting biases in knowledge-provision, namely that the voices heard are mainly those from the 'north.' The sixth and final set of e-barriers is created by the powerful impediments due the economics of Internet access that make it difficult for most people, in most places, to participate in the new cyber domain.

In the first two chapters, we address each of these e-barriers to sustainability and we define an integrated operational solution. Operationally, the research task is to focus on specific knowledge-objectives as the terms of reference for the solution strategy; define the characteristic features of solution venue, namely knowledge e-networking, and address the computational features of the operational solution strategy

On this basis, we introduce GSSD, the knowledge e-networking system designed and developed to address individual solutions to the specific barriers at issue, and we integrate these into an overall computational system for distributed e-networking. Throughout the rest of Part I, we illustrate key user-centered features of the system (in terms of front stage features) and we note key operational features that are designed to reduce the e-barriers of concern (in terms of backstage properties).

Chapter 3 focuses on the collaborative strategy required to engage in global knowledge e-networking. This means that we move from the theoretical value of knowledge e-networking activities toward the fundamentals of creating and managing a distributed global e-networking system. Specifically, we focus on three anchors for engaging in effective global e-collaboration and develop their operational features. The first is the *provision of knowledge.* This anchor refers to content-submission by various users to enhance the coverage in the overall knowledge base at the core of this initiative. The second is the *workflow process* in both design and practice. In so doing, we demonstrate how knowledge-content submitted in diverse e-locations worldwide is processed throughout the GSSD system – from the initial input at the point of entry, to GSSD review to translation to replication and synchronization across all servers in all locations, and finally to web publication. The third anchor is to the design and implement of a *multilingual strategy* for distributed networking systems worldwide.

Chapter 4 concludes Part I by addressing three aspects of our inquiry into the design and implementation of a knowledge e-networking strategy. One pertains to the *roles and functions* in each location if a mirror-site strategy is to work effectively. We show the type of organization needed and the division of labor required to make a distributed system work effectively, and at the same time, retain a degree of autonomy, flexibility, and adaptability. In other words, the first feature is about *who* does *what*, *when*, *how*, and *why.*

A second aspect addresses the operational features of the *cyber-partnerships* that constitute GSSD as a global e-knowledge networking system. We highlight specific challenges of partnering by focusing on select activities and deliverables (with examples for illustrative purposes). We design flow-diagrams to represent the processes involved in customizing each type of partnership.

And a third is an integrative nature and serves as a general conclusion to Part I. Accordingly, we revisit the solution strategy and pull the pieces into a coherent whole. By definition, distributed knowledge e-networking and collaborative management involve decentralization, diversity, and differentiation. It also involves addressing complexity, emphasizing clarity, and facilitating coordination. Thus, we come full circle – returning to the issues raised in the Preface of this book – and provide the foundations for Part II.

20.3 Knowledge e-Networking and the Value Chain

Part II focuses on the issue of added value generated by knowledge e-networking, coupled with the potentials for extending knowledge. Some chapters address 'behind-the-scenes' view of the processes discussed earlier, motivated by the belief that in order to move forward, we first must examine our previous experiences. Others extend the premises and show the potentials of new developments in theory, methods, and computation. More specifically, Part II addresses contextual, institutional, and operational challenges associated with knowledge e-networking, while exploring particular types of innovations and technological applications. Salient among these are key methodological institutional, and cross-cultural challenges related to global knowledge e-networking as well as uses in fundamentally different cultural, linguistic, socio-economic, political, and decision contexts.

20.3.1 Experience to Date

Chapter 5 reviews the organizational and institutional challenges central to the management of distributed knowledge e-networking. It addresses the lessons learned in the course of the GSSD initiative. Several specific issues are singled out for close scrutiny in order to illustrate the operational difficulties associated with learning-by-doing in a cross-cultural and cross-language context – even when the development partner is Lotus-IBM. The first set of institutional challenges is related to GSSD at MIT as the initiating institution, and the difficulties created by its role as the focal point for framing and generating a global e-network. The dilemma is shaped by conflicting imperatives. Clearly, we must make every effort to meet the project's research schedule. At the same time, however, since GSSD is developed in an academic context, we are bound by all of the usual norms that characterize scholarly pursuits, notably those that define the difference between innovation in academic versus commercial contexts.

The second set relates to managing the collaboration between GSSD at MIT and Lotus-IBM as each entity encounters its own institutional parameters and constraints. Each organization has its own dilemmas. Lotus-IBM has been a committed collaborator, seeking to provide product development support for a university-based research initiative, while at the same time retaining the operational practices required by its own organizational imperatives. At the same time, however, the multilingual needs of GSSD confronted Lotus-IBM with a new situation, one that had not been encountered earlier.

The third, and perhaps most fundamental set of challenges, pertains to the organizational and technological dilemmas that impeded the development and deployment of a distributed knowledge e-management strategy. This challenge was shaped by the disconnect between the working styles of the Lotus-IBM developers assigned to this collaboration and the GSSD vision of a large-scale global strategy and that would engage each of the partners around the world effectively. As a result, the GSSD team took on a challenge for which it had little skills or background experience, namely designing and implementing a global knowledge e-networking system itself. Under the leadership of the system administrator, the entire GSSD system was redesigned, taking on directions different from those envisioned earlier by the Lotus-IBM developers. The value of the collaboration thus resulted from an eventual mutual accommodation. The GSSD team designed the new system and the Lotus-IBM developers provided the lead in framing and testing the implementation.

Recognizing the organizational dilemmas in the course of product development is important, but equally important is recognizing the characteristic features of potential users and the problems that they face day to day. Chapter 6 focuses on conditions-on-the-ground in the area of information and communication technology (ICT) in one region, namely the Arab countries. In a comprehensive analysis, this chapter demonstrates central tendencies as well as wide variations among the Arab countries. The evidence indicates that, despite recent gains, most of the countries fail to adequately address the ICT needs of their societies. Their ICT strategies are underdeveloped, both relatively and absolutely. Evidence points to the importance of strengthening ICT-related initiatives in the countries of the region, and to address the operational contexts as well as policy constrains.

Chapter 7 can be seen as a response to the dilemmas reviewed in Chapter 6. It provides the situational logic and content for the provision of Arabic language e-tools on the one hand, and for the development of GSSD-Arabic, on the other. The chapter begins with the nature of the *demand* for Arabic language e-content, and then addresses the *supply* side by presenting a behind-the-scenes view of the developmental of operational GSSD-Arabic. In this context, the development of GSSD-Arabic represents a particularly daunting case for the GSSD multilingual e-system. Parenthetically, all of the challenges noted in Chapter 5 were encountered during the formation of GSSD-Arabic version. These compounded the basic difficulties of working in Arabic. Since the discussion in Chapter 7 reports on the experience of implementing the concepts and designs presented in Part I – as well as meeting the need for e-tools in Arabic – as such it consists of a prototype of learning-by-doing.

Chapter 8 focuses on the experience of GSSD-China. In many ways, it parallels GSSD-Arabic, but with major differences. Compared with most regions of the world, China has a robust track record in managing and participating in cyber venues. Its experience and performance is far greater than anything observed in the Arab region. For this and related reasons, the China situation on-the-ground is very different from that depicted in Chapter 6. Accordingly, Chapter 8 highlights key features of GSSD-China, reviewing the evolution of the collaboration, and summarizes some developments to date on the domains of knowledge provision and knowledge sharing. Additionally, given that GSSD-China is located in ACCA21, its proximity to the great wealth of Chinese-language resources bearing on sustainable development issue is a major asset to the GSSD e-network worldwide.[1]

Against this background, Chapter 9 analyzes the performance of GSSD as a whole. Its purpose is to review the performance of GSSD at one point in time, to identify central tendencies, and to provide some insights into directions for potential re-engineering. Given that interactive and distributed knowledge e-networking is of rather recent vintage, multilingual distributed e-systems are even more recent vintage. The rules for evaluation are not yet formally codified, nor are the methodological norms generally agreed upon. This chapter uses two sets of criteria as basic barometers to review GSSD's performance, namely the nature of knowledge *content* and the characteristics of *user-traffic*. Following the evaluation, the chapter then highlights some implications of the GSSD editorial policy, its architecture, and the attendant system operations.

20.3.2 New Directions in e-Networking

Earlier, in Part I, we presented the principles upon which the frame system for mapping sustainability is based. The principles are generic in structure and design. This means that their applications and implementations are neutral with respect to the substantive issues or subject matter at hand. Given

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[1] Recall that the combination of mirror-sites and multilingualism is one of the most distinctive GSSD features. Therefore, while Chapters 6 and 7 focused on GSSD-Arabic, and Chapter 8 on GSSD-China, it is important to keep in mind that all GSSD sites in all locations are, at any point in time, intended to be exact mirrors or replicas of each other.

that the knowledge representation strategy is decoupled from its application to the domain of sustainable development, Chapters 10 and 11 focus on the knowledge management needs of large-scale multinational enterprises, and, in doing so, charts new directions for future extensions of GSSD.

Chapter 10 is about uses of knowledge networking strategies for the purposes of enhancing knowledge acquisition and creation, and leveraging such knowledge in the context of global business. Special attention is given to the enterprises' own view of knowledge, the role of knowledge networks in global companies, and the characteristic features of e-networking for extended enterprises.

Chapter 11 demonstrates ways in which the basic GSSD architecture can be adapted to, and further developed and adapted to the needs of extended enterprises. The results of this effort are represented in terms of a fully developed frame system and architecture for *GSSD-Enterprise.* For actual implementation purposes, however, such a system requires backbone infrastructure and an integrative architecture for the enterprise's communication and knowledge management systems. An application to the Sony Corporation is presented in order to illustrate *GSSD-Enterprise.*

20.4 New Explorations and Innovations

Part III – on new explorations and innovation in theory, methods, and policy – considers a range of issue areas in order to illustrate both novel perspective as well as potential applications. While each chapter can be seen on a stand-alone basis, collectively they serve three objectives. The first is to provide insights from the very activity of *exploration* itself, whereby novel research approaches are used and uncharted terrain begins to derive some characteristic features. The second objective is to articulate the value of drawing upon alternative forms of *theory* and attendant assumptions that help broaden our views of international relations and global politics. The third is to draw attention to *substantive* challenges that have not been central to the sustainable development discourse but are recognized as critical to the realities at hand.

We now turn to each of these sets of efforts, and we highlight select features of each chapter.

20.4.1 New Applications and Empirical Investigations

The first set of investigations consists of new applications and empirical investigations. Chapter 12 focuses on uses of *visualization technologies* for better understanding patterns of growth and development in a global system. Drawing upon tools from Geographic Information Systems (GIS), this chapter shows how to manipulate and retrieve spatially-referenced multivariate data, and then link the data to computer-generated maps. GIS allows the analyst to produce a variety of visual renditions of statistical data and to represent these renditions in the familiar idiom of geographical maps. This chapter also illustrates ways in which a multitude of exploratory and quantitative tools for analyzing the data can be displayed on a given map. Several applications focus on the theory of lateral pressure in order to show how theory-driven visualization tools can help articulate the theory further. This chapter concludes by putting forth the design for an integrated client-server visualization system. The novelty of this chapter lies in the combined uses of theory, database management techniques, GIS-type technologies, and user-based selections of alternative modes of calling up the various functionalities and rendering connections among the various components.[2]

Chapter 13 examines the emerging domain of *e-governance.* Reviewing recent trends in electronic governance to date, this chapter examines several ramifications for governance, with clear implications for social sustainability. Among the key findings include, first, the predictable result that rich countries have better e-government platforms in place; and second, the far less predictable result that the rich and the poor countries are improving their e-governance capabilities at roughly similar rates. Also relevant is the related idea that while the Digital Divide is well documented at the international level, the same type of cleavage may be manifested at the national level as well. An added contribution of this chapter lies in providing the initial baseline against which future work can address matters of e-efficiency in governance.

Chapter 14 analyzes the role of *property rights protection* in the management of environmental degradation by focusing on the triangular relationship between property rights, environment, and economic growth. The contributions of this chapter are theoretical (by addressing directly the relevant literatures and attendant findings), analytical (by undertaking quantitative cross-national statistical and regression analyses), and inferential (by generating important results that address both theory and methods issues head on).

The relationship between economic growth and pollution has been the subject of much debate. The familiar Kuznets curve (EKC) hypothesis is often cited as illustrative of the issues at hand. The relationship between economic growth and institutional quality, such as the nature of the property rights regime, has also been studied. By contrast, however, the empirical

[2] Clearly, the server-client application concept is not new. However, its application to the broad domain of social science inquiry in general and to those associated with growth, development, and transformation in particular is new. In other words, the individual pieces of this client–server system are already in place – in one form or other – but their conjunction and integration into one operational system is yet to be done. This is the core of the exploration; the potential for eventual innovation lies in the ways in which the various pieces can be put together.

connections between property rights protection, on the one hand, and environmental pollution, on the other, have not been examined to date. In theory, if property rights over environmental resources are well defined and enforced, then this contingency will promote more judicious patterns of use. This chapter defines the empirical indicators for each of the core variables (environmental, economic growth, and property rights protection), then develops a set of empirical equations, and estimates the parameters guided by several different lines of inquiry.

Among the notable results are the following: first, despite plausible theoretical arguments and several empirical studies that support them, the evidence does not support the oft-cited inverted-U relationship between sulfur dioxide emissions and economic growth. Indeed, environmental pollution levels monotonically increase with economic growth. Second, despite powerful theoretical and empirical consensus on the importance of secure property rights for economic growth, the relationship does not appear to survive across the various estimation methods used. Third, improved property rights regimes do appear to generate notable environmental benefits. This last finding is especially important. On the one hand, it may well be a function of time frame of this study, namely a five year horizon. On the other, it may be that the quality of the property rights regime does not influence environmental quality at all.

Chapter 15 explores applications of *graph theory* in order to improve our understanding of the international system, focusing specifically on international trade. Graph theory has been previously demonstrated as a useful method for understanding the structures and effects of network properties in a variety of different contexts. The contributions of this chapter are theoretical, methodological, and empirical. Theoretically, the challenge is to examine the structure of the international system through conceptual approaches that to date have not been considered central to the social sciences. Methodologically, the contributions include a careful juxtaposition of key concepts and their mathematical and visual representation, on the one hand, with specification of relevance to a particular domain of interaction, on the other. The empirical value of this chapter lies in delineating the particular structural representation that seems to best represent contemporary patterns of international trade when the world as a whole is taken into account. Among the core findings of using graph theory for analyzing the network of trade is evidence of the propensity of the international system toward horizontal (lateral) and top-down (hierarchical) diffusion of influence and impact rather than bottom-up diffusion of influences.

20.4.2 Institutional Challenges – Two Examples

The second set of investigations in Part III focuses on institutional challenges bearing on sustainable development, including the relationship between law and sustainability and the role of the financial intermediaries in response to climate change

Chapter 16 focuses on the potential *synergy of law and sustainability*, and the mutually-beneficial gains of relating law and legal reasoning, on the one hand, and the associated demands and requirements of sustainability, on the other. Framed at a general level of analysis, this chapter highlights some of the emergent issues at the intersection of these two domains. By adopting a broad perspective on the issue of ethical precepts governing social interactions, this chapter points to some generic underlying issues central to the provision of order in complex social contexts. This chapter also points to some of the dilemmas posed by our increasing appreciation of the imperatives of complexity – in theory and in practice. This chapter also discusses the potential added value derived from two fundamentally different sources, namely, law and legal practice versus science and computability.

Chapter 17 examines the responses of the *financial system* to emergent imperatives of climate change. Its contribution consists of insights into the banking system's perceptions and conceptions of risk associated with climate change. So far, the financial sector has been given little attention in relation to climate change, and the banking system been not yet the focus of inquiry. And yet we all recognize that money will be needed, that has to come from somewhere, and that regardless of the source, the role of the banking system – as a powerful intermediation mechanism – will be central to the eventual outcomes.

The chapter concludes by proposing a new way of framing the risks associated with infrastructure finance in light of climate change. Based on a comprehensive survey of the literatures on different aspects of risk, an integrated view of risk associated with infrastructure investments is put forth. This new view can now serve as the basis for further inquiry into the complex matter of risk.

20.4.3 Contending Perspectives and Presumptions

The third set of investigations in Part III examines critical implications of contending perspectives, actions and assumptions in international relations theory and practice. Chapter 18 addresses the relevance and uses of yet another type of methodology to explore patterns of human actions and reactions. The chapter reports on the pilot phase of *Global Agenda!*, a simulation game designed to explore the complex nature of interactions among actors in a global landscape.[3] It presents the design, computational strategy, and type of 'plays' in a game about managing and responding to fundamental realities in international relations, such as action–reaction, feedback dynamics, trade-offs, uncertainty, human–nature interactions, and connections between internal politics and foreign policy.

For the player, the strategic and competitive core of *Global Agenda!* consists of responding to Hotspots (defined as problem areas or specific challenges). Any response will have various consequences, and these consequences themselves will also shape the context for the next moves. To simplify, since Hotspots cannot be predicted in advance – and they can appear on the global landscape at any point and in any combination, the challenge for the player is to manage effectively without undermining his position or his country's fate. All of this adds considerable complexity to any notions of winning or losing.

Chapter 19 steps back and considers the implications of two theoretical perspectives on the study and analysis of international relations. At issue is less the matter of facilitating learning, but rather focusing on the assumptions underlying what it is that is to be learned. Accordingly, Chapter 19 compares the analytical structure of *basic* versus *complex logic* in the study of international relations. In so doing, the analysis highlights key differences between traditional assumptions and those that reflect fundamental departures from convention. The purpose is to provide a systematic comparison, without engaging in a philosophical critique or semantic debate.

20.5 Value of Collaboration

In its entirety, this book is an international initiative. It is the product of sustained collaboration among a large number of individuals in the scientific and academic communities, in business and industry and in the public policy, nationally and internationally. Many aspects of this effort are rooted in activities of the *Alliance for Global Sustainability* – notably in the *Framing Project.* Throughout this book, we have engaged in relatively untested modes of inquiry for enhancing our stock global knowledge, focusing on value-added for the sustainability domain, and facilitating modes of knowledge-based responses to meeting fundamental needs of present and future generations. In the absence of coherent and well recognized precedents, our research initiatives amount to an experiment in learning-by-doing.

In this connection, we hope that this record will motivate further work and create precedents of value to the knowledge enterprise generally and to

[3] In this context, we consider games as combining fun and education, with the objective of gaining a better understanding of the complexities of international relations.

sustainable development as a knowledge domain, specifically. This book is the product of a collaborative effort. It involves the ideas, efforts, contributions, initiative and insights of a large number or students, colleagues, and international collaborators. A brief review of selective results illustrates the range of issues addressed and their convergence around improving our understanding of sustainable development as a knowledge domain.

Since the underlying purpose of this initiative is to highlight new directions in collaborative research focusing on sustainable development – as well as implications for theory and policy – it can only be seen as one step of a long and complex research program. It goes without saying that such an effort is enabled by advances in information and communication technologies, in conjunction with increased uses of cyberspace for scientific research, and for decision and action. For this reason, it is our hope that this book provides insights into the state of the art – a baseline early in the 21st century – for *Mapping Sustainability* and for developing new approaches to *Knowledge e-Networking and the Value Chain.*

APPENDICES

Appendix A

GUIDE TO CORE CONCEPTS

This appendix presents the detailed knowledge content for each of the fourteen domains of human activity – each defined along four dimensions – consistent with the frame system and the ontology of sustainability in Chapter 1. The dimensions consist of (a) human activities and conditions; (b) sustainability problems; (c) scientific and technical solutions; and (d) social, economic, political and regulatory solutions. Each dimension is further differentiated according to the connectivity rules in Chapter 1.

The appendix is organized by individual domains. The domains are presented sequentially. The sequence is consistent with the entires in Figure 1.5, viewed counter-clockwise – from 'population' to 'governance and institutions.' The display for each content-domain begins with a brief statement of domain definition.

The indentation format represents the structure of the nested system following the frame system rules defined in Chapter 1. The entries in Figure 1.10 depict only individual items of the first order disaggregation (identified as A, B, C, etc.) in each of the dimensions (identified as I, II, III, etc.). This appendix presents the full system in its disaggregated (unbundled) form.

A.1 Population

Includes size, density, composition, and distributions of people in a given locate, as well as changes in these factors.

- I. **Activities and Conditions**
  - *A.* ***Population variables***
    - **1. Size**
      - a. Growth
      - b. Fertility, mortality, migration
    - **2. Composition**
      - a. Age, gender
      - b. Skills/education
      - c. Socio-economic
      - d. Other
    - **3. Distribution**
      - a. Spatial
      - b. Density
    - **4. Changes in size, composition, and distribution**

II. Sustainability Problems

- ***A. Social and resource constraints relative to demand***
  - **1. Structure of distribution**
    - a. Absolute shortages
    - b. Competition between present demands
    - c. Competition between present and future demands
    - d. Unequal distribution of resources
  - **2. Type of goods**
    - a. Government provided goods
    - b. Consumer goods, disposable income
    - c. Non-renewable resources
    - d. Renewable resources
    - e. Space or congestion level
- ***B. Gender and age-specific problems***
  - **1. Gender inequality**
    - a. Low status of women outside motherhood
    - b. High fertility
    - c. Female and infant health
    - d. Girl education
    - e. Intra-family resource competition
    - f. Early marriage
  - **2. Aging**
    - a. Dependence costs
    - b. Healthcare costs
    - c. Emptiness/alienation
    - d. Labor effects – relative shortage of young labor force – labor imports (legal and illegal)

III. Scientific and Technical Solutions

- ***A. Fertility***
  - **1. Population awareness programs**
    - a. On desired family size
    - b. On child development
    - c. On contraception
  - **2. Fertility control**
    - a. Family planning
      - i. Contraceptives: costs, accessibility, acceptance
    - b. Fertility enhancing technologies
- ***B. Health services***
  - **1. Technical**
    - a. Improved medicine/cures
    - b. Epidemic control
    - c. Prevention
    - d. Accessibility

2. **Organization**
    a. Central systems
    b. Grass-roots systems
    c. Other
3. **Orientation/target group**
    a. By age: infants, children, young adults, elderly
    b. By income/social group

IV. Social, Economic, Political, and Regulatory Solutions

A. Education
1. **Type of education**
    a. Vocational skills – traditional, apprenticeship, modern
    b. Formal
    c. Retraining
2. **Level of education**
    a. Basic school education for children
    b. Basic education for adults
    c. Higher education
3. **Public awareness campaigns**

B. Improvement of women's opportunities and skills
1. **Legal status**
2. **Job opportunities**
3. **Skill improvement**
4. **Empowerment groups**

C. Age-specific support programs
1. **Elderly**
    a. Pension and financial similar systems
    b. Care system – nursing homes, live-in nurses, family help subsidies
    c. Support of extended family
    d. Activities for elderly
2. **Children**
    a. Children in poverty
    b. Child-oriented infrastructure
    c. Various forms for improving family life
3. **Safety nets**
    a. Low-cost health, housing, other services
    b. Food aid
    c. Income redistribution system

A.2 Urbanization

An increase in the number and/or size of urban areas. A profound change in the life-style, the economy, and the culture of a region from predominantly rural based to urban/city based.

- **I. Activities and Conditions**
  - ***A. Urbanization***

- **II. Sustainability Problems**
  - ***A. Poverty expansion***
    - **1. Poverty imported from other poor areas through immigration to cities**
    - **2. Poverty endogenously created in the city**
      - a. Business disinvestment/unemployment/ underemployment
      - b. Natural growth of poor population
      - c. Infrastructure breakdown, reduction of services to the poor
  - ***B. Social stress***
    - **1. Congestion**
    - **2. Marginalization**
      - a. Higher crime rate
      - b. Greater homelessness
    - **3. Mass political upheaval potential**
    - **4. Conflict due to relative depravations**
  - ***C. Urban pollution and natural resource shortages***
    - **1. Pollution**
      - a. Polluted mediums
        - i. Air
        - ii. Water
        - iii. Land
      - b. Pollution types
        - i. Exhaust emission
        - ii. Chemicals/toxins
        - iii. Solid and liquid waste dumping and accumulation
        - iv. Pestilence
    - **2. Health effects**
    - **3. Resource constraints**
      - a. Energy
      - b. Water
      - c. Land/space
  - ***D. Spatial dynamics***
    - **1. Obstacles to access resources**
    - **2. Cities and megacities**

a. Merging
b. Expansion

3. **Encroachment on non-urban areas**

III. Scientific and Technical Solutions

A. Solve high density problem/improve urban infrastructure

1. **Type of infrastructure**
   a. Fresh water
   b. Sanitation
   c. Drainage
   d. Waste minimization
   e. Transport system
   f. Communication
   g. Adequate shelter
2. **Targeted areas**
   a. General areas
   b. Marginal areas

B. Density management strategies

IV. Social, Economic, Political, and Regulatory Solutions

A. Waste management

B. Urban services

1. **City planning and management**
2. **Police force/law enforcement**
3. **Health services**
4. **Education**
5. **Functioning market/retail system**
6. **Others**

C. Strengthening urban communities

1. **Community centers**
2. **Religious organizations**
3. **Group-specific activity groups**

D. Expand rural services

A.3 Migration and Dislocation

Voluntary and involuntary movement of people, within or across national borders.

I. Activities and Conditions

A. Type of flow

1. **Refugee flows (involuntary)**
   a. Political
   b. Economic
   c. Conflict
   d. Environmental

2. **Socio-economic migration (voluntary)**
    a. Caused by wage differentials
    b. Family/group reunion and separation
    c. Brain drain/gain
3. **Combined rights**

B. Direction of flows

1. **Internal mobility**
2. **External mobility**
3. **Return mobility**

C. Characteristics of flows

1. **Phases of migration**
2. **Poles of migration**
3. **Push-pull mechanisms**
4. **Changes in sending/receiving population-economic balances**
5. **Duration of flows**

D. Status and benefits

1. **Access to socio-economic and political benefits**
2. **Access to citizenship benefits and responsibilities**
3. **Access to property rights**
4. **Access to basic rights and needs**

II. Sustainability Problems

A. Stresses related to changes in group composition

1. **Types of changes**
    a. Ethnic/religious/racial
    b. Socio-economic
    c. Age structure
    d. Other
2. **Effects**
    a. Marginalization
    b. Pressure on existing socio-economic structures
    c. Impacts on resources
        i. Land
        ii. Water
        iii. Fuels
        iv. Forests
    d. Changes in density and pattern
    e. Distribution tensions
    f. Political shifts

III. Scientific and Technical Solutions

A. Responsive infrastructure strategies

1. **Transportation systems affecting the costs of moving**

2. **material infrastructure affecting differential benefits of living in migration poles**

B. ***Resettlement strategies***

1. **Forced**
2. **Incentive-based**

IV. Social, Economic, Political, and Regulatory Solutions

A. ***Migration policies and strategies***

1. **Political discourse**
2. **Restrictive, selective, or open policies**
3. **Type of migration flows admitted**

B. ***Safeguards to human and natural habitats***

1. **Maintain/attain a desire population distribution (protect places where people live)**
2. **Designating places where people cannot live (national parks, wildlife areas)**
3. **Particular regulations for vulnerable areas**
4. **Other**

C. ***Migrant support programs***

1. **(Cultural) integration support – to acquire new culture**
2. **Programs to protect sending culture in receiving area**
3. **Enhancing migrant capacity**

D. ***Legal status***

A.4 Consumption

Use of final goods and services, as well as basic necessities for survival by individuals as consuming entities; represents intermediate processes between population and environment includes what, how, and how much is being consumed.

I. Activities and Conditions

A. ***Consumption***

II. Sustainability Problems

A. ***Resource use and depletion***

1. **Scarcity of goods and services**
   a. Availability
   b. Affordability
2. **Livelihood and production**

B. ***Waste accumulation***

1. **Forms of waste**
   a. Solid
   b. Liquid
   c. Gas

2. **Type of waste**
    a. Degradable/non-degradable
    b. Recyclable/non-recyclable
3. **Spatial condition and distribution of waste**
4. **Mobility of waste**
5. **Effects of waste accumulation**
    a. Nature's assimilative capacity
    b. Human habitat
    c. Biodiversity

III. Scientific and Technical Solutions

A. ***Waste management and minimization***

1. **Treatment of waste**
    a. Landfills
    b. Incinerators
    c. Recycling
2. **Waste collection**
    a. Central collection agency
    b. Public–private partnership
    c. Private collection agencies
    d. Individual disposal
3. **Waste minimization behavior**
    a. Household disposal
    b. Waste separation
    c. Waste reduction
4. **Improving the production process**

IV. Social, Economic, Political, and Regulatory Solutions

A. ***Changes in consumer behavior***

1. **Reduce excess consumption**
2. **Reduce luxury consumption**
3. **Purchase multi-purpose goods**
4. **Purchase goods that require less input in sue**
5. **Substitution to environmentally sustainable goods and services**
    a. Renewable–non-renewable
    b. Choosing products with less toxicity level
    c. Using more homemade products
6. **Maintenance**

B. ***Mechanisms for consumption change***

1. **Market system**
    a. Relative accessibility of products
    b. Relative price of products
2. **Regulations**
    a. Standards
    b. Prohibitions

c. Taxes/subsidies

3. **Value changes**

A.5 Unmet Basic Needs

Inability to provide for one's own and for one's dependents the food, clothing, housing, and healthcare needs due to limited income and/or resources.

I. Activities and Conditions

- ***A. Unmet basic needs***

II. Sustainability Problems

- ***A. Poor quality of life***
  1. **Insufficient personal material goods**
  2. **Lack of healthy and humane environment**
  3. **Insecurity in lifestyle**
     a. Employment
     b. Housing
     c. Disasters
     d. Education constraints
     e. Gender and minority issues
  4. **Disease**
  5. **Gender inequalities**
- ***B. Malnutrition***
  1. **Income constraints**
  2. **Market failure distribution failure**
  3. **Political intervention**
  4. **Agricultural failures due to annual fluctuations (temporary effects)**
  5. **Technical failures**
- ***C. Health hazards***
  1. **Limited hygienic measures**
     a. Lack of sewage system
     b. Contaminated water
     c. Waste management measure
     d. Air pollution
  2. **Reduced immunities**
  3. **Pollution due to production**
  4. **Limitations of laws to protect sound rights**
- ***D. Environmental degradation***

III. Scientific and Technical Solutions

- ***A. Access to technology and infrastructure***
  1. **Type of technology and infrastructure**
     a. Knowledge
     b. Equipment

c. Management

2. **Scale of technology**
   a. Large projects with capacity to affect a region (e.g. utilities, dams, sewerage)
   b. Individually-based technology (e.g. farming, building methods)
   c. Reduce obstacles to
      i. Internal development
      ii. External access
3. **Entrepreneurial opportunities**
   a. Type of business
      i. Small-scale business
      ii. Co-op
      iii. Informal sector
   b. Type of support
      i. Management/organization
      ii. Start-up
      iii. Product management
      iv. Credit systems
4. **Food Security**
   a. Technical innovations
   b. Distribution efficiencies

IV. Social, Economic, Political, and Regulatory Solutions

A. Poverty alleviation assistance (i.e. income enhancement/creation policies/enhanced income opportunities

1. **Job creation**
   a. Permanent government jobs/public services
   b. Temporary poverty alleviation work
   c. Improve investment climate
2. **Improved resource access and management**
   a. Land
   b. Water rights
   c. Fishing rights
   d. Property rights
   e. Informal contracts
3. **Empowerment of women**

B. Enhanced capacity building (i.e. enhanced income earning capabilities)

1. **Institutions**
   a. Research
   b. Education
2. **Support (e.g. funding, policies)**
3. **Management strategies**
4. **Public administration and regulatory bodies**
5. **System and institutional structures**

C. Improved health and environment management

D. Responsive legal systems
1. **Tax law**
2. **Tenure law**
3. **Labor law**
4. **Property law**
5. **Business law**
6. **Informal regulations**

A.6 Energy Use and Sources

Energy is generally defined as the ability to do work.

I. Activities and Conditions

A. Energy uses
1. **Direct use (fuel, wood, direct heat, steam and related)**
2. **Production of electricity**
3. **Internal combustion**
4. **Distribution of transportation**

II. Sustainability Problems

A. Depletion of non-renewable resources
1. **Proven and estimated global reserves**

B. Pollution
2. **Air**
3. **Wastes**
4. **Ecological/ecosystem**

III. Scientific and Technical Solutions

A. Alternative production technologies
1. **Co-generation, improved efficiency in generation**
2. **Improved location and extraction of resources**
3. **Generation choice-natural gas, clean coal technology**
4. **Biomass**
5. **Alternative fuels for vehicles, hybrid electric**

B. Efficient use
1. **Energy efficiency**
2. **DSM**

C. Pollution control
1. **Pre-combustion**
2. **Post-combustion**

D. Renewable non-polluting resources
1. **Solar**

2. **Wind**
3. **Geothermal**
4. **Hydro**
5. **Tidal**
6. **Fuel cells**
7. **Hydrogen**

IV. Social, Economic, Political, and Regulatory Solutions

A. ***Market-based policies***
1. **Market-driven changes in end-use**
2. **Culturally-driven changes in end-use**

B. ***Direct regulatory control***
1. **Command and control (CAA, CAAA, EPACT)**
2. **Government programs (DSM, LIHEAP, eff-standards, CAFE)**

C. ***Government research and development***
1. **Tax credits for using renewable energy (PURPA)**
2. **Technology transfer**

A.7 Forest and Land Use

Focused mainly on forest use and land coverage by trees, underbrush, and related growth.

I. Activities and Conditions

A. ***Forest uses***
1. **Food**
2. **Fuel**
3. **Chemicals and medicines**
4. **Pulp and paper**
5. **Timber**
6. **Watershed protection**
7. **Absorbs carbon dioxide, air pollutants**
8. **Major ecosystems and wildlife**
9. **Genetic resources**
10. **Recreation**

II. Sustainability Problems

A. ***Forest overuse***
1. **Deforestation (for food/fuel)**

B. ***Forest destruction***
1. **Deforestation (for urbanization)**
2. **Rainforest destruction**

3. **Desertification**
4. **Ecosystem and biodiversity demise**
5. **Pollution and acid rain**

III. Scientific and Technical Solutions

A. ***New techniques for forest use and reforestation***
1. **More efficient use of forest products**
2. **More successful reforestation**

B. ***Sustainable logging practices***
1. **Sustained yield removal of trees**
2. **Thinning or patch-cutting vs. clear-cutting**

C. ***Use of information technologies***

D. ***Monitoring change***

IV. Social, Economic, Political, and Regulatory Solutions

A. ***Improved legislation***
1. **Logging regulations**
2. **Green labeling**
3. **Determination of land-property rights**
4. **Governmental departments**

B. ***Agro-forestry forms***
1. **Reforestation**
2. **Tree conservation**
3. **Forest protection**

C. ***Forest management programs***
1. **Transfer of finances, resources, and technology**
2. **Biological diversity management**

D. ***Other***

A.8 Water Sources and Uses

Activities related to access and uses of the essential life-supporting liquid.

I. Activities and Conditions

A. ***Sources and types***
1. **Non-point source**
   a. Land runoff
   b. Precipitation
   c. Atmospheric deposition
      i. Dry deposition (direct deposition from air)
      ii. Wet deposition (from precipitation, fog, etc.)
   d. Drainage, seepage, or hydrolic modification

2. **Point source (i.e. discernible, confined, and discrete conveyance), Including:**
    a. Pipe, ditch, channel, tunnel, conduit
    b. Well, discrete fissure, container, rolling stock
    c. Concentrated animal feeding operation, vessel, and floating craft

B. Types

1. **Basic forms**
    a. Deltas
    b. Estuaries
    c. Coastal zones
    d. Shelves
    e. Deep seas
        i. Animal products of the sea
        ii. Vegetable products of the sea
        iii. Mineral products of the sea
    f. Salt-water lakes
2. **Fresh-water types**
    a. Atmospheric water
        i. Precipitation
        ii. Water vapor
        iii. Condensed water
    b. Surface water
        i. Lakes
        ii. Rivers
        iii. Wetlands
    c. Ground water and soil water
        i. Renewal ground water
        ii. Fossil ground water
3. **Manufactured water**
    a. Desalinated water for industrial and human uses
    b. Bottled & purified drinking water

C. Manufactured water

1. **Desalinated water for industrial and human uses**
2. **Bottled and purified drinking water**

D. Uses and services

1. **Household and municipal uses**
2. **Industrial uses**
3. **Agricultural**
4. **Eco-system uses**
5. **Technological and scientific uses**

II. Sustainability Problems

A. Human impacts on sources and needs

1. **Agricultural activity**
    a. Land degradation
        i. Salinity
        ii. Toxics
        iii. Pesticides
        iv. Fertilizers
        v. Domestic animals
    b. Excessive withdrawals from aquifers and wetlands
2. **Health and sanitation impacts**
    a. Limited access to water
    b. Municipal sewage
    c. Synthetic detergents
    d. Solids in household wastes
3. **Industrial/commercial activity**
    a. Diversion
        i. Dams for hydropower
        ii. Irrigation
        iii. Recreation
        iv. Industrial diversion
    b. Acid rain
    c. Eutrophication
    d. Disposal (Nuclear and chemical waste treatment)
    e. Fresh water pollution
    f. Sea pollution
4. **Human interactions with hydrological cycle**
    a. Through socio-economic activities
    b. Through recreational purposes
    c. Through alterations of physical landscapes
    d. Through technological interventions and practices
5. **International water issues**
    a. Water sharing
    b. Upstream/downstream riparians
    c. Transboundary pollution
6. **Natural causes and impacts**
    a. Droughts
        i. Scarcity
        ii. Famine
    b. Floods
        i. Water-logging
        ii. Displacement
        iii. Diseases
    c. Intensification and exacerbation
        i. Driven by socio-economic and demographic factors

ii. Driven by public policies and decisions
iii. Driven by international actions

7. **Joint human and natural causes**
   a. Deteriorating water quality
   b. Aquatic ecosystem destruction
   c. Potential climate impacts
   d. Loss of biodiversity
   e. Disappearing wetlands
   f. Accelerating degradation
   g. Other

III. Scientific and Technical Solutions

A. Supply-side alternatives

1. **Water development projects**
   a. Surface water
      i. Dams
      ii. Reservoirs
      iii. Canals
      iv. Ground water aquifers for reservoir use
   b. Ground water
      i. Wells
      ii. Pumps
      iii. Interbasin transfers
      iv. Recycling and reuse
      v. Desalination
      vi. Weather modification (cloud seeding)
      vii. Vegetation management and water harvesting

B. Demand-side management

1. **Network rehabilitation and optimization**
   a. Leakage control
   b. Transferring water among alternative uses
2. **Water conservation techniques and devices**
   a. Metering and monitoring
   b. Improved irrigation practices
   c. Improved industrial practices
3. **Water quality improvement**
   a. Wastewater treatment
   b. Hazardous and municipal waste management
   c. Pollution prevention control
   d. Other

IV. Social, Economic, Political, and Regulatory Solutions

A. Planning and management

1. **Voluntary participation**
    a. User groups management
    b. Stakeholder involvement
2. **Formal regulations**
    a. Pricing, standards
    b. Tradable permits
    c. Taxes, subsidies
    d. Other
3. **Market strategies and mechanisms**
    a. Treating water as an economic commodity
    b. Incentives, trading, etc.
4. **Public and private interactions**

B. ***Subsidies modes***
C. ***Privatization of services***
D. ***Equity strategies***
E. ***Improved information systems***

A.9 AGRICULTURE

Cultivation of the soil, producing crops, and raising livestock and fish.

I. Activities and Conditions

A. ***Agriculture***

1. **Agricultural production**
    a. Crop production
    b. Livestock and feedstock production
    c. Fisheries production
2. **Management of supply and demand**
    a. Management of natural resources
    b. Agricultural science, engineering, and technology
    c. Storage of products
        i. Supply networks
        ii. Inventories and storage
    d. Processing and packaging
    e. Shipment and distribution

II. Sustainability Problems

A. ***Impacts of chemicals and pollutants***

1. **Impacts on land, water, and air**
    a. Soil erosion and rangeland degradation
    b. Erosion
    c. Water and air pollution
        i. Emission of nitrates

- ii. Leaching and evaporation of fertilizers
- iii. GHG emissions
  1. Depletion of soil organic matter
  2. Livestock methane emission

B. Damage to natural systems

1. **Damages due to irrigation systems**
2. **Damming/diversion of rivers**
3. **Wasting of water via evaporation**
4. **Impacts of production choices**
   - a. Narrow genetic base crops and loss of biodiversity
   - b. Breed substitution and crossbreeding
   - c. Destruction of local vegetation and wildlife
5. **Ecological dislocations**
   - a. Creation of ponds for fishing
   - b. Deforestation
   - c. Erosion of agricultural capacity

C. Socio-economic dislocations

1. **Economic impacts**
   - a. Income effects
   - b. Diminishing returns to intensive production
   - c. Instability of the market
   - d. Unfair competition
   - e. Induced inequalities
2. **Social impacts**
   - a. Demographic dislocations
   - b. Social dislocations
3. **Hazards and wastes**
   - a. Health and safety hazards
   - b. Agricultural and agro-industrial residues
     - i. Excessive use of fertilizers and pesticides
     - ii. Plastic and other debris in marine systems
     - iii. Other toxic and non-toxic wastes
4. **Mismanagement and misuse of technology**
   - a. Heavy use of inputs, energy, and chemicals
   - b. Building of resistance in insect species
   - c. Elimination of natural enemies

   d. Faulty construction and management of services
   e. Faulty allocation of land

III. Scientific and Technical Solutions

A. Improved agricultural practices

1. **Better farm machinery and irrigation systems**
2. **Less damaging fertilizer application methods**
3. **Improved capital/labor balances**
4. **Minimizing use of hazardous chemicals**
   i. Recycling and reuse
   ii. Management of hazardous wastes and chemicals
5. **Principles and practices**
   a. Integrated pest management (IPM)
   b. Total quality control measures (TQCM)

B. Biotechnology innovations and use

1. **Improved genetically-engineered plants**
2. **Improved breed productivity**
3. **Advances in tissue culture**

IV. Social, Economic, Political, and Regulatory Solutions

A. Improved markets and mechanisms

1. **Effective financial instruments**
   a. Fees and taxes
   b. Subsidies and other incentives
   c. Effective pricing practices
2. **Improved market access and performance**
3. **Reliable sources of finance for agriculture**
4. **Market-based measures for regulation**

B. Government oversight

1. **Provision of resources**
2. **Enforcing standards in inputs and processes**
3. **Monitoring of stocks, performance, and quality**
4. **Innovation in policies and credit facilities**

C. Improved socio-economic conditions

1. **Reduction/termination of debt**
2. **Improved income distribution**
3. **Better working conditions**
4. **Enhanced role of women**
5. **Improved health and sanitation conditions**

D. New policy responses

1. **Formal intra- and inter-national cooperation**
   a. Technology transfer
   b. Improved cross-border relations
   c. Measures to alleviate debt, trade barriers, and other obstacles

2. **Informal intra- and inter-national activities**
    a. NGO activities
    b. Collaboration in research and development
    c. Business measures and joint ventures
3. **Enhanced institutional collaboration**
    a. Intra- and inter-governmental collaboration
    b. Activities supporting international collaboration
    c. Activities towards new agreements
4. **New policies and principles**
    a. Precautionary principle (PP)
    b. Evolution of new principles

A.10 Trade and Finance

Institutionalized exchanges in goods and services, including financial transfers, and investments

I. **Activities and Conditions**
  A. Trade
    1. **Who trades**
    2. **What is traded**
    3. **How it is traded**
  B. Finance
    1. **Financial systems**
    2. **Investments**
    3. **Instruments**

II. **Sustainability Problems**
  C. Environmental impacts of trade
    1. **Wastes due to conventional process and production methods (PPMs)**
        a. Product-related PPMs (PPMs transmitted by product)
            i. Food safety and health
            ii. Non-recyclable packaging
        b. Non-product related PPMs
    2. **Type of environmental impact**
        a. Transboundary pollution
            i. Water pollution
            ii. Air pollution
            iii. Resource damage and depletion
            iv. Loss of biodiversity

- b. Global environmental degradation
- c. Regional, national, and local environmental impacts

D. ***Impacts of trade competitiveness***

1. **Distortions in input uses**
2. **Reallocations due to environmental regulations**

III. Scientific and Technical Solutions

A. ***Improved products and processes***

1. **Less-polluting materials**
2. **effective standards**
   - a. Product standards
     - i. Sanitary measures
     - ii. Health measures
   - b. Process standards
     - i. Improved waste management
     - ii. Safe waste disposal

B. ***Improved packaging and shipment***

1. **Returnable and multi-life containers in packaging**
2. **Non-polluting shipment methods**

C. ***Cleaner production***

D. ***Eco-efficiency measures***

1. **Products and processes**
2. **Waste management and disposal**
3. **Minimizing inputs**
4. **Streamlining processes**
5. **Substitutes**

IV. Social, Economic, Political, and Regulatory Solutions

A. ***Market strategy***

1. **Equity and efficiency**
2. **Incentives for financial and technical assistance to LDCs**
   - a. Market access
   - b. Debt relief
   - c. Access to finance and investment
   - d. Access to "new" technology
3. **Type of government intervention**
   - a. Government intervention
   - b. Innovation in manufacturing process
   - c. Pricing of natural resources
4. **Shifts in consumer behavior**
   - a. Responsive investment decisions
   - b. Environmental consciousness
   - c. Consumer pressures for health and environment

- ***B.*** ***Novel financial instruments***
- ***C.*** ***Trade measures and policies***
  1. **Trade instruments for environment**
     a. Bans and restrictions
     b. Trade sanctions
     c. Tariffs
     d. Border tax adjustments
     e. Countervailing duties
     f. Mandatory eco-labels
  2. **Environmentally-sensitive trade policies**
     a. National environmental legislations
     b. Harmonization
     c. Environmental agreements
        i. CITES
        ii. Basel Convention
        iii. Montreal Protocol
        iv. Other
     d. International institutions for trade
        i. GATT
        ii. WTO
        iii. UNCTAD
        iv. ITO
        v. Other
     e. Voluntary arrangements and agreements
- ***D.*** ***Improved accounting and measurements***
  1. **Products and processes**
  2. **Trade and related exchanges**
- ***E.*** ***Provisions for dispute resolution***
  1. **Mode**
     a. Formal
     b. Informal
     c. Mixed
  2. **Status**
     d. Binding
     e. Non-binding

A.11 Industry and Manufacturing

Includes mining, manufacturing, and construction.

- **I.** **Activities and Conditions**
  - ***A.*** ***Industry and manufacturing***
    1. **Final products**
       a. Construction
       b. Mining, extraction, processing

c. Manufacturing
d. Energy industries
e. Electronics and electronic industries
f. Paper and pulp
g. Automotive and transport industries
   i. Air
   ii. Land
   iii. Water
   iv. Space
   v. Underground
      1. Machinery and equipment
      2. Information and telecommunications industries
      3. Food and agriculture
      4. Service sector
      5. Legal and financial services
      6. Other services

2. Intermediary products and processes
   a. Industrial operations

3. Supplier systems and networks

4. Waste-related industries

II. Sustainability Problems

A. Environmental impacts

1. Impacts on land, water, air, and underground spaces
   a. Air pollution
   b. Water, river ways, aquifers, and marine pollution
   c. Soil degradation
   d. Chemical changes
   e. Reduced visibility and smog effects

2. Specific modes and mediums of pollution and dislocations
   a. Acid rain
   b. Emission of trace metals
   c. Other toxic emissions

3. Threats to life-supporting properties
   a. Los of habitat
   b. Deforestation
   c. Damages to marine life
   d. Reduction of biodiversity

B. Climate change

1. Greenhouse gas emissions

2. CFC impacts and ozone depletion

3. **Interactive effects of GHG**

C. *Hazards and wastes*
1. **Solid and non-solid wastes**
2. **Safety, health, and related hazards**

D. *Socioeconomic dislocations*
1. **Economic impacts**
    a. Income effects
    b. Employment effects and unemployment
2. **Social and political impacts**
    a. Demographic dislocations
    b. Quality of life impacts
    c. Urbanization strains
3. **Consumption of non-renewable resources**
    a. Energy resources
    b. Minerals resources
    c. Other natural resources
        i. Wood and wood products
        ii. Food-related products
        iii. Providers of ecological services

III. **Scientific and Technical Solutions**

A. *Designing for environment*
1. **Industrial ecology**
2. **Life-cycle analysis**
3. **Industrial metabolism**
4. **Input–output mechanisms**

B. *Best S and T practices*
1. **Substitution and design alternatives**
    a. Pertaining to functions
    b. Pertaining to products
    c. Pertaining to entire production process and products
    d. Pertaining to sales of products or of functions
2. **Cleaner production**
3. **Strategies toward waste and discharges**
    a. Waste minimization
    b. Waste management
    c. Waste as raw material
4. **Eco-efficiency**

IV. **Social, Economic, Political, and Regulatory Solutions**

A. *New principles and best practices*
1. **Polluter pays principle (PPP)**
2. **Pollution prevention**
3. **Eco-labeling**

4. **Prior informed consent (PIC)**
5. **Separate, but differentiated responsibility**
6. **Other evolving principles**

B. *Green regulation and legislation*

1. **Formal regulations**
    a. Improved standards and codes
    b. Harmonization policies
        i. National
        ii. Regional
        iii. International
        iv. Sectoral
2. **Voluntary restrictions and regulations**
3. **Informal regulations**

C. *Market strategies*

1. **Incentives for greening**
    a. Target of incentives
        i. For waste minimization
        ii. Waste management
        iii. Other adjustments
    b. Instrument of incentives
        i. Financial instruments
            1. Subsidies
            2. Taxes
            3. Deposit-refund systems
            4. Experimental measures
                a. Performance instruments
                b. Evaluation instruments
2. **New market instruments**
    a. Emission trading
    b. Financial instruments
    c. Insurance strategies
    d. Other instruments

D. *Full cost accounting*

1. **Targeted to activities and agents**
    a. For economies and firms
    b. For tradable and non-tradable
2. **Related to requirements for undertaking full cost accounting**
    a. Education of public and industrial workers
    b. Training programs
    c. Experimental and innovative accounting mechanisms

A.12 Mobility and Transportation

The movement of goods, services, and persons from place to place, and the various means by which such movement is accomplished.

- **I. Activities and Conditions**
  - ***A. Mobility and transportation***
    - **1. Utilization of transport systems and modes**
      - a. Road transport
        - i. Motorized road transport
        - ii. Non-motorized road transport
      - b. Railways
      - c. Air transport
      - d. Marine transport
    - **2. Management of transportation supply and demand**

- **II. Sustainability Problems**
  - ***A. Global change and greenhouse gas (GHG) emissions***
    - **1. Broad impacts**
      - a. Climate change
      - b. Ozone depletion
      - c. Air pollution
    - **2. GHG emissions**
      - a. Emissions due to mobility and transport
        - i. Carbon dioxide emission
        - ii. Methane emission
        - iii. Nitrous oxide emission
        - iv. Chlorofluorocarbons emission
        - v. Toxicity
      - b. Effects of interactions among GHG
  - ***B. Environmental and health effects***
    - **1. Local and regional impacts**
      - a. Basic mode
        - i. Due to emissions
        - ii. Due to congestion
      - b. Specific impacts
        - i. Acid rain
        - ii. Photochemical smog
        - iii. Other impacts
      - c. Impacts of excessive use of fossil fuel
        - i. Health hazards in urban areas
        - ii. Concerns about energy insecurity
        - iii. Problems associated with fossil fuel dependence

C. ***Socio-economic dislocations***

1. **Problems due to mobility systems**
    a. Traffic congestion and density
    b. Poor maintenance of systems, modes, vehicles
    c. Improper manufacturing of vehicles and building of system
    d. Excessive and inefficient fuel consumption
    e. Expanded wastes and material byproducts
    f. Pollution of waterways
2. **Problems shaped by physical conditions**
    a. Local topographical conditions
    b. Space configurations
    c. Implications of regulatory conditions
3. **Problems due to uses and users**
    a. Traffic accidents
    b. Noise pollution
    c. Social strains
    d. Loss of natural habitats
    e. Loss of agricultural lands
4. **Specific locations of concern**
    a. Megacities
    b. Rapidly urbanized areas

III. Scientific and Technical Solutions

A. ***Efficient mobility systems***

1. **Search for alternative transport fuel**
    a. Forms of alcohol fuel
    b. Solar electric vehicles
    c. Hydrogen as fuel
2. **Improved networks and transportation**
    a. Rationalizing transport systems and modes
    b. Encouraging low or no fuel-based transport

B. ***Improved vehicles and fuel types***

1. **Vehicle innovations**
    a. Hybrid cars
    b. Other new transport modes
2. **Cleaner fuel and chemical inputs**
    a. Fuel-related
    b. Substitutions for damaging chemicals

C. ***Substitution of functions***

1. **Communication vs. transportation**
2. **Shifts and reduction in transport loads**

IV. Social, Economic, Political, and Regulatory Solutions
- ***A. Emission standards and audits***
  - **1. Creating and enforcing standards**
  - **2. Mandating and undertaking audits**
- ***B. Markets and mechanisms for cleaner mobility***
  - **1. Incentives for cleaner mobility**
  - **2. incentives for recycling and minimizing materials and wastes**
  - **3. effective fare structures and systems**
- ***C. Eco-efficiency and safety measures***
  - **1. Improved supply-demand planning systems**
  - **2. Encouraging investments in new technologies**
  - **3. Improving transport management systems**
  - **4. Designing and enforcing transport systems safety**
    - a. Design, manufacture, and operation of vehicles
    - b. Harmonization of policy approaches
      - i. Within jurisdictions
      - ii. Within transport systems
      - iii. Across national jurisdictions
      - iv. Across International jurisdictions
  - **5. Improved international responses**
    - a. Response channels and actors
      - i. Non-governmental channels
      - ii. Governmental channels
    - b. Mode and type of response
      - i. Formal and mandated
      - ii. Voluntary regulation
      - iii. Mixed types and modes
  - **6. Enforcing safety in transport, packaging, and storage of hazardous goods and materials**

A.13 Conflicts and Wars

Manifestations of organized goal-seeking violent behavior associated with hostility, undertaken by individual entities singly or jointly.

I. Activities and Conditions
- ***A. Types of conflict***
  - **1. Scope and extent**
    - a. Civil vs. international
    - b. Limited vs. diffused
    - c. Organized vs. non-organized

2. **Participant characteristics**
    a. Size
    b. Demography
    c. Capability
3. **Types of warfare**
    a. Conventional
    b. Nuclear
    c. Terrorist activity
    d. Guerrilla conflict
    e. Independence movements
    f. Combined activities

B. ***Causes and sources***

1. **Security concerns**
    a. Windows of opportunity
    b. Pre-emptive strikes
    c. Territorial concerns
    d. Resources
    e. Alliances
    f. Capabilities
2. **Economic**
    a. Access and control of resources
    b. Market competition
3. **Socio-political**
    a. Gender issues
    b. Nationalism
    c. Militarism
    d. Ideology
    e. Ethnicity
    f. Religion
4. **Conflict processes**
    a. Spirals
    b. Arms races and competition
    c. Collapse of empires or governments
5. **Misperceptions vs. strategic moves**

C. ***Military-related activities***

1. **Military systems**
    a. Components
        i. Armies, navies, air forces
        ii. Regular, reserve, and mixed
            1. Wants and needs of the organizations and the wishes of senior officers affect a government's policy
            2. The military experience affects society's values

- b. Weapons and weapon systems
  - i. Types
    - 1. Conventional
    - 2. Chemical
    - 3. Biological
    - 4. Nuclear
  - ii. Manufacture, trade, and distribution
  - iii. Disposal
  - iv. Management

II. Sustainability Problems

A. Environmental damages

1. Conventional warfare

- a. Transportation
- b. Direct impact (destruction of terrain)
- c. Indirect impact (destruction of human-made facilities)
  - i. Radiation from nuclear facilities
  - ii. Release of high-level toxins from chemical manufacturing and storage
  - iii. Release of enormous quantities of water from the destruction of dams
- d. Post-war remnants
  - i. Land and sea mines
  - ii. Duds (artillery, bombs, grenades, etc.)
- e. Seepages

2. Possible effects of nuclear war

- a. Immediate effects
- b. Long-term effects
  - i. Climate
  - ii. Atmosphere
  - iii. Radiation
  - iv. Biological response

B. Social impacts

1. Demographic damages

- a. Casualties
- b. Genocide
- c. Ethnic targeting
- d. Forced dislocation

2. Refugees and returnees

- a. Location
  - i. Internal and external
  - ii. Regional and international

- b. Extent of flow and concentration
- c. Costs and impact
  - i. On people
  - ii. On governments
  - iii. On institutions

3. **Health impact**
   - a. Spread of disease
   - b. Famine and malnutrition
   - c. Psychological
   - d. Phsyical
4. **Education and human capacity**
   - i. Perpetuating false histories due to national policies
   - ii. Diverts research towards war and military-related aims
   - iii. Constraints on skill development
5. **Restriction of civil liberties**

C. ***Economic impacts***

1. **Economic losses from conflict and violence**
   - a. Farmland and pastures
   - b. Forests and timber
   - c. Shipping routes
   - d. Crime and plunder
   - e. Other tangibles and intangibles
2. **Problems from wartime conditions**
   - a. Stricter regulation and control
   - b. Higher taxation
   - c. Diversion of labor and conscription
   - d. Dependence of economy on defense industries

D. ***Impacts on sovereignty***

1. **Imperialism and colonialism**
   - a. State destruction
2. **State-building**

III. Scientific and Technical Solutions

A. ***Improved warning systems***

1. **Intelligence**
2. **Communication**

B. ***Enhanced monitoring systems***

C. ***Improved disposal of munitions***

IV. Social, Economic, Political, and Regulatory Solutions

A. ***Confidence building measures and improved dispute resolution***

B. ***Diplomacy and negotiations***

1. **Types of negotiations**

a. Formal and informal
b. Governmental and non-governmental

2. Scale and scope

a. Unilateral
b. Bilateral
c. Multilateral
d. International organizations

3. Enhancing social contracts

a. Formal and Informal mechanisms
b. Reinforcing accountability

C. Post-conflict reconstruction

1. Rebuilding

a. Socio-economic
b. Physical
c. Environmental remediation
d. Support

2. Strengthening restitution and accountability

a. Repatriation and safe supports
b. Protection measures
c. Rebuilding policy

3. Improved institutional forms and measures

a. Legal arrangements
b. Institutional developments
c. Organizational arrangements

A.14 Governance and Institutions

Authoritative and legitimate modes of managing public and private interests, at international, national, state and regional, and local/municipal levels.

I. Activities and Conditions

A. Provision of public goods

1. Physical infrastructure

a. Transportation
b. Communication
c. Other

2. Social infrastructure

a. Identity confirmation
b. Defining and maintaining national image

3. Regulation

a. Formal modes
b. Informal modes
c. Mixed modes

4. Legislation

a. Executive modes and decrees

- b. Legislative systems
  - i. Formal institutional
  - ii. Informal or traditional

5. Adjudication and dispute settlement

- a. Formal mechanisms
  - i. Courts of law
  - ii. Claims systems
- b. Informal mechanisms
- c. Traditional mechanisms

6. National security

- a. Defense from external threats
  - i. Funding of defense-related activities and research and development
  - ii. Procurement and maintenance of armed forces
- b. Internal law and order

7. Distribution of benefits and entitlements

- a. Social security
- b. Unemployment benefits
- c. Insurance coverage
  - i. Medical
  - ii. Social services
  - iii. Personal damages

B. Management of interests and policies

1. Articulation of demands

- a. Balancing interests
- b. Representation of interests
- c. Defining authoritative preferences

2. Intermediation processes

- a. Political parties
- b. Informal political groupings
- c. Forms of representation
- d. Forms of political participation

3. Influencing external activities and policies

- a. Shaping foreign and economic policies
- b. Defining position toward globalization processes

4. Managing governance loads and capabilities

- a. Succession issues
- b. Accountability and related issues
- c. Policy formulation and consequences
- d. Managing government capabilities

II. Sustainability Problems

A. Socioeconomic and political pressures

1. Population demands

- a. Changes in amounts of demand for basic resources (food, energy, etc.)
- b. Demands due to rural-urban
- c. Demands due to immigration

2. Equity demands and pressures

- a. Enhanced ethnic, cultural, racial disparities in wealth and opportunities
- b. Enhanced income and/or class disparities
- c. Enhanced regional and/or spatial disparities

3. Changes in the composition of demand

- a. For types of foodstuffs
- b. For energy resources
- c. For infrastructure and services
- d. Other

B. Challenges to legitimacy

1. Internal challenges

- a. Failures of representation
  - i. Cultural or ethnic tensions
  - ii. Tensions due to changes in demographic composition
  - iii. Pressures due to migration (internal and external)
- b. Conflicts for control of governance
- c. Breakdown of social order and/or the social contract

2. External challenges

- a. Foreign military activity
- b. Competitive pressures in the international economy
- c. Intended or unintended population inflows
- d. Specific economic threats

3. Changes due to territorial boundaries

- a. Due to session movements
- b. Due to territorial acquisitions
- c. Due to unification

III. Scientific and Technical Solutions

A. Marshalling innovations for demand management

1. Monitoring consumer and voter behavior

2. Uses of technology networks for connectivity to constituencies

3. Facilitating access to benefits and services

B. Pursuing eco-efficiency in public infrastructure and enterprises

1. Greening of governance and institutions

a. Greening of infrastructure and services
b. Greening of physical processes and deliverables

IV. Social, Economic, Political, and Regulatory Solutions

A. Improved conduct of collective action

1. **Demand management**
2. **Collective security provisions**
    a. Formal accords and agreements
        i. Bilateral
        ii. Regional
        iii. International
            1. Informal arrangements
3. **Improving representation**
4. **Effective interest articulation**
5. **Routinization of responses**
    a. Bilateral
    b. Regional
    c. International

B. Effective institutional and civic feedback

1. **Strengthening civic performance**
    a. Empowering community participation
    b. Facilitating feedback on action and decision
2. **Establishing institutional accountability**
3. **Commonality in reporting formats**
4. **Facilitating access to financial resources**
    a. Creation of new credit mechanisms
    b. Expanding opportunities
    c. Strengthening effectiveness of safety nets

Appendix B

GSSD GLOSSARY AND DEFINITION OF TERMS

The entries in this Glossary are listed in alphabetical order. In some cases, cross reference is noted, as relevant.

Abstract — A document that contains information on a sustainability-related resource on the Internet.

Abstract (abstract form) — A short paragraph describing the site containing sustainability-related resources.

Abstract Breadth (abstract form) — An abstract is classified into one of three groups if it covers 70% or more of that group's concepts: All GSSD holdings, Industry holdings, or AGS holdings.

Abstracts Submitted in English (workflow) — Pre-published English abstracts that need to be reviewed.

Activities and Conditions — Refers to modal types of human activities and conditions, including those reflected in national income accounts as well as others representing generic forms of human activities and conditions.

Agreements — Treaties, resolutions, accords, or other binding agreements reached by states, regional and international organizations, and/or special interest groups on relevant topics of study. Includes national level legislation.

AGS — Refers to the Alliance for Global Sustainability, a research collaboration among Chalmers University of Technology, the Massachusetts Institute of Technology, the Swiss Federal Institute of Technology Zurich – ETH, and the University of Tokyo focusing on sustainable development.

AGS Investigator(s) (abstract form)	Principle researchers for a particular AGS project.
AGS Dates of Activity (abstract form)	Research time frame for a particular AGS project.
AGS Cell (abstract form)	The intersection of an AGS ring and an AGS slice.
AGS Slice (abstract form)	One of six radial sections specifically related to AGS research that should be used when classifying an AGS abstract. These are: Climate Change, Water and Agriculture, Urban Systems, Cleaner Technologies, Energy, and Mobility.
AGS Ring (abstract form)	One of four oval-shaped rings that make up the AGS research structure. These are: Basic Understanding, Education and Implementation, Methods/ Process Development, and Policy and Decision-Making.
All Other Abstracts (workflow)	Pre-published English abstracts that originated in another GSSD-supported language and needs to be reviewed.
Amazon South America	Regional descriptor referring to Brazil, Paraguay, and Uruguay.
Andes South America	Regional descriptor referring to Peru, Bolivia, Argentina, and Chile.
Arabic to English Translations (workflow)	Pre-published Arabic abstracts that are ready to be translated to English.
Bibliographies and Reports	Compilations of books, reports, research papers, links, or other documents, including reports, technical papers, policy papers, and instructions on implementation of knowledge.

Caribbean Central America	Regional descriptor referring to the Bahamas, Cuba, Jamaica, Haiti, Dominican Republic, Puerto Rico, Barbados, Dominica, Grenada, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines.
Case Studies	Projects, initiatives, programs, or experiments carried out by one or more organizations, academic institutions, or governments on a global, regional, or local level.
Cell	The intersection of a ring and a slice.
Central Africa	Regional descriptor referring to Eritrea, Djibouti, Sudan, Chad, Niger, Mali, Senegal, Nigeria, Burkina Faso, Togo, Ghana, Benin, Senegal, Gambia, Guinea-Bissau, Guinea, Sierra Leone, Liberia, Ivory Coast, and Cape Verde.
Chinese to English Translations	Pre-published Chinese abstracts that are ready to be translated to English.
Commonwealth of Independent States - Asia	Regional descriptor referring to the Ukraine, Georgia, Moldova, Belarus, Armenia, Azerbaijan, Estonia, Latvia, and Lithuania.
Concept	One of the subtopics within a cell.
Continental Central America	Regional descriptor referring to Mexico, Guatemala, Belize, Honduras, El Salvador, Nicaragua, Costa Rica, and Panama.
Continental North America	Regional descriptor referring to Canada and the United States excluding Hawaii.
Core	The central ring, referring to holdings whose breadth spans the sustainability domain.
Country (abstract form)	Country of origin of the site, if any. This can often be found by looking at the end of the website address for a country abbreviation, such as .ca for Canada or .it for Italy.

Database A set of documents (definition is specific to Lotus).

Datatype (abstract form) One of eight types of information pertaining to a core concept. These are: definitions/theories, indicators, agreements, case studies, organizations, models, events, and bibliographies.

Definitions/ Theories Documents that clarify the meaning of a concept, including its composition or key components, and the relationships among its elements.

Dimension Refers to the four characteristic features pertaining to each domain of human activity (specified as modal type and associated conditions). These address the nature of: Activities and Conditions; Sustainability Problems; Scientific and Technical Solutions; and Social, Economic, Political and Regulatory Solutions. Global Accords. Refers also to *ring* (see below). A fifth dimension or ring focuses on International Responses and Global Accord (IRGA as defined below).

Document An entity containing data that is part of a Lotus database.

Domain Refers to one of the fourteen modal types of human activities and associated conditions. These are: Energy Use and Sources, Trade and Finance, Industry, Mobility, Agriculture, Forest and Land Use, Water Use and Sources, Conflicts and Wars, Urbanization, Consumption, Unmet Basic Needs, Population, Migration and Dislocation, and Governance and Institutions. Referred to also as *slice* (see below).

Eastern Asia Regional descriptor referring to China, Mongolia, North Korea, South Korea, Japan, and Taiwan.

Eastern Europe Regional descriptor referring to Finland, Norway, Sweden, Germany, Austria, Slovenia, Croatia, Hungary, Czech Republic, Romania, Russia,

	Bulgaria, Poland, Albania, Slovakia, Greece, Bosnia and Herzegovina, Macedonia, Serbia, and Montenegro.
email address (abstract form)	Email address for the person submitting the abstract via the web.
Equatorial South America	Regional descriptor referring to Colombia, Venezuela, Ecuador, Guyana, Suriname, French Guiana, Trinidad, and Tobago.
Events	Include conventions, conferences, workshops, symposiums, or other activities or gatherings designed to address the issues surrounding one or more concepts (of issues, problems, or challenges).
GSSD Supported Languages	The languages which have been used to translate the GSSD knowledge-base. Languages currently supported are Arabic, Chinese, and English.
id file	A file generated by Lotus software that authenticates a user to the Lotus system (e.g., JaneDoe.id).
Image Map	WWW feature that allows the user to access different WWW pages by clicking on different parts of an image. The GSSD homepage, the buttons in the left hand frame, and the search navigators are examples of image maps.
Indicators/Data	Statistics (or metrics) that represent the condition or direction of a social, economic, environmental, scientific, or other measurable variable.
Industry Cell (abstract form)	The intersection of a ring and an industry slice.
Industry Slice (abstract form)	One of fourteen radial sections specifically related to industry that should be used when classifying an abstract with industry-specific information. These are: Construction, Extraction and Processing, Manufacturing, Chemical, Energy, Electronics, Information and Telecommunications, Transport,

Machinery and Equipment, Timber, Paper and Pulp, Food and Agriculture, Service Sector, Legal and Financial, and Other Services.

Input by (abstract form) The name of the person entering the abstract.

IRGA Refers to international responses and global accords and consists of the fifth ring in the GSSD framework. It is akin to the social dimension of the "fourth image" in the study of international relations – namely, the individual; the state; and the international system. This use of "image" or level is due to K. Boulding and K. N. Waltz (images 1–3) in social systems only; and Robert C. North, extending the three images along two lines of theoretical reasoning: (a) behaviors in social and natural conditions and (b) extensions to the fourth image; i.e. the global system that transcends conventional social and political categories as well as the more conventional notions of "environment."

Knowledge-Base Substantive content in the GSSD database (which consists of abstracts of Internet resources).

Lotus Administrator Software for managing the Lotus environment.

Lotus Designer Software for creating Lotus databases, agents, views, and other design element.

Lotus Domino Software for running Lotus databases on a server.

Lotus Domino Global Workbench Software for translating Lotus databases into multiple languages.

Lotus Notes Software for accessing and using Lotus databases.

Middle East Regional descriptor referring to Turkey, Syria, Lebanon, Iraq, Iran, Israel, Saudi Arabia, Jordan, Kuwait, United Arab Emirates, Oman, Yemen, Libya, Egypt, Cyprus, Bahrain, and Qatar.

Models	Representation of an object, system, or plan used to study its characteristics or make inferences about its effects. Models typically generate an output in response to user input, or generate output in response to endogenous adjustments.
Northern Africa	Regional descriptor referring to Tunisia, Algeria, Morocco, and Mauritania.
Oceania	Regional descriptor referring to Indonesia, Papua New Guinea, Australia, New Zealand, Hawaii, Vanuatu, New Caledonia, Fiji, Philippines, Samoa, Palau, Marshall Islands, Micronesia, and the Solomon Islands.
Organization Information (abstract form)	Information on the host of the web site, if the site is managed by an institution or an organization.
Organizations	One or more groups of people brought together by a common interest or purpose, in formal or informal arrangements, and with continuity over time.
Originator Information (abstract form)	Information about the person entering the abstract.
Published Abstracts (workflow)	All the abstracts available on the GSSD website.
Publishing Abstracts: Step 1 (workflow)	Instructions on all non-English abstracts that are ready to be published, with or without fixes.
Publishing Abstracts: Step 2 (workflow)	Non-English abstracts that can be published once the instructions in "Publishing abstracts: step 1" have been followed.
Region (abstract form)	Regions of the world which are covered in the content of the site.
Replica	A copy of a shared *Notes* database.

Replication A process that updates and distributes replicas on different servers.

Ring One of five oval-shaped rings that make up the GSSD structure; also referred to as a *dimension* These are: Activities and Conditions, Sustainability Problems, Scientific and Technical Solutions, Social, Economic, Political and Regulatory Problems, and International Responses and Global Accords.

Scientific and Technical Solutions Current understandings of technological and scientific interventions that could minimize damages due to human activities.

Slice One of fourteen radial sections that form an oval of the GSSD structure. Referred to also as a *domain.* See above.

Social, Economic, Political and Regulatory Solutions Current understandings potentials ways in which social behaviors can be managed (curtailed, altered, or reoriented), through a variety of methods (such as government interventions, sanctions, different forms of incentives, or market mechanisms).

South Eastern Asia Regional descriptor referring to Bhutan, Bangladesh, Myanmar, Laos, Thailand, Vietnam, Cambodia, Malaysia, Brunei, Singapore, and Lao People's Democratic Republic

Southern Africa Regional descriptor referring to South Africa, Namibia, Botswana, Swaziland, Lesotho, Zimbabwe, Mozambique, Angola, Zambia, Malawi, Madagascar, Mauritius, and the Comoro Islands.

South Western Asia Regional descriptor referring to India, Nepal, Pakistan, Tajikistan, Turkmenistan, Uzbekistan, Kyrgyzstan, Kazakhstan, Sri Lanka, and Maldives.

Standard Notes Interface (workflow) Old user interface for GSSD, prior to the implementation of the August 2001 workflow.

Sub-Saharan Africa	Regional descriptor referring to Cameroon, Central African Republic, Uganda, Ethiopia, Somalia, Kenya, Congo, Gabon, Zaire, Burundi, Tanzania, Rwanda, Equatorial Guinea, Sao Tome and Principe, and Seychelles.
Submission Language (abstract form)	The ***original*** language in which the abstract is written. The current choices are: English, Chinese, and Arabic.
Submission Type (abstract form)	The format(s) of the information presented on the site. The categories are: WWW (web pages), Acrobat (PDF files), Dataset, FTP, and Map/GIS.
Submit Abstract (workflow)	The *Notes* form for entering new abstracts.
Sustainability Problems	Addresses the wide range of social and environmental damages due to human activities.
Sustainable Development	The process of meeting the needs of current and future generations without undermining the resilience of the life-supporting properties or the integrity and cohesion of social systems.
Synchronization	The process of distributing abstracts to the relevant mirror sites for translation to all language databases.
Termweight	The Termweight operator is used to alter the relevance ranking of search words. Documents in which the search text is most important appear at the top of the list of search results when you sort the results are sorted by relevance.
Title (abstract form)	A short description of the abstract.
Translations in Progress (workflow)	English abstracts that are ready to be translated into the other GSSD-supported languages.
Translations to be Reviewed (workflow)	Non-English abstracts that need translation review.

URL Arabic (abstract form)	The web address for the Arabic version of the site described in the abstract.
URL Chinese (abstract form)	The web address for the Chinese version of the site described in the abstract.
URL English (abstract form)	The web address for the English version of the site described in the abstract.
URL French (abstract form)	The web address for the French version of the site described in the abstract.
URL Spanish (abstract form)	The web address for the Spanish version of the site described in the abstract.
URL Other (abstract form)	The web address for any other language version of the site described in the abstract.
View	A listing of a particular set of documents in a database.
Western Europe	Regional descriptor referring to the United Kingdom, Ireland, Iceland, Switzerland, Spain, France, Italy, The Netherlands, Belgium, San Marino, Andorra, Malta, and Luxembourg.
Workflow	The process for getting abstracts published to the web and part of the GSSD knowledge-base.

Appendix C

CONTENT PROVISION

This appendix addresses three issues: options for content provision to the GSSD knowledge-base, troubleshooting pointers, and a procedural End Note.

Submission

Content provision is undertaken via (a) the submission of document abstracts via the web, using the GSSD web-form, or (b) the *Notes client,* using the GSSD *Notes* form. The GSSD content editor reviews the submission for content and format.

Troubleshooting

Specific steps for content provision include the following:

- Select the most relevant *slices* that represent the core concepts, or topics, of the submission page.
- Repeat step 1 with respect to applicable *rings.*
- Draft the abstract text. Do not quote directly from the site unless absolutely necessary (and if so, place the text in quotes).
- Check to confirm that the abstract form contains the relevant cells, concepts, and sub-concepts (as needed).
- Complete in the rest of the form.
- Consult the Glossary in Appendix A for the definition of abstract fields, as needed.
- Review and confirm that the abstract form is filled out in its entirety. Failure to do so will result in delays or deletions.

End Note

For consistent content development, every knowledge item under consideration must be treated as follows for every candidate abstract (i.e. knowledge item): selected sites must follow the submission procedure. This will ensure that potential issues related to relevance, uncertainties, and other problems are not overlooked. In cases of uncertainty about potential relevance, or viability of content, contact the system administrator.

Appendix D

ILLUSTRATING PERSPECTIVES

This appendix presents some illustrative examples of basic and complex logics. Only three references are noted in each section, therefore the illustrations are indicative at best. The entries follow the format and sequence in Chapter 19 and are labeled (1)–(10) within the major categories, namely core assumptions, economic and social processes, and sovereignty and security.

D.1 Core Assumptions

D.1.1 Epistemological Foundations

D.1.1.1 Basic Logic

Gilpin, R. G. (1986). The richness of the tradition of political realism. (In R. O. Keohane, (Ed.) *Neorealism and its critics*. New York: Columbia University Press)

Morgenthau, H. J. (1985). *Politics among nations: the struggle for power and peace*. (New York: Knopf)

Waltz, K. N. (1979). *Theory of international politics*. (Reading, MA: Addison-Wesley)

D.1.1.2 Complex Logic

Choucri, N. and North, R. C. (1975). *Nations in conflict*. (San Francisco: W. H. Freeman and Company)

Cioffi-Revilla, C. (1998). *Politics and uncertainty: theory, models, and applications*. (New York: Cambridge University Press)

North, R. C. (1990). *War, peace, survival: global politics and conceptual synthesis*. (Boulder, CO: Westview Press)

D.1.2 System Behavior

D.1.2.1 Basic Logic

Gilpin, R. (1981). *War and change in world politics*. (Cambridge: Cambridge University Press)

Keohane, R. O. (1986). Theory of world politics: structural realism and beyond. (In R. O. Keohane (Ed.) *Neorealism and its critics.* New York: Columbia University Press)

Waltz, K. N. (1979). *The theory of international politics.* (Redding, MA: Addison Wesley Publishing)

D.1.2.2 Complex Logic

Choucri, N. and North, R. C. (1993). Global accord: imperatives for the twenty-first century. (In N. Choucri (Ed.) *Global accord: environmental challenges and international responses*. Cambridge, MA: MIT Press)

Kratochwil, F. (1986). Of systems, boundaries, and territoriality. *World Politics*, 39(1), 27–52.

Ruggie, J. G. (1986). Continuity and transformation in the world polity: toward a neorealist synthesis. (In R. O. Keohane (Ed.) *Neorealism and its critics*. New York: Columbia University Press)

D.1.3 Actors

D.1.3.1 Basic Logic

Becker, G. (1976). *The economic approach to human behavior*. (Chicago: The University of Chicago Press)

Grieco, J. M. (1996). Anarchy and the limits of cooperation: a realist critique of the newest liberal institutionalism. *International Organization*, 42(3), 485–507.

Van Evera, S. (1999). *Causes of war*. (New York: Cornell University Press)

D.1.3.2 Complex Logic

Axelrod, R. and Bennett, D. (1993). A landscape theory of aggregation. *British Journal of Political Science*, 23(2), 211–233.

Ostrom, E. (1998). A behavioral approach to the rational choice theory of collective action: presidential address. American Political Science Association, 1997. *American Political Science Review*, 92(1), 1–22.

Simon, H. (1991). *Models of my life*. (New York: Basic Books)

D.1.4 Time Horizons and Temporality

D.1.4.1 Basic Logic

Mingst, K. A. and Snyder, J. L. (2004). *Essential readings in world politics, 2nd ed.* (New York: W. W. Norton & Company)

Rothenberg, J. (1993). Economic perspectives on time comparisons: an evaluation of time discounting. (In N. Choucri (Ed.) *Global accord: environmental challenges and international responses*. Cambridge, MA: MIT Press)

Singer, J. D. (1989). System structure, decision processes, and the incidence of international war. (In M. I. Midlarsky (Ed.) *Handbook of war studies*. Ann Arbor, MI: The University of Michigan Press)

D.1.4.2 Complex Logic

Cioffi-Revilla, C. (2006). The big collapse: a brief cosmology of globalization. (In B. Gills and W. R. Thompson (Eds.) *Globalization and global history*. New York: Routledge)

Rothenberg, J. (1993). Economic perspectives on time comparisons: alternative approaches. (In N. Choucri (Ed.) *Global accord: environmental challenges and international responses*. Cambridge, MA: MIT Press)

Weiss, E. B. (1993). Intergenerational equity: toward an international legal framework. (In N. Choucri (Ed.) *Global accord: environmental challenges and international responses*. Cambridge, MA: MIT Press)

D.2 Economic and Social Processes

D.2.1 Political Economy

D.2.1.1 Basic Logic

Goodland, R. and Ledec, G. (1987). Neoclassical economics and principles of sustainable development. *Ecological Modeling*, 38, 19–46.

Pearce, D. W. and Atkinson, G. D. (1993). Capital theory and the measurement of sustainable development: an indicator of weak sustainability. *Ecological Economics*, 8, 103–108.

Solow, R. (1988). Growth theory and after. *The American Economic Review*, 78(3), 307–317.

D.2.1.2 Complex Logic

Cerny, P. G. (1995). Globalization and the changing logic of collective action. *International Organization,* 49(4), 595–625.

Choucri, N. and North, R. C. (1993). Growth, development, and environmental sustainability: profile and paradox. (In N. Choucri (Ed.) *Global accord: environmental challenges and international responses*. Cambridge, MA: MIT Press)

Pezzey, J. (1989). Economic analysis of sustainable growth and sustainable development. *The World Bank, Environment Department*, Working Paper No. 15.

D.2.2 Knowledge and Technology

D.2.2.1 Basic Logic

Keylor, W. R. (1996). *The twentieth century world, third edition.* (Oxford University: Oxford University Press)

Skolnikoff, E. B. (1993). Science and technology: the sources of change. (In N. Choucri (Ed.) *Global accord: environmental challenges and international responses*. Cambridge, MA: MIT Press)

Solow, R. (1962). Technical progress, capital formation, and economic growth. *The American Economic Review*, 52(2), 76–92.

D.2.2.2 Complex Logic

Arthur, B. B. (1998). Increasing returns and the new world of business. (In D. Neef (Ed.) *The knowledge economy*. Boston: Butterworth-Heinnemann)

Choucri, N. (2000) Introduction: Cyber Politics in International Relations. *International Political Science Review*, 21(3), 243–264.

Morowitz, H. J. (2002). *The emergence of everything.* (Oxford: Oxford University Press)

D.2.3 Decision

D.2.3.1 Basic Logic

Allison, G. (1969). Conceptual models and the Cuban missile crisis. *American Political Science Review*, 63(3), 689–718.

Demeny, P. (1986). Population and the invisible hand. *Demography*, 23(4), 473–487.

Victor, D. G., Chayes, A., and Skolnikoff, E. B. (1993). Pragmatic approaches to regime building for complex international problems. (In N. Choucri (Ed.) *Global accord: environmental challenges and international responses*. Cambridge, MA: MIT Press)

D.2.3.2 Complex Logic

Haas, P. M. and Sundgren, J. (1993). Evolving international environmental law: changing practices of national sovereignty. (In N. Choucri (Ed.) *Global accord: environmental challenges and international responses*. Cambridge, MA: MIT Press)

Simon, H. A. (1969). *The sciences of the artificial*. (Cambridge, MA: MIT Press)

Snyder, G. H. and Diesing, P. (1977). *Conflict among nations: bargaining, decision-making, and system structure in international crises*. (Princeton, NJ: Princeton University Press)

D.2.4 Institutions

D.2.4.1 Basic Logic

Krasner, S. D. (1983). *International regimes*. (Ithaca, NY: Cornell University Press)

Martin, L. L. and Simmons, B. A. (1999). Theories and empirical studies of international institutions. (In P. J. Katzenstien, R. O. Keohane, and S. D. Krasner (Eds.) *Exploration and contestation in the study of world politics*. Cambridge, MA: MIT Press)

North, D. C. (1990). Institutions and a transaction-cost theory of exchange. (In J. E. Alt and K. A. Shepsle (Eds.) *Perspectives on positive political economy*. New York: Cambridge University Press)

D.2.4.2 Complex Logic

DiMaggio, P. J. and Powell, W. W. (1991). Introduction. (In W. W. Powell and P. DiMaggio (Eds.) *The new institutionalism in organizational analysis*. (Chicago, IL: University of Chicago Press)

Ostrom, E. (1995). New horizons in institutional analysis. *American Political Science Review*, 89(1), 174–178.
Shepsle, K. A. (1989). Studying institutions: some lessons from the rational choice approach. *Journal of Theoretical Politics*, 1(2), 131–117.

D.3 Sovereignty and Security

D.3.1 Sovereignty

D.3.1.1 Basic Logic

Bull, H. (1977). *The anarchical society*. (New York: Columbia University Press)
Krasner, S. D. (1988). Sovereignty: an institutional perspective. *Comparative Political Studies*, 21(1), 66–94.
Hirst, P. and Thompson, G. (1999). *Globalization in question. second edition*. (Malden, Ma: Blackwell Publishers, Inc.)

D.3.1.2 Complex Logic

Alker, H. R., Jr. and Haas, P. M. (1993). The rise of global ecopolitics. (In N. Choucri (Ed.) *Global accord: environmental challenges and international responses*. Cambridge, MA: MIT Press)
Haas, P. M. and Sundgren, J. (1993). Evolving international environmental law: changing practices of national sovereignty, (In N. Choucri (Ed.) *Global accord: environmental challenges and international responses*. Cambridge, MA: MIT Press)
Litfin, K. T. (1998). The greening of sovereignty: an introduction. (In K. T. Lifton (Ed.) *The greening of sovereignty in world politics*. Cambridge, MA: MIT Press)

D.3.2 Security

D.3.2.1 Basic Logic

Jervis, R. (1978). Cooperation under the security dilemma. *World Politics*, 30(2), 167–214.
Mearsheimer, J. J. (2001). *The tragedy of great power politics*. (New York: W.W. Norton & Company)
Posen, B. R. (1986). *Sources of military doctrine: France, Britain and Germany Between the World Wars*. (Cornell, NY: Cornell University Press)

D.3.2.2 Complex Logic

Pirages, D. and Cousins, K. (Eds.) (2005). *From resource scarcity to ecological security*. (Cambridge, MA: The MIT Press)
Tainter, J. A. (1988). *The collapse of complex societies.* (Cambridge: Cambridge University Press)
Turchin, P. (2003). *Historical dynamics: why states rise and fall.* (Princeton, NJ: Princeton University Press)

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