Contributions to Finance and Accounting

Darko B. Vukovic
Moinak Maiti
Elena M. Grigorieva *Editors*

Digitalization and the Future of Financial Services

Innovation and Impact of Digital Finance

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Contributions to Finance and Accounting

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For ours
Damian and Sofia Vuković, Junior Maiti, and
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Preface

The motive to edit the book *Digitalization and the Future of Financial Services* came out from our last decade of publishing in different issues of finance, methodologies, and machine learnings in finance. In the last ten years, much has changed in both academic and practical world in finance. The new areas of financial research have emerged, such as crypto markets and currencies, new financial services, and the most recently, high market turbulence caused by various crises, including the COVID-19 pandemic. The global academic community follows all new trends and, through numerous studies, contributes to the development of new theories and literature. Machine learning techniques are essential today as a method of studies in digital finance, increasingly substituting classical econometric models.

The same trends exist in practice. Companies and individuals are less going to banks to use almost all financial services. Practically, any service can be done from home or office, whether one trades on the financial market, opens deposit accounts, performs various transactions, concludes an insurance contract, or performs any other financial service. Moreover, one does not even need a computer/laptop to use these services, a cell phone is enough. Software solutions and applications on today's cell phones allow the user to perform all services from anywhere and anytime. On top of all this, the COVID-19 pandemic came at the beginning of 2020, which further transformed financial services to "online," digital, "distantly." Lockdowns around the world and physical distancing between people have accelerated the use of digital financial services.

With all this in mind, we aim to edit and present the book that collects chapters which extend our understanding on how digitalization and the future of financial services can be helpful in different business circumstances in many cross-functional financial areas. The authors of the chapters contribute to this, through presenting different cases, literature reviewing, applying most recent methods, and giving their valuable opinions. We would like to acknowledge every author and co-author of this effort for their contribution and an exceptional initiative to successfully complete

this book. Finally, the editors Darko Vukovic and Elena M. Grigorieva have been supported by the RUDN University Strategic Academic Leadership Program, for their work.

Moscow, Russia — Darko B. Vukovic
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Introduction

In the last two decades, the digitalization of products and services in finance has been characterized by great developments in the theory and practical implications in the field of finance. With the advent of new financial technologies, financial institutions have offered new infrastructures, products, and services with the purpose of increasing the efficiency of its business and strengthening its competitiveness. However, this process also influences financial flows and stability, with both positive and negative influences. The new financial paradigm has started the race of financial institutions to create and offer the most diverse services and products. This process is the driver of knowledge and innovation in digital finance, resulting in the constant development and emergence of new technologies. The more financial products and services are based on blockchains and Internet of Things, where cryptocurrencies have become the mainstay of financial technology development.

Among the most significant technological advances is the development of artificial intelligence, which is often used today in the analysis of financial time series, as well as the prediction of various financial phenomena. This also contributes to the theoretical development of new models, such as kernel-based models or advanced neural networks models, which are used in predictions of financial time series (among many machine learning models). Financial markets and institutions have adapted to the various challenges of technology-driven changes in financial services. This process creates digital environment on financial markets, regulated by policy makers and central banks with the purpose of sustainable financial stability and existence of effective transmission mechanisms.

The recently ongoing COVID-19 pandemic has forced the products and services in finance for digital transformation. Physical distancing, closing state borders, and fear of infection encourage all stakeholders to use digital finance as the only possible solution in their business. Even though the term "digital transformation" appears to be simple, it has several implications in practice. It is important to understand the impact of digital transformation on the products and services in finance, holistically. It has a direct connection with the transition of the products and services in finance in business process. Hence, at this moment the global products and services in finance

are adopting and leveraging heavily on new technologies to achieve the cost and operating efficiencies. On the one hand, digital transformation brings bunches of opportunities, but on the other hand, it is a threat for the global products and services in finance. With this above background the edited edition of the *Digitalization and the Future of Financial Services: Innovation and Impact of Digital Finance* is built up. The edited collection has a total of 11 chapters covering various aspects of the present theme and contributing authors representing wide geographies.

Chapter 1 talks about how the different aspects of financial inclusion are promoting economic growth in the global context. The chapter concludes that more work remains to be done to increase financial inclusion worldwide. Chapter 2 deals with the tale of fintech-based innovations in the development of overall economic activity and social circumstances. The chapters imprint that the modern financial world is at a crossroads and financial innovation has led to alter the financial structure, as digitization knows no borders and competition is at the global level. The advent of new technologies and the evolution of business models have led to a significant transformation of the fintech sector in recent years.

In this regard, Chap. 3 highlighted the crucial roles of central banks and regulatory bodies in the world of FinTech's. Most importantly, the chapter emphasized that revolution in the fintech space improved financial inclusion and lowered transaction costs. But on the other hand, it raises several issues related to information security, data breaches, cyber-attacks, and threat to financial stability, among others. Keeping these in mind Chap. 3 identified several challenges faced by the regulators in regulating fintech companies. The chapter concludes that there is an immediate need for more studies on the regulatory aspects of fintech's.

Chapter 4 details the dematerialization of money in the age of the COVID-19 pandemic. The chapter underlined that over the years money was turned into fiat money, scriptural money, electronic money, and recently digital money (cryptocurrency). The chapter also showed that the growing trend toward the use of cryptocurrencies has been reversed with the emergence of the COVID-19 pandemic. Chapter 5 discusses the international financial markets operations in the age of digitalization. It brings the detailed discussion on electronic trading systems to the high-frequency algorithmic trading.

Chapter 6 sheds light on the importance of Bitcoin as an alternative asset class amid global financial turmoil and provides practical guidance for investors in developing investment portfolio development. Chapter 7 covers the overall impact of digitalization on the global BFSIs sector initially. Then it narrows down its focus to the impact of "RegTech" and "SupTech" on achieving financial stability.

Chapter 8 deals with some of the emerging technologies, namely AI, blockchain, and IoT that are significantly used by the BFSIs organizations nowadays. This chapter delves into the basic understanding of each of the triads and how they complement each other's drawbacks in possibly revolutionizing the entire financial domain. Chapter 9 brings an interesting discussion on the role of digital financial inclusion in promoting economic growth and freedom. It illustrated how digital financial services through the proliferation and penetration of information and communications technology (ICT) lead to financial freedom and financial

development. More specifically, it debates on the idea of financial freedom in the context of banking performance and its efficiency.

Chapter 10 focuses on the digital corporate sustainability reporting for the reporting organizations, regulators, and users of the information. This chapter argues that application of Extensible Business Reporting Language (XBRL) is considered to be one of the significant steps toward digitalization of accounting and reporting. As the XBRL-based digital corporate reporting will save capital expenditures, and enhance analyst forecast accuracy. Chapter 11 is devoted to the problem of digitalization, risks, and financial freedom.

This book develops insights of digitalization and the future of financial services to originate an innovative approach to financial field, to underpin research and practice in the wide area of digital finance. The aim of this book is to extend our understanding on how digitalization and the future of financial services can be helpful in different business circumstances in many cross-functional financial areas, such as financial markets, financial risk management, financial technologies, and investment finance. Thus, the book aims at addressing the relevance of digital finance for different players, highlighting differences in tools and processes, and identifying innovative practices in financial digitalization. This can result in some novel theoretical and practical insights that can foster financial players, to proactively explore/exploit opportunities in financial digitalization and/or offset financial risks and increase efficiency.

The book presents the chapters in a comprehensive way that readers have a complete picture of the most important insights of digitalization and the future of financial services. Theory and examples are presented at the global level (the most important world markets), to attract larger audience. In addition to this, the book offers a methodological part, which primarily relates to the management of financial time-series data through digital technologies.

This edited collection would be useful for the academicians, students, scholars, practitioners, or anybody who have interests in the present theme. This will give it a good basis to use as additional literature to courses at bachelor's, master's, and executive level and courses in fintech, digital finance, and blockchain and cryptocurrency. Even more, the book covers the very current situation under the COVID-19 pandemic, which affects the development of digital finance in daily businesses and the emergence of new financial technologies.

Contents

About the Editors

Darko B. Vukovic is full professor and the Head of the International Laboratory for Finance and Financial Markets at the Faculty of Economics, People's Friendship University of Russia (RUDN University), in Moscow, Russia. Since 2008, Dr. Darko Vukovic works at Geographical Institute "Jovan Cvijic" of the Serbian Academy of Sciences and Arts, as Head of Department of regional geography. He has published more than 60 papers indexed in leading index databases: Web of Science (Clarivate Analytics), Scopus, and ABS (CABS), including leading journals in the field of finance and financial forecasting (*Expert Systems with Applications, Financial Innovations, Physica A: Statistical Mechanics and its Applications, Research in International Business and Finance, International Journal of Finance and Economics, North American Journal of Economics and Finance*, and more). The research interests of Prof. Vukovic are financial markets, financial forecasting, financial risk management, investment finance, and regional economics. In 2017, he received Honorary Doctor of Excellence, *honoris causa (Excellentia Doctor),* from CIAC - Confederation of International Accreditation Commission in Mumbai, India.

Moinak Maiti is author of the book *Applied Financial Econometrics* published by Palgrave Macmillan. Besides an author he is an active speaker and invited to share the world-renowned platforms of the World Bank, United Nations, World Trade Organization (WTO Studies), SAS®, Bloomberg LP, Max Plank Society, PEP Canada, Ivy League Universities, and many others. He is in the editorial board members of several international journals published by Elsevier, Emerald, Wiley, and other reputed publishing houses. His articles are regularly published as research articles, book chapters, cases, blogs, newspaper articles, and others by renowned publishing houses. His research has been awarded multiple times, the most recent being the Emerald Literati Award 2021 for "Outstanding Paper" in the *British Food Journal*. His area of interest and expertise is finance, more specifically in asset pricing, financial econometrics, fintech, IoT, and technology innovation. He is open to collaborate and discuss interesting consultancy projects.

Elena M. Grigorieva is the deputy dean for science of the Faculty of Economics of the RUDN University. She is also the head of the Department of Finance and Credit of the Faculty of Economics of the RUDN University, where she is program director of the master's program "Modern Financial Technologies in Investment and Banking Business." Dr. Elena M. Grigorieva's research is devoted to banking, financial management, new financial tools, and sustainable development. She is the author of more than a hundred scientific papers in the field of finance and economics.

Digital Finance and Financial Services

Mustafa Özer

1 Introduction

The neoliberal phase of capitalistic system has created many inequalities among countries and within the countries as well. These problems became more apparent after the Great Recession of 2008–2009 and the Great Recession accelerated the interest in financial inclusion (Danisman & Tarazi, 2020). To decrease these inequalities among the countries and within the countries, the inclusive growth policies are suggested and try to be implemented. Even though world has witnessed significant and important developments in financial sector, the role of financial sector has become very crucial.

We have seen and witnessed the developments of many new financial products and instruments and establishment of new financial institutions. Despite this progress, unfortunately, inclusion of countries and some people in these financial developments is either so limited or absent. According to the latest World Bank data published in 2017, there are still approximately 1.7 billion adults who remain unbanked, that is, financially excluded. Gender, income, and educational attainment differences are still matter in this exclusion.

To include those financially excluded billions of people, international community, governments, policy makers, and regulators have been adopting and suggesting many new measures. Since the financial inclusion has been seen as a crucial driver of inclusive growth, many countries around the world are implementing ambitious strategies to increase their populations' access and use of financial services. These strategies have been helping, especially women to access and use of financial services. However, it is a fact that most of the world's women still cannot access

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and use financial services as much as men use. In addition, all measures implanted so far are failed to financial inclusion gap among the countries and people within the countries.

The success of strategies aimed to increase the degree of financial inclusion lies in the people's access and use of digital financial services, which include mobile money services, payment cards, and other financial technology (or fintech) applications. There is a fast expansion of digital technology, and this fast expansion of digital technology has greatly helped people's access to financial services over the past decades. Despite this fact, it is hard to argue that everyone equally benefits from the range and quality of services available. Low-income countries and low-income households have limited access to financial services, especially digital financial services. Fast increase in financial technology may turn those financially excluded people into included ones, since they have the potential to improve the lives of low-income. Thus, digital financial inclusion should be seen as a game changer. It is a game changer for those financially excluded and underserved low-income households as well as micro- and small businesses. As the degree of financial inclusion increases, people will have more chances to reduce poverty and will make significant improvements in their well-being.

With this backdrop, in this chapter we will try to summarize the current state of financial inclusion and show the importance of stability in the performance of developed markets' companies, which offer technology-driven financial services. For this purpose, we will explain the financial inclusion in the second section and present a summary of existing literature in the third section. In the fourth section, we will carry out an empirical work to show the importance of stability of performance of technology-driven financial services' companies and then we conclude.

2 Financial Inclusion

Financial inclusion has become a top global task and an emerging priority for policymakers and regulators in financial sector development as a part of sustainable and inclusive growth strategies. According to Zulkhibri (2016), many international organizations such as World Bank, United Nations, G20, and multilateral development banks (MDBs) now see the financial inclusion as their main concern.

Traditionally financial inclusion is defined as "individuals and businesses have access to useful and affordable financial products and services that meet their needs – transactions, payments, savings, credit and insurance – delivered in a responsible and sustainable way". Based on this definition, one can easily argue that it helps to promote the economic growth, reduce income inequality, and alleviate poverty. Moreover, according to Ofori-Abebrese et al. (2020), financial inclusion can be a key factor in achieving eight out of the seventeen sustainable development goals (SDGs) such as no poverty, zero hunger, good health and well-being, gender equality, decent work and economic growth, industry, innovation and infrastructure, reduced inequalities, and partnerships.

Financial inclusion can be measured in three different ways. First, it can be measured by using the indicators of traditional financial inclusion by taking into account of its "indicators related to access to and/or usage of traditional financial services, such as the number of bank account per capita and ATM per capita or combining these indicators into a composite index" (Khera et al., 2021). Second, it can be measured by focusing on a single aspect of digital financial inclusion at a time and by tracking the records on mobile money accounts and financial transactions using mobile phone, aiming at the digital financial (Sy et al., 2019; Loukoianova et al., 2019). Lastly, as is done in Khera et al. (2021), it can also be measured by constructing a comprehensive financial inclusion index (CFII). To construct CFII, digital financial inclusion index with an index of financial inclusion measured traditionally focusing on traditional financial institutions such as banks (traditional financial inclusion index).

There are some benefits of financial inclusion. First, it makes two complementary contributions to poverty alleviation. By driving economic growth, which indirectly reduces poverty and inequality, and, by creating appropriate, affordable, financial services for poor people, it can improve their welfare. Financial inclusion is a key helper in reducing poverty and boosting prosperity. Second, financial inclusion allows individuals and firms to participate in and benefit from the formal financial system. Individuals who are not financially excluded are able to invest in education and launch businesses, and this contributes to poverty reduction and economic growth (Beck et al., 2007). Finally, financial inclusion provides individuals with the possibility of having a safe place to save for the future and so can foster financial stability, as a high level of use of bank deposits contributes to a more stable deposit base for banks in troubled times (Han & Melecky, 2013).

The meaning of financial inclusion can be different for developed and developing countries. In developed countries, financial inclusion is seen as more about the knowledge of fair and transparent financial products. On the other hand, for developing countries, it is mostly a question of both access to financial products and financial literacy (Zulkhibri, 2016).

3 Stylized Facts of Financial Inclusion

To assess the state of financial inclusion and understand the different aspects of financial inclusion, we should focus on the developments in the main indicators of financial inclusion globally. Major indicators that we will use are mainly the adult indicators, such as adults with an account, adults using digital payments, payments using a mobile phone (from an account), payments using the Internet, payments using a bank card, and payments using account. Moreover, we will focus on saving prosperity, type of borrowing, and debit and credit card ownership as well. For this purpose, we will use the Triennial Global Findex data provided by World Bank. First, we will look at worldwide adult data about the percentage of adults who report having an account with a formal financial institution, saved at the financial

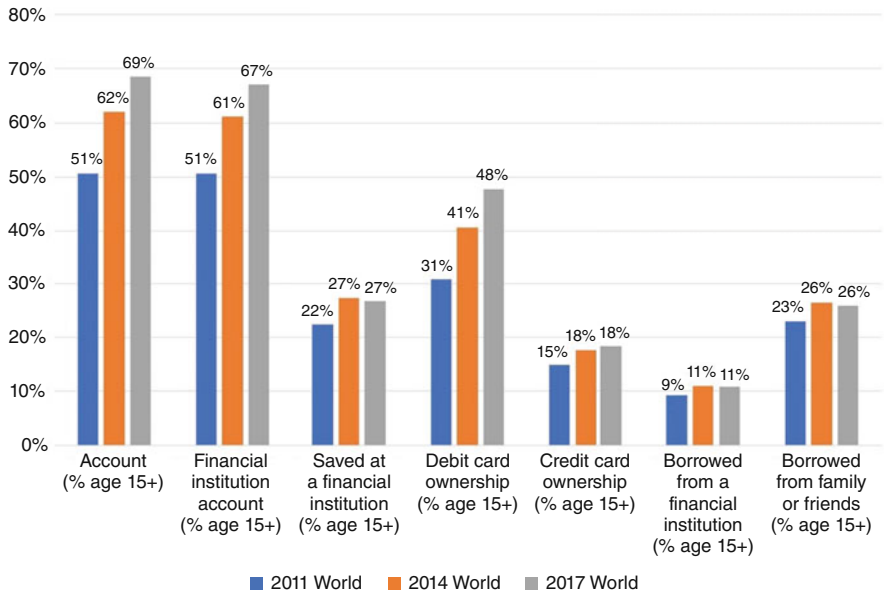

Fig. 1 World's financial inclusion indicators. Source of data: World Bank (2017), made by author

institution, type of borrowing, and ownership of debit and credit cards. Figure 1 summarizes developments in all these indicators.

According to indicators in Fig. 1, there is a notable increase in the level of financial inclusion between 2011 and 2017. From 2011 to 2017, there are 1.2 billion adults who managed to access formal financial accounts for the first time. Most of these increase resulted from an increase in mobile money accounts. In addition, between 2014 and 2017, 515 million adults opened an account at a financial institution or through a mobile money service causing an increase in the portion of adults with accounts from 62% to 69%. Despite this significant increase in the number of adult accounts, there are still more than 1.7 billion adults remain unbanked, that is financially excluded. Moreover, between 2014 and 2017, three of the seven indicators continued to increase. However, four of them remained the same. Those of the adults that borrowed from a financial institution remain low and stagnant. Credit card ownership shows the same tendency. Thus, even though there is an increase in adults' accounts, access to some financial services remains low. The degree of financial inclusion between developed and developing countries differs significantly. Figure 2 presents these differences.

As is seen clearly from Fig. 2, there are significant differences in the degree of financial inclusion between developed and developing countries. These differences are more apparent in terms of both the percentage of adults reported to have an account and access and use of the financial services. The largest differences are in debit and credit card ownership. This is mainly having something to do with the differences in banking sector activities between developed and developing countries.

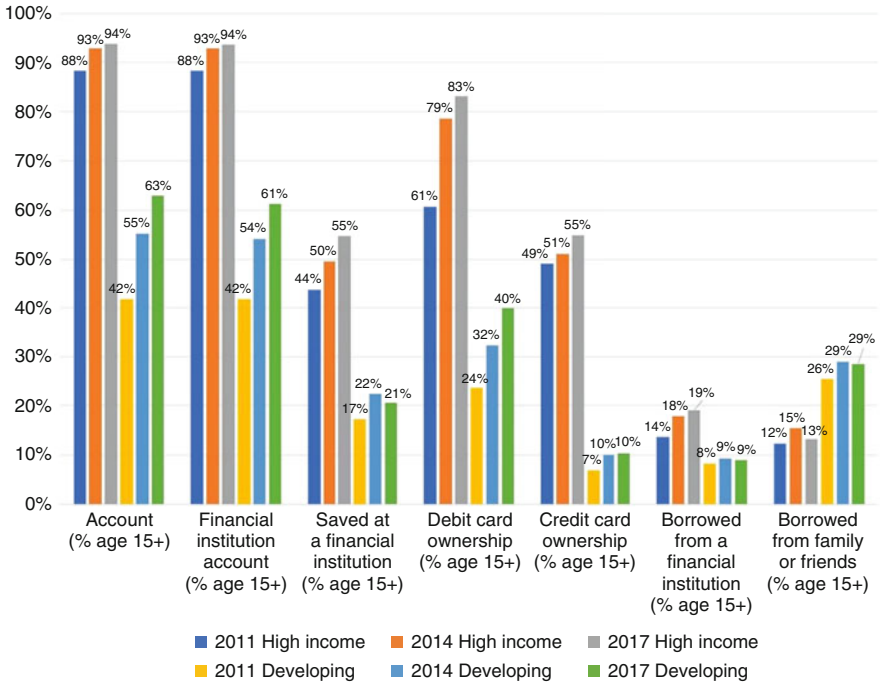

Fig. 2 Financial inclusion indicators: High income and developing countries. Source of data: World Bank (2017), made by author

Moreover, percentage of adult saved at financial institution is very low in less developed world comparing to that of developing countries. The low saving ratio in the less developed world is one of the major obstacles to achieve sustainable and inclusive growth in these countries. Also, absence of financial depth in these countries constrains the usefulness of the accounts, causing low use and high sluggishness. Thus, the increase in the level of financial inclusion will contribute to the future growth of these countries by increasing the saving ratio and access to sources of credit. There is also a significant gender gap in adults' accounts. Figure 3 shows these differences clearly.

These gender differences have been more apparent in low-income and developing countries. The portion of women who has a bank account is 9 percentage points less likely than that of men in developing countries in 2017. This is something to do with the women's role and participation in economic activities in these countries. Also, discriminatory policies against women in the less developed world play significant role in low ratio of women who has a bank account. The differences in adult with accounts can be also reflected in differences in educational attainment levels. Figure 4 shows these differences clearly.

According to Fig. 4, differences in adult accounts between primary education or less and secondary education or more have been decreasing in both developing and

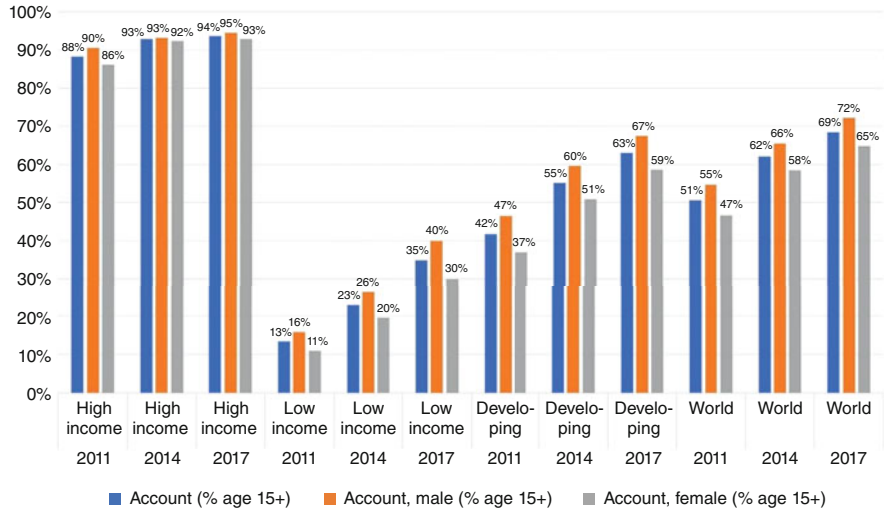

Fig. 3 Gender gap in accounts. Source of data: World Bank (2017), made by author

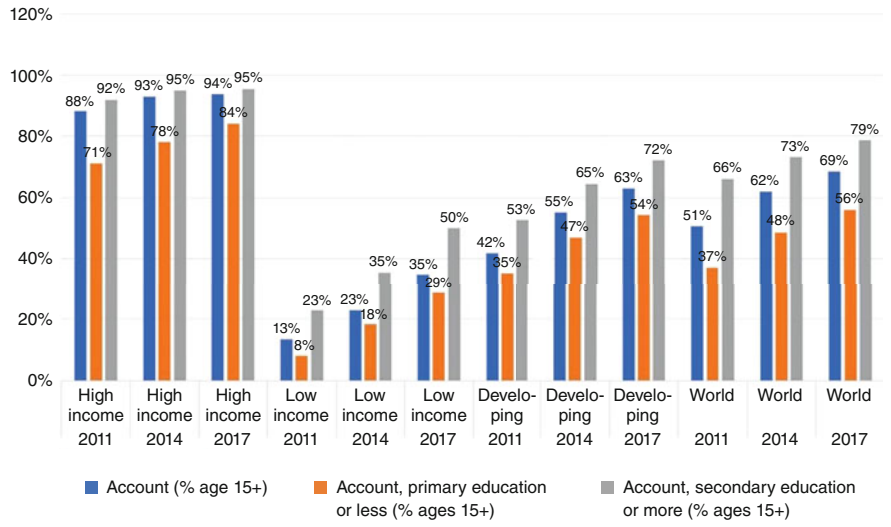

Fig. 4 Accounts across the education. Source of data: World Bank (2017), made by author

developed countries. However, portion of both educational attainment level in low-income countries and developing countries still far below that of developing countries. This is something that should be increased immediately putting excluded adults into included ones. The degree of financial inclusion in terms of adult accounts also significantly differs across level of income. Figure 5 illustrates this fact.

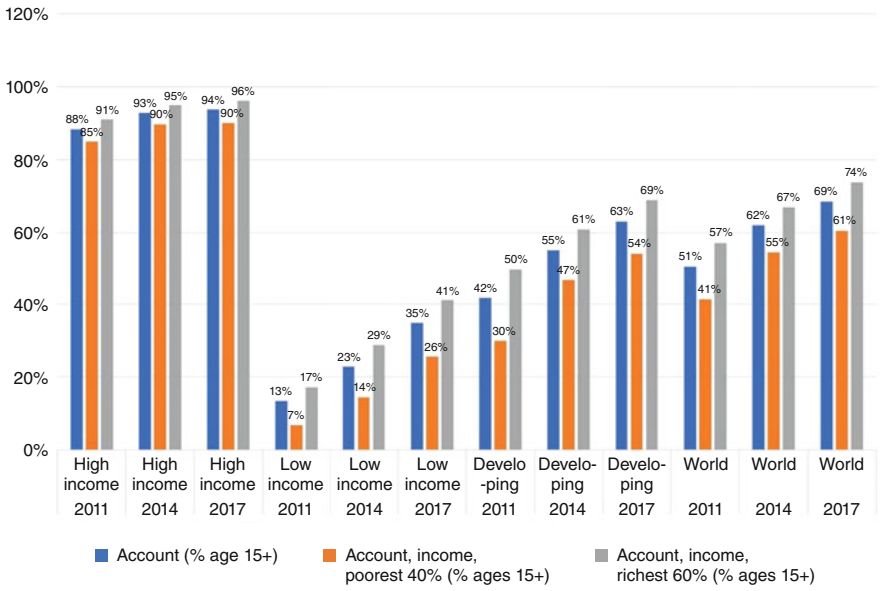

Fig. 5 Accounts and income differences. Source of data: World Bank (2017), made by author

For developed world, there is a minor gap between poorest and richest in terms of the percentage of adults reported to have account at a financial institution. But, same gap for developing and low-income countries are wider compared to developed world. This is the result of not only a less developed financial system in developing world but also unequal distribution of income. This result can be taken as a major argument for why increasing the level of financial inclusion along with developing financial system in less developed world will be a good policy choice to accelerate the growth and equally distribute the income.

We can also evaluate the developments in the financial inclusion all over the world by focusing on other indicators such as percentage of adults who made or received digital payments. For this purpose, we can examine the following three figures. Figure 6 shows portion of adults using the Internet to pay bills or to buy something online in the past year (% age 15+).

According to Fig. 6, use of Internet in developed world has been increasing so fast comparing the developing countries. This could be a result of the existence of Internet services and its accessibility. To increase the level of Internet use in the developing world, there is an urgent need for international cooperation led by international organizations such as the United Nations and World Bank. The way that how adults pay their utility bills is also different between developed and developing worlds (Fig. 7).

There are significant differences in the portion of adults who have paid bills in last year between developed and developing countries. These differences have become clearer when it comes to the way that adults pay their utility bills. Again, the results

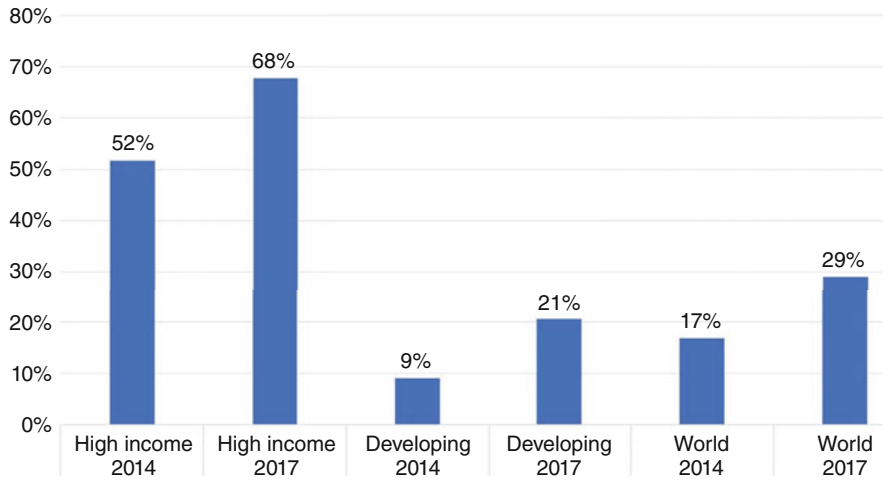

Fig. 6 The portion of adults using the Internet to pay bills or to buy something online in the past year (% age 15+). Source of data: World Bank (2017), made by author

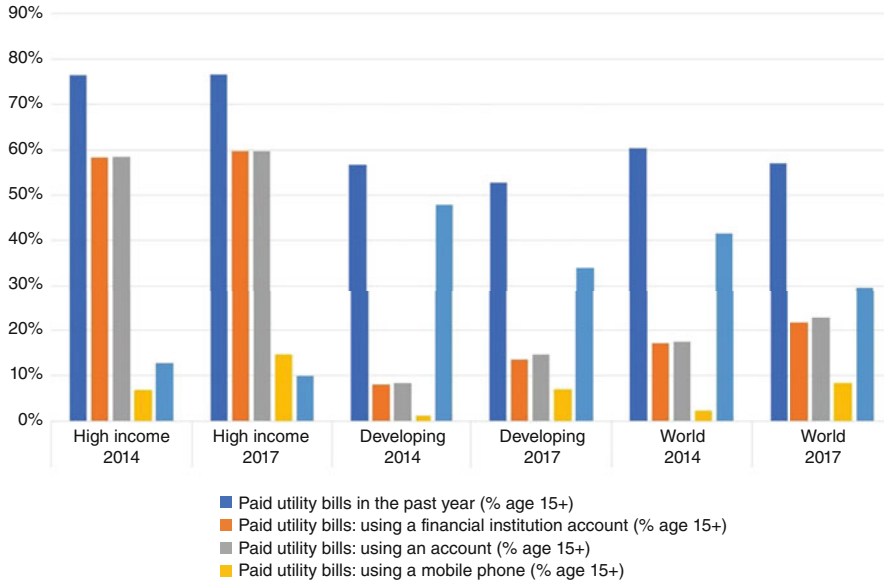

Fig. 7 Payments of utility bills. Source of data: World Bank (2017), made by author

reinforce the fact that developing world has real problem not only accessing the technology but also using it. The international community should focus more on this area. Obviously, this significant difference in the use of Internet among the countries is also reflected in the way that people are getting their wages. Figure 8 displays this fact.

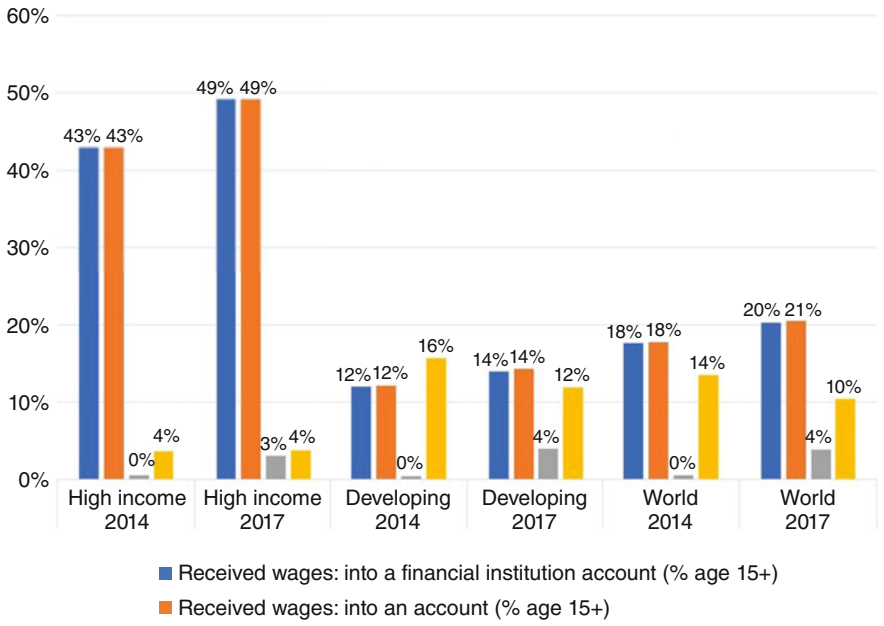

Fig. 8 Form of receiving wages. Source of data: World Bank (2017), made by author

Most of the adults in the developing world have been receiving their wages in ways that are more convenient compared to low ratio of adults in developing countries. 1.2 billion adults gained access to formal financial accounts for the first time between 2011 and 2017. Many of these are mobile money accounts. This fact also reinforces the fact that there is an urgent need to develop the financial system of developing countries so that more people can access its services, use it to make payments, and receive their wages. Otherwise, the goal of increasing financial inclusion, especially in developing countries could be just a dream. By assessing the state of financial inclusion across the world, we can develop appropriate strategies and policies to increase accessibility, use of quality of financial services, and support the financial inclusion goals of nations.

4 Literature Review

Financial inclusion means an adult population that has access to a wide range of financial products and services (savings, credit, insurance, transfer, means of payment, etc.), offered by various institutions (banks, NGOs, savings and credit cooperatives, other nonbanking financial institutions), in a competitive and appropriate environment (legal, legal, and political) guaranteeing efficiency and sustainability. According to the World Bank, the term “financial inclusion” refers to providing

access to financial services to "all." Morduch (1999) noted four dimensions of affordability: reliability, convenience, continuity, and flexibility. First, "reliability" relates to the availability of resources when they are needed. Next, "convenience" refers to the ease with which customers have access to financial services. "Continuity" refers to continuous or sustainable availability, i.e., accessibility repeatedly. Finally, "flexibility" refers to the fact that the product must be adapted to the real needs of the customers.

For many countries, financial inclusion is considered a major economic and social issue, because it makes it possible to fight against poverty, exclusion, and gender disparities and promotes the economic and social well-being of populations. Moreover, for these countries, it is a major priority and continues to grow in importance. Sarma (2008) understands financial inclusion as a process whose objective is to allow easy access, availability, and use of formal financial systems to all actors in an economy.

Soumare et al. (2016) in their study, which aims to identify and analyze the determinants of financial inclusion in Central and West Africa, showed that access to formal financing in these regions is mainly determined by gender, age, education, employment status, income, household size, area of residence, marital status, and degree of trust in financial institutions.

For Kanobe et al. (2017), there is no doubt that mobile phones have become an essential tool with the potential to promote financial inclusion. Chatterjee (2020) in his study showed that the development of information and communication technologies can be an important determinant of financial inclusion. Indeed, in the banking sector, the use of mobile phones and Internet penetration has increased. This study shows that financial inclusion individually or paired with mobile and Internet improves per capita growth.

The African continent has serious gaps and low levels of financial inclusion. In their study, Chinoda and Kwenda (2019) analyzed using a VAR model the importance of economic growth, mobile phones, stability, and banking competition for financial inclusion. It appears from their study that financial inclusion reacts significantly and positively to the various shocks of mobile phones, banking competition and banking stability, and economic growth. They add that while these variables are important for financial inclusion, the latter is also necessary for their effective functioning.

Nowadays, financial inclusion has been the subject of study on the possible link with economic growth. Finance has been recognized as an engine of economic growth and several researchers including Beck and Demirgüç-Kunt (2008), Jalilian and Kirkpatrick (2005) have established the direct and indirect links between finance and poverty reduction. Indeed, several studies have shown that financial inclusion is an important driver of economic growth (Claessens & Perotti, 2007). To do this, improvements in the financial services sector are usually accompanied by an efficient allocation of resources that leads to economic growth (Akinboade & Kinfack, 2014). Several studies including that of Cull et al. (2014) have proven the significant impact of access to and use of financial services on the lives of individuals and businesses, which will subsequently lead to the growth of savings, the increase in

productive investment, consumption, poverty reduction, and empowerment of women.

As Van et al. (2021), theoretically, financial inclusion is known to have a positive effect on economic growth. However, empirically, the evidence seems limited, especially for emerging markets. To provide a comprehensive overview of the relationship between financial inclusion and economic growth, they construct a multidimensional index to measure financial inclusion at the international level. They conclude that the relationship between economic growth and financial inclusion is positive and that for countries with low income and degree of financial inclusion, the relationship is stronger. Also on their side, Kim et al. (2018) while applying dynamic panel analysis, find that this positive relationship between financial inclusion and economic growth is also observable in the Organization of Islamic Cooperation countries. The study by Nizam et al. (2020) on the effect of financial inclusion on economic growth in 63 developing and developed countries between the years 2014 and 2017, revealed the existence of a threshold effect between these two entities. This implies that the positive relationship between financial inclusion and economic growth is non-monotonic.

Kim (2016) on the other hand looked at the question of how financial inclusion affects income inequality and economic growth across 40 member countries of the European Union (EU) and the Organization Economic Co-operation and Development (OECD). He found that financial inclusion improves the relationship between economic growth and income inequality, but also that the decline in income inequality due to financial inclusion helps move from a negative relationship between economic growth and income inequality into a positive relationship.

5 Modelling the Volatilities of Performance of Technology-Driven Financial Services Companies

To evaluate the volatility in the performance of developed markets' companies, which offer technology-driven financial services, we use the index that is formed to measure these companies' performance, called "The Indxx Global Fintech Thematic Index." The index's base date is on June 30, 2015, and its initial value is 1000. Currently, there are two indexes to track the performance of these companies. These are Net Total Return (Bloomberg Ticker: IFINXNT) and Total Return (Bloomberg Ticker: IFINX). In our analysis, we used the first index. Data are extracted from Indxx website (Indxx Global Fintech Thematic Index, 2022).

To obtain the volatility of the index, we estimate the ARCH/GARCH models, which include GARCH, EGARCH, PARCH, CGARCH, and FIGARCH. We start our analysis by visual inspection of the time series plots of both levels and the first difference of logarithmic values of IFINXNT. Figures 9 and 10 display them.

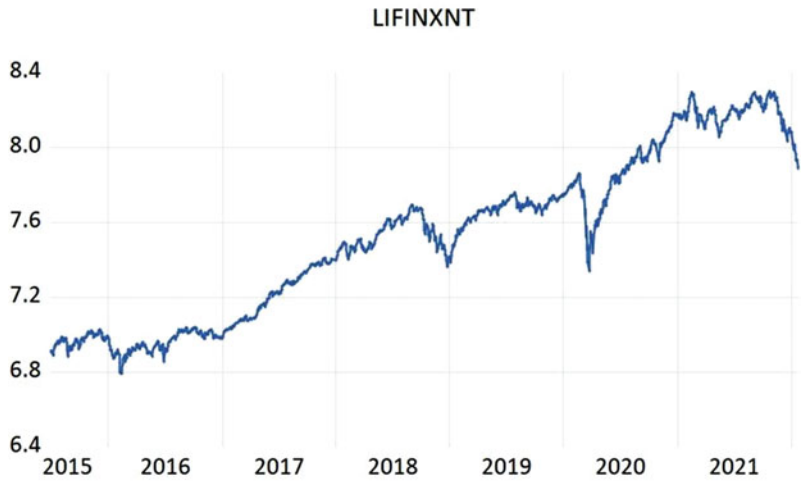

Fig. 9 Logarithmic values of IFINXNT. Source: Indxx Global Fintech Thematic Index 2022l; made by author

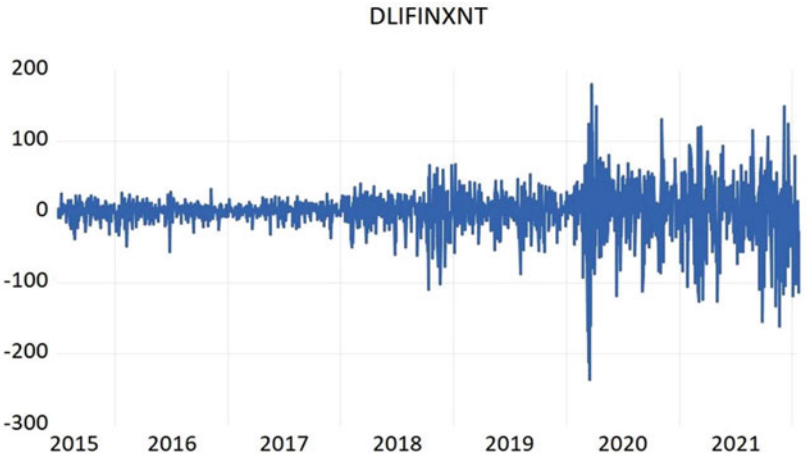

Fig. 10 First differences of logarithmic values of IFINXNT (DLIFINXNT). Source: Indxx Global Fintech Thematic Index 2022; made by author

As is seen clearly, in Fig. 9, there is an increasing trend in logarithmic values of IFINXNT with three major declines and the level of series is not stationary. On the other hand, first differences in series seem too stationary (Fig. 10).

Before estimating the ARCH/GARCH models, we need to determine the degree of the integration of the series. Four this purpose, we employ three traditional unit root tests of ADF, PP, and KPSS. In the first two tests, the null hypotheses state that

Table 1 The results of unit root tests

Variable	ADF		PP		KPSS	Decision	
LIFINXNT	Level	First Difference	Level	First Difference	Level	First Difference	
	−1.183	−12.60***	−1.205	−40.09***	5.032***	0.116	I(1)

Note. All *p-values* are 1% significance ***. Source: Author's calculation

Table 2 Estimation results of the GARCH models

	GARCH (1,1)	EGARCH (1,1)	PARCH (1,1)	CGARCH (1,1)	FIGARCH (1,1)
Mean equation					
C	1.302*** (0.3423)	1.207*** (0.340)	1.2408*** (0.3322)	1.497*** (0.341)	1.478*** (0.355)
Variance equation					
ω	2.183*** (0.649)	−0.109*** (0.019)	0.3034* (0.1617)	15170.96*** (5708.08)	16.144*** (4.430)
α	0.115*** (0.101)	0.236*** (0.022)	0.1279*** (0.0126)	0.0390*** (0.010)	0.096 (0.063)
β	0.893*** (0.008)	−0.035*** (0.011)	0.1359*** (0.0559)	0.1015*** (0.017)	0.426*** (0.099)
γ	–	0.989*** (0.002)	0.8968*** (0.0099)	0.8162*** (0.035)	–
Log likelihood	−7682.6	−7677.2	−7678.2	**−7672.4**	−7674.3

Note. Standard errors in parentheses. ***$p < 0.01$. *$p < 0.1$. Source: Author estimations

series are not stationary as opposed to stationary null hypothesis in KPSS test. Table 1 presents the results of these unit root tests.

Since all test results indicate that the series is first difference stationary, that is, they are I (1), we estimate all GARCH models by using the first difference of index. Table 2 shows the estimation results of t GARCH models.

Figure 11 shows the conditional volatilities of LIFINXNT.

From 2015 to the beginning of COVID-19 pandemic, there is low volatility in index. In the first wave of pandemic, there is a sharp increase in volatility and following months we have seen the high volatility to continue. This rise in volatility should be taken as a serious indication of rising uncertainties in the performance of developed markets' companies, which offer technology-driven financial services. Thus, since there is a significant increase in the volatilities in the performances of the companies, which offer technology-driven financial services, during the Covid-19 pandemic, the policy makers should take into consideration of this fact implementing policies designed to increase the financial inclusion.

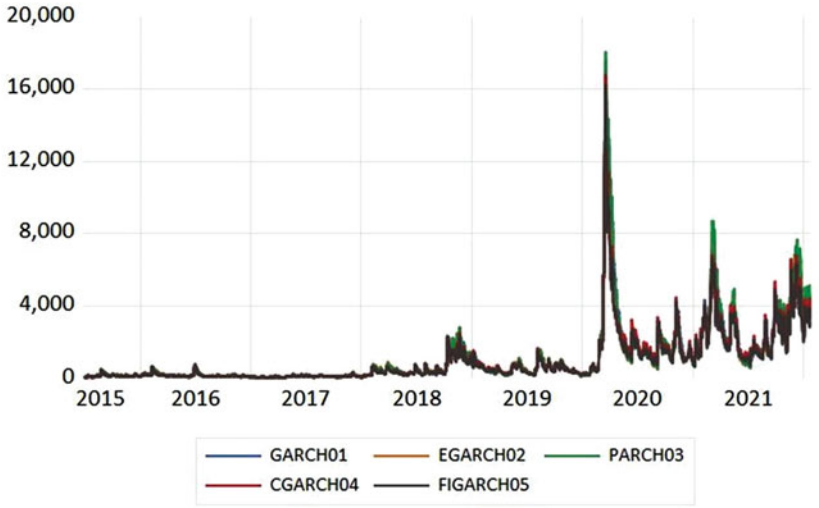

Fig. 11 The conditional volatilities. Source: Author's calculation

6 Conclusion

Since early 2000s, like the inclusive growth, financial inclusion has been one of the main issues being a top priority for policymakers, regulators, and international organizations. Despite this fact, there are billions of people around the globe who still are not able to access and use most of the financial services. However, the improvements made between 2011 and 2017 are remarkable.

We know that financial inclusion facilitates day-to-day living and helps households and companies to make plans for everything from long-term goals to unexpected emergencies. As accountholders, one can have the ability to use other financial services, such as savings, credit, and insurance, start and expand businesses, invest in education or health, manage risk, and weather financial shocks. Doing all these in a right way will help to contribute to improve the overall quality of everyone in the society.

To efficiently and inclusively implement the financial inclusion policies, understanding the meaning and scope of financial inclusion in accord with today's highly developed financial markets and services, is one of the key issues. This requires first an urgent need to broaden the definition of financial inclusion and the way we measure the financial inclusion. To do this, we need a clearly defined and accepted notion of the term. Then we should state the goals that are aimed to achieve by financial inclusion. Most importantly, we should develop appropriate measures for financial inclusion. For this purpose, we strongly suggest supporting of initiatives aiming to develop a comprehensive measure of financial inclusion. In this regard, we believe that more attention should be given to regional, country specific, and population vise differences in terms of use of traditional financial services and digital

financial services. In this context, rational approach towards financial inclusion should include the elements of emphasizing the importance of robust consumer protection frameworks and effective financial capability interventions. By adopting these kinds of strategies, we believe that we can address the opportunities and risks of digital finance and fintech in a most correct way.

Another issue related to financial inclusion is that it should be seen as an integral part of global initiative to reduce the worldwide inequalities across countries, genders, and across people who have a different ethnic and races. In other words, the policies designed to increase degree of financial inclusion should focus on policies that mainly aimed to decrease disparities that exist among the different countries, people from different educational, social, and economic backgrounds. In other words, financial inclusion policies should first ensure the financial inclusion of the poor and disadvantaged. Also, before developing the appropriate policies for each country, we have to take into account the fact that the reasons for financial exclusion may vary from country to country. Thus, we should avoid adopting one size fits all policies. It is extremely important to know the fact that financial inclusion is a building block for both poverty reduction and opportunities for economic growth. In addition, success of it will be increased with access to digital financial services, which is critical for joining the new digital economy. Therefore, to accelerate the process of financial inclusion, we have to increase the speed of both traditional financial inclusion and digital financial inclusion, paying more attention to digital financial inclusion. This can be efficiently done by adopting relevant national strategies and action plans based on the new digital models for achieving digital financial inclusion policy goals along with realization of effective coordination between policymakers, central banks, financial supervisors, relevant regulatory authorities, and market professionals with responsibilities related to digital financial services, including telecommunications, competition, and consumer protection agencies. Most importantly, we should eliminate the barriers preventing development and uptake of digital financial services as well as easier access and usage of the Internet and mobile devices.

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Innovation and Fintech

Dejan Erić

1 Introduction

This chapter is dedicated to the analysis of financial innovations primarily from the aspect of financial technology development (fintech). In the last two decades, the financial service industry has been strongly influenced by several groups of factors, of which the most prominent are: digital transformation, the emergence and development of fintech, and regulatory reforms and changes. A kind of fintech revolution can be discussed by exploring the scope, dynamics, and impact that financial technologies have on many areas of modern finance (Arner et al., 2015; Blakstad & Allen, 2018).

The financial services sector is one of the most dynamic economic sectors which has always had a large number of innovations. Financial institutions and participants in the financial system and markets have always been open to technological innovation. This is especially evident from the middle of the twentieth century and the introduction of the first computers. Computer and telecommunication technology has gained an increasing role in performing many financial tasks. As computer technology has improved in terms of hardware and software, new and growing innovations have taken place. Since the beginning of the 1990s, automation and digitalization of many financial operations have become more and more present. As a result, there is increased efficiency, expanded range of services, raised quality, reduction of many costs, etc. (Corrado & Hulten, 2010; Grinin & Grinin, 2020).

Technological developments and changes, which have intensified especially in the last 15 years, have also affected the changes in the structure of the financial services industry. New "players" have emerged, i.e., new types of financial service

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providers. Neobank (or Bank type 4.0.), Insurance 3.0. or 4.0, online brokers, cryptocurrencies exchanges, and other types of financial ecosystems have changed the world of financial institutions as it existed. Some authors even claim that fintech innovations have led to the overall growth of entrepreneurial initiatives and projects and contributed to a significant intensification of competition within the entire financial sector, which has led to changes in the financial structure (Berman et al., 2022). Regarding the development of fintech, some authors point out "*Among the hot research topics, fintech is leading the trend in terms of the newest technology applications"* (Moşteanu & Faccia, 2021).

Finally, it must be kept in mind that the financial sector is without a doubt one of the most regulated sectors of any economy (Mishra & Reshef, 2019; Jones & Knaack, 2019). In the period after the global crisis of 2008–2009, many big financial institutions faced huge losses. This fact, as well as growing regulatory requirements, have made their services inefficient and simply too expensive. The combination of the mentioned factors has contributed to the appearance of new "players" and changes in the financial structure. Also, there were changes in existing and introduction of new business models and working methods. All of the above have opened up a number of regulatory issues and challenges that have caused a number of regulatory changes (Philippon, 2016).

This chapter is organized into four basic sections. Section 1 examines, in brief, the history of the development of financial innovation. The close and unbreakable connection between the development of finance and innovation is emphasized. In Sect. 2. will be researched the world of modern finance, which is full of various innovations. There are different approaches and understandings about their classification. However, there is no doubt that financial innovation is one of the paradigms of modern finance and the financial services industry. Section 3 is devoted to analyses of emergence, growth, and development of the importance of financial technology. In Sect. 4, we are analyzing the areas of application of financial technologies in various segments of modern finance and prospects for future development. Finally, in Sect. 5, we are drawing basic conclusions.

1.1 A Brief History of the Development of Financial Innovation

Observed throughout history, there is a close intertwining of innovation and finance. There is almost no period in the development of money and finance in which there were no innovations. Their scope and dynamics were different. They were influenced by the general social and economic circumstances in the given epoch, as well as the level of general economic development. As the economic structure developed and as the financial system and financial markets within them developed, the level and diversity of innovations increased.

It can be freely said that the roots of innovation date back to the first written traces of modern civilization. They lead us to the area of Mesopotamian c. 3100 BC where records of business transactions on clay tablets are preserved. Some of them can be found in various museums today, such as the British Museum in London. Significant traces of the regulation of certain financial affairs in which there are elements of innovation can also be found in the famous Hammurabi Code (c. 1750 BC). This historical document is also preserved and is in the Louvre Museum in Paris. Among the 282 laws, some refer to the field of insurance, loan regulation, and other relations between debtors and creditors. In this document, not only certain novelties but also the foundations of certain financial operations regulations can be found (Gordon, 1965; Nagarajan, 2011).

Probably one of the biggest, almost revolutionary innovations in human civilization is related to the small state of Lydia, somewhere around 750–640 BC, where the first real fiat money was created. Instead of commodity money that existed until then and was widely used, the first coins appear and are regularly used, i.e., coins minted in gold and silver (Finley, 1973; Crown, 1996; Mundell, 2002). This innovation very quickly began to spread throughout the ancient world. The money was taken over by Greek cities-states (polises) and further perfected. It was similar in ancient Rome. Many other innovations are related to the ancient period, such as the emergence of the first bankers (*τραπεζίται*—trapezitai in Greece, argentarius in Rome), the emergence of the first forms of raising capital in a form reminiscent of today's actions, etc. (Goetzmann, 2016).

There were also financial innovations during the Middle Ages. One of the largest came to Europe around the 13th and 14th centuries from China. In this ancient country, a couple of centuries earlier, there was a further innovation in the development of fiat money, where in addition to metal, paper money was created (c. 900–1000 AC). The next important innovation took place in the cities of northern Italy, where the first modern banks were established—such as the Medici Bank around 1397 and The Bank of Saint George in 1472 (It. *Casa delle compere e dei banchi di San Giorgio*, Goetzmann, 2016, p. 289). The first securities of the type of bill of exchange, municipal, or government bonds were recorded in Venice, the so-called "prestitti"(Goetzmann, 2016). In that period, other great innovations emerged—the first stock exchanges (initially as commodity exchanges, and since the seventeenth century as financial markets), the development of double entry bookkeeping to record business and financial transactions (from the end of the fifteenth century). In the seventeenth century, bonds and stocks appeared widely as financial instruments for raising capital. At the end of the century, the first central banks appeared. The first was the Swedish Riksbank in 1668—*Sveriges Riksbank*), and the second Bank of England (1694).

This brief overview of some of the most important innovations in the history of money and finance is only an orientation overview that should illustrate the thesis of the close connection between finance and innovation. These processes intensified especially in the twentieth century, especially in the second half. With the growth of internationalization and globalization of the world economy, innovations have become even more dynamic and have become an integral part of modern finance

world. They have very often gone hand in hand with the processes of globalization, so there is a high level of convergence between these two processes. Hence, it can be stated that financial innovations, as well as globalization, have been a very important feature of the modern finance world for more than three decades (Erić et al., 2021).

Financial innovations have brought benefits to all participants in the world of modern finance. They have led to the expansion of the financial services market, improvement of processes and operations, raising quality, reducing costs, and many other benefits. Many of them are related to technical and technological improvements. Technological advances have had a powerful effect on accelerating financial innovation. At this point, it can be said that this trend will continue in the future. For example, almost half a century ago, two completely new financial instruments were introduced into stock exchange operations—financial futures and options. Today, they are an integral and indispensable part of the range of financial instruments used for hedging activities by many participants in financial markets. In doing so, their use is increased in used algorithmic programs for trading as well as artificial intelligence within fintech innovations.

2 Modern World of Finance—World of Innovation

Many factors have led to the fact that the modern world of finance can be treated as a world full of financial innovations. There are several explanations for the reasons and motives that contributed to the intensification of the process of creating financial innovations in the late 20th and early 21st centuries. Some of the most important are (Erić, 2003; Erić and Djukić 2012):

- Globalization of financial services—which has led to the breaking down of barriers between different countries and opened space for further geographical expansion of the business of many financial institutions. Today, no one has a "monopoly" on innovation. In the past, innovations mainly came from the most developed countries in the world, by the largest and strongest financial institutions. However, with the development of decentralized finance (DeFi), these trends are changing (Zetzsche et al., 2020). Of course, the big "players" still have a dominant role and can dictate trends, but more and more innovations come from the once less developed so-called emerging markets (Shan 2015).
- Increasing levels of uncertainty and instability in the economic systems of many countries. This factor has been particularly present since the early 1970s when the gold standard was abandoned and the transition from fixed to fluctuating exchange rates took place. In that period of intensified monetary shocks, there was a trend of rising inflation in many developed countries, which affirmed the need for increased protection against two types of risks—exchange rate and inflation. This constellation of factors is a condition of innovation in hedging business through the emergence of new financial instruments—derivatives, above all options, futures and swaps. This factor is closely related to the growth of

international competition in the financial services industry, which was further intensified by the dynamization of globalization. Occasional financial crises, such as the 1997 Asian crisis or Russia's public debt crisis a year later, and even the early twenty-first-century crisis in the USA (after the big corporate scandals and especially the September 9/11) and finally the global crisis of 2008–2009 have definitely shown that high level of uncertainty in global financial markets, high volatility and occasional instability in the financial and real sectors of the economy have become an integral part of the business decisions of financial and business people. What about the outbreak of the global COVID-19 pandemic and its impact on increasing uncertainty and instability in the financial services sector?

- Technical–technological innovations—especially in the field of development of computers, mobile, and smart phones and devices, other information technologies, telecommunication equipment, and accompanying systems.
- Regulatory reforms—which from the 1980s until the global crisis of 2008–2009 went in the direction of deregulation of financial systems (Moosa, 2015). In this way, the competition between financial institutions was strengthened, which were stimulated to use the appropriate regulatory freedom in order to create new and innovative, primarily financial products. Since the global crisis, there has been a new trend—increased regulation (Girasa, 2013). Other trends, primarily related to globalization and the risks that come with the development of financial technology with all the challenges that accompany it, have imposed the need for regulatory review, reform, and rapid and proactive response. One of the proofs that a lot is being innovated in this field is the influence of technology in this area, which is popularly called *regultech* (Barberis et al., 2019).
- Increase in the level of knowledge, expertise, education, and development of science. In the past, finance was mostly done by economists or lawyers. Today, the world of finance requires interdisciplinary teams of experts from different disciplines. The development of quantitative methods, new ways of processing, storing, and analyzing data have led to the fact that the world can no longer be imagined without quantitative finance. Psychology and analysis of the individual participants' behavior led to the development of behavioral finance.

The development of financial innovations has moved in several directions, of which we emphasize the following:

I. Innovations aimed at adapting to the new market requirements—the essence of which is to better meet the needs of all participants in financial operations. For example, only in the field of banking in the mid-1980s Bank for international settlement (BIS) identified several types of innovations from this group (Bank for International Settlements, 1986): innovations in the field of price risk transfer, instruments for credit risk transfer (especially default risk), innovations to increase liquidity, to improve lending, to obtain new and additional share capital.

   Most of the innovations from this group at the end of the 20th and the beginning of the twenty-first century went in the direction of satisfying the

specific requirements of participants in financial affairs. Such as, for example, the need for hedging, which has led to the emergence of financial futures, options, credit default swaps (CDS), etc. Some were an expression of the need for financial institutions to expand the range of investment opportunities, such as exchange trade funds (ETFs) or alternative ways to raise capital in the form of initial coin offers (ICOs), securitized token offers (STOs), or special purpose acquisition companies (SPAC), etc.

II. Innovations are the result of development and increasing application of quantitative methods in finance. Modern finance is definitely a multidisciplinary field in which, in addition to possessing knowledge in the fields of economics, business, finance and law, mathematicians, statisticians, econometricians, IT and telecommunications experts, etc. are increasingly involved and whose background is in mathematics or physics. Innovations in this area have led to the emergence of structured finance products and securitization processes. Securitization itself has contributed to the expansion of the offer of new forms of financial assets in the form of mortgage backed securities (MBS) and assets backed securities (ABS). Thus, for example, the creation of one of the most famous MBS—collateralized debt obligations (CDOs) is a direct consequence of the popularization and development of copula techniques, which has significantly improved the analysis of returns and risks and helped create tranches for CDOs (Kolman, 2017).

   This type of innovation has found great application in the field of stock exchange trading, where the programming and application of quantitative methods have been applied in the definition of algorithmic, programmed, and high frequency trading (HFT). These may include flash order or flash trading (Harris & Namvar, 2016). Innovations also took place in the improvement of trading places, which became electronic trading networks (ETN), which later led to the development of alternative trading facilities, multilateral trading facilities, etc.

III. Innovations aimed at avoiding regulatory and tax burdens. It has already been pointed out that modern finance is one of the most regulated economic areas (Erić et al., 2021). Regulatory requirements often represented a kind of "burden" for individual participants, which meant the process of "moving" capital and financial affairs to countries in lower demand. It is similar to activities aimed at avoiding or reducing tax obligations. Some of the typical innovations that could be included in this group are, for example, the creation of Total Return Swaps (TRS), which enabled the conversion of dividends into capital gains. (Lou, 2018), in cases where the tax rate is lower. In the USA, dollar accounts located in off-shore zones (so-called eurodollars) or NOW accounts are sometimes included in this group (Errico & Musalem, 1999).

In addition to the above, there are slightly different ways in which financial innovations can be shared. For example, some authors are grouped into two large groups (Ross, 1989; Erić, 2003; Erić et al., 2021) as follows: A). Emergence of new financial products—primarily new financial instruments (structured financial

products, junk bonds, strips, medium term notes (MTN), securities arising from the securitization process, combinations of different financial products, new financial derivatives—credit default swap–CDS (Vuković et al., 2022), contracts for difference—CFD, binomial options, ...), etc. B). Emergence of new strategies—created based on the use of new instruments.

Financial innovation has led to increased interest and easier access to many financial "products" and services for a wider range of participants. At the same time, some of them have made it possible to reduce costs and create new opportunities for managing funds on the one hand and collecting them on the other. However, what followed at the end of the first decade of the twenty-first century and in the years after that definitely introduces the world of finance into a new dimension.

3 Emergence and Growth of the Financial Technology (Fintech) Significance

In recent times, changes that are happening in the modern economy have become a very attractive topic for research and analysis. This is very popular using the analogy that exists in the development of the industrial revolution (Moore, 2002) from 1.0. to 4.0. (Covidino et al., 2019). Some authors use the same terminology to describe the stages in the development of the use of technology in the field of finance (Arner et al., 2015). According to these authors, there are three phases in the development of technology in finance, from 1.0. to 3.0.:

- The roots (beginnings) of the introduction of technology in the field of finance, today the mentioned authors (Arner et al., 2015) call it phase 1.0.—represents the period in which the mass use of telegraphs began, especially after the laying of cables on the bottom of the Atlantic Ocean (sometime around 1860) and lasted until the mass use of computers and programming in finance (around 1987). This phase includes, in addition to the telegraph, the introduction and use of telephones for communication, as well as computers (mid-twentieth century). More about this will be elaborated below.
- Phase 2.0.—refers to the period from 1987 to 2008—marked by a significant rising in the use of computers and the increasing digitalization of financial services and processes. The phase ended with the outbreak of the global financial crisis and the problems faced by many financial institutions, as well as investors.
- Phase 3.0.—from the crisis of 2008—until 2015–2016, when many technological innovations appeared, which led to the affirmation of financial technology. Fintech first began to develop in the field of payments, but very soon, the emergence of blockchain, cryptocurrency, began to spread to many other areas of banking, insurance, and later the entire financial services industry. It is especially important for this phase that many innovations come from the developed and developing world.

In addition to the mentioned three phases from the cited paper (Arner et al., 2015), we could be added phase 4.0 as well (Erić et al., 2021):

Phase 4.0.—which started in 2015–6 and has been going on today. It is expected to be present in the next few years. It is closely linked to the further development of the fintech industry, the huge affirmation of machine learning, artificial intelligence, etc. All this combined with the new opportunities offered by the latest Internet generation through the 5G network creates ample space for further innovation in fintech.

Analyzed throughout history, there is a close connection between the development of technology and finance. In the opinion of the author, four major innovations have had a particular impact on the development of the financial services sector. They are important for many other areas of human civilization, but they will be looked at primarily from the perspective of their contribution to the development of finance. These are: telegraph, telephone, computers, and the Internet.

One of the first major technological innovations in the field of telecommunications that quickly found application in the field of sales and information transfer was the telegraph. It is considered that a baron Pavel Lvovitch Schilling (1786–1837) invented the modern telegraph in 1832, but the first commercial electric telegraph was developed by the company Cook and Wheatstone in 1837. A few years later Samuel Finley Breese Morse (1791–1872) developed a specific system of encoding and decoding messages into electronic impulses and vice versa, which was named after him the Morse code. In order for the telegraph to function, it required the expansion of the network, which led to the development of telegraph companies. As their number increased, as a technological superior innovation of its time in the field of communications, the telegraph quickly found application in the field of stock exchange and banking. Around the 1860s, a telegraph cable was laid between the United Kingdom and the United States. An additional impetus to the development of the use of telegraph technology was brought by the invention of the stock ticker. This ingenious invention that is still used today to mark the tick symbols of many companies and prices (but through digital technology) is believed to be named after Edward A. Calahan (1838–1912) who found it in 1867 (Pratt, 1921; Sobel, 1977). This has led to a significant increase in communications and benefited not only business people in the field of finance, but also much wider to all economic and social sectors. In combination with the telegraph cable at the bottom of the Atlantic, financial institutions and investors from the UK and the USA have especially benefited. For the mentioned reason, that period is taken as phase 1.0. in the development of financial technologies, and it must be pointed out that this term will officially appear only in about 130 years.

The second extremely important technological innovation that found its use in the field of finance only a few months after its discovery was the telephone. Although several innovators worked on the invention of the telephone and its technical improvements, it is believed that Alexander Graham Bell (1847–1922) first patented this device in 1876. In the initial stages of implementation, there were a lot of technical problems and limitations due to the imperfections of the devices and the

network. However, the advent of the telephone was a major step forward in the development of communication in many areas of human activity, and of course finance. Just 2 years after the patent, the phone found its application in broker communication on the New York Stock Exchange—NYSE (Erić et al., 2021). Over time, the devices themselves improved and the network expanded. Telephone companies have improved their services and communication has become more efficient and cost-effective. How important this technological innovation is even today for the modern world of finance and fintech is shown only by the fact that the sales of modern versions of this device in the form of mobile and smart phones are growing.

The third extremely significant technological innovation that has crucially influenced the further development of the application of technology in the field of finance in history is the invention of computers. Today, there is almost general agreement that the invention of the analytical engine by the British inventor, mathematician, and businessman Charles Babbage (1791–1871) around 1832 was the forerunner of modern computers. Although his business venture experienced great business and financial failure during the discovery period, we can be grateful to Babbige for many of the principles on which modern computers operate. It took almost a century for the first computers to appear. They have been used since the middle of the twentieth century. In the initial stages, computers were used as electronic devices mainly for data processing according to strictly defined procedures and protocols. Over time, both hardware and software components improved, so that the field of application of computers expanded. Until the end of the 1970s, large and bulky computers dominated, and after that another innovation appeared—personal computer (PC). Everything after that is a history that is still going on and experiencing great changes, which we are also witnessing.

Finally, another technological innovation that has dramatically changed the whole world, and accordingly the field of finance, is the emergence of the Internet. Although the roots of the interconnection of computers into a single network date back to the late 1960s in the military field, it was not until the mid-1990s that the world wide web (www) developed, almost synonymous with the Internet today. The Internet is a kind of civilization that has changed the world. The life and work of billions of people on the planet earth today is almost unthinkable without access to the Internet and social networks. In the field of finance, the Internet has been used almost from the very beginning, with a growing number of possible uses from year to year. This tendency has especially been pronounced in the last 15 years, due to a strong development of financial technology (fintech). It is almost impossible to imagine the development of fintech without the Internet. Today, there is almost no financial instrument without any adequate information online or which cannot be traded through any of the online trading platforms. Electronic—E-trading, E or M banking, insurance, and investments are an integral part of the daily life of not only financial experts but almost all modern businesses and ordinary people.

Financial technology has also appeared in the constellation of the growth in the number and volume of financial innovations on the one hand and technological progress on the other. It is believed that John S. Reed (1939–), at that time Chairman

of Citicorp. (today City) was the first to use that term in 1990. Within certain innovations and realization of certain technological development projects that the bank realized at that time, Mr. Reed combined two terms—1. Finance (Fin) and 2. Technology (Tech). This is how the term FinTech was officially born (Hochstein, 2015; Magnuson, 2018). Some authors point out that "*FinTech today is often seen as a uniquely recent marriage of financial services and information technology*" (Arner et al., 2015). It is closely connected with the technological development and application of technology in the field of finance, which led to the emergence of digitalization, i.e., digital transformations.

Digitization in finance has been present since the last decade of the twentieth century (previously mentioned phase 2.0). It can be most simply explained as the process of integrating digital technologies into all areas of financial business (Erić et al., 2021). Some authors point out that these processes involve five key pillars that need to be properly understood (Scardovi, 2017):

1. Advanced data and information management.
2. Applied analytics through machine learning and artificial intelligence (AI).
3. New approaches to doing business that are richer and with more opportunities for adding value.
4. New business solutions that take into account the interests of a wider range of interested stakeholders (so-called multi-stakeholder approach).
5. Trust, i.e., maintaining a good reputation in conditions of high levels of uncertainty, cyber risks, threats to loss of privacy, and a number of other threats. Regarding this element, one of the most important issues with digitalization and fintech as innovation is the question of believing in something that is intangible, digital, often unregulated or insufficiently regulated, and hidden behind an unknown dot.com digital institution.

Fintech was a step further in the process of digitizing financial services. This innovation has accelerated the processes of digital transformation and brought benefits to many participants in economic and social life, from users of financial services, individuals, consumers, SMEs to large financial institutions and companies. FinTech quickly found application in the areas of payments and payment systems, banking, insurance (InsurTech), the emergence of blockchain and cryptocurrencies, investment fund business, new ways of raising capital, improving brokerage business, etc. The range of services offered by fintech companies spread rapidly, so that today there is almost no area where fintech is not present.

According to the Oxford Dictionary fintech is defined as "*computer programs and other technology used to support or enable banking and financial services*."[1] The first modern fintech companies appeared during and immediately after the global financial crisis of 2008–2009. The key reason for their appearance is the fact that in that period many large and well-known financial institutions (above all banks, insurance companies, etc.) faced large financial losses and the danger of

[1] www.oxfordlearnersdictionaries.com/defnition/english/fntec

bankruptcy. Fintech has led to the emergence of a number of new companies that specialize in providing financial services through technologically advanced online platforms. They offered their services using modern IT and telecommunication technology and devices (computers, tablets, mobile and smart phones, watches, etc.). Thus, they began to offer completely new approaches to the provision of financial services and business models for the functioning of financial institutions. This led some researchers to state that fintech began to "transform certain niches and market segments of business in the financial services sector, after which it quickly expanded into other segments of the entire industry" (Arjunwadkar, 2018).

It is a kind of paradox that fintech was not received too well and with great enthusiasm in the beginning. Rather, it could be said that some of the innovations were met with considerable skepticism among investors and the financial community. The first companies in this field were relatively small. They usually came from the IT sector and had all the hallmarks of entrepreneurial start-up projects. However, after several very successful innovations, investors became very interested in investing in many fintech companies. Although the first companies originated in the United States, the expansion of fintech quickly spread around the world. After a couple of years, very successful and large companies appeared that did not come from Western countries, but also from other parts of the world, such as China, Russia, India, the Far East, South America, and even Africa (Arner et al., 2015, Shan, 2015).

Today, fintech is treated as one of the most attractive and promising economic sectors. Many countries have recognized the potential of the fintech industry and have begun to attract and support the development of these companies. According to some authors, the factors that particularly favored the development of fintech are: government support for development, developed culture of innovation, easy access to service users, a large number of talented young people with creative ideas, flexible regulations, etc. Taking into account these factors fintech mentions London, New York, Singapore, Hong Kong, Shanghai, Silicon Valley (with its center in Palo Alto near San Francisco USA), etc. (Rubini, 2019).

Data and facts are the best evidence of the growing importance and economic strength of the fintech industry. At this point, it must be emphasized that it is not always easy to get reliable data on this industry, so the following data should be accepted with a significant dose of reserve, more as indicators that prove the thesis of the growing role of the fintech sector. Some of the data are as follows:

- The value of the global fintech market in 2020 was estimated at around 6000 billion euros with a prediction of further rising.
- The number of user services in the fintech industry is constantly growing. Back in 2017, that number exceeded 2 billion users. During 2020–1, it exceeded the figure of 3 billion, and it is expected that by 2025 there will be almost five million users.[2]

[2] www.home.kpmg/xx/en/home/insights/2022/01/top-fintech-trends-in-h2-2021.html

- Growth in turnover—only in the largest segment of the fintech industry—digital payments—total value of transaction exceeded 7000 billion euros in 2021 (www.statista.com).
- The increase in investments in fintech companies has been growing steadily from 2010 to 2019, when the level of 200 billion euros was exceeded. This growing trend was halted during the pandemic 2020, when they fell by about 40% to about 120 billion euros, and from 2021 there will be another increase in investment in this industry worldwide (www.statista.com).
- Increasing the number of fintech new startups—for example, only in November 2021 the number was higher than 25,000 (in the USA about 10,730 and the rest of the world about 15,000). In comparison, during 2018 there were a total of about 12,000 fintech startups (about 5600 in the USA and the rest in the other countries all over the world.[3]
- Overall fintech sector revenue worldwide in 2017 was 80, in 2018—92 billion euros and is expected to grow to over 150 billion in 2022 (www.statista.com).

In addition to the above, there is an increase in funding in fintech (over 100 billion euros just in 2020, Erić et al., 2021). Not only is there an increase in the number of fintech companies and the volume of investments in the entire fintech industry, the circle of investors is also expanding. There are changes in the methods and structure of financing of these companies, which indicates that the industry is entering a more mature phase of development. For start-up companies, classic financing methods of small and medium-sized enterprises (SMEs) such as venture capital (VC), business angels or private equity still dominate. In addition, there is a growing presence of alternative ways of financing through tokens—initial coin offers (ICO) and securitized token offers (STO), or crowdfunding, special purpose acquisitions companies (SPAC), etc. Finally, a part of the companies that matures and becomes bigger decides to go public through the processes of initial public offer (IPO).

There are still no reliable data for many segments of these activities, which makes research and drawing conclusions somewhat difficult. Many companies are not public and have no obligation to disclosure their financial statements and data. Hence, many of the data presented here must be taken with a certain amount of reserve. In addition, many fintech companies come from less developed countries, where some areas of their business are still not fully regulated and where there is even less reliable public information. All this makes it difficult to accurately identify key performance indicators (KPIs), especially for some newer business segments such as alternative lending, asset management, or robo analytics or robo-advising. However, despite the mentioned limitations, there is no doubt that the fintech industry is growing year by year according to many observed parameters.

[3] www.statista.com/statistics/893954/number-fintech-startups-by-region

4 Financial Technology Application

Financial technology is a rather broad term that encompasses a new trend in the financial services industry that is associated with the increasing use of modern information and telecommunications equipment. Fintech leads to many changes in the work of financial institutions. It is a specific type of innovation that improves and automates many processes through the creation of appropriate software and algorithms that make it easier for users and providers of financial services to perform many financial tasks and contribute to reducing time and costs (Moşteanu & Faccia, 2021).

Many segments of financial business have undergone major changes and innovations under the influence of fintech development. Some of the most important areas of application of fintech are the following:

- Electronic payments.
- Banking.
- Insurance.
- Electronic trading places (platforms) for trading of financial instruments.
- Loans.
- Personal finance.
- Venture capital.
- Assets and wealth management.
- Cryptocurrencies and tokens and coins exchanges.
- Financial analysis.
- Financial and investment advising, etc.

The mentioned list of areas of application of fintech can by no means be considered final. For example, fintech applications, cyber security, credit rating and reporting, financial data provisioning, robot-advisor, process automation, and crowdfunding online platforms, and many other areas of application are not included here (Utzerath & Fernández, 2017). It is very difficult to find an area or segment within the financial services industry where fintech has not found its application.

One of the first areas where fintech development began was the infrastructure for electronic payment and processing of transactions. This is a segment in which young and innovative fintech companies initially offered quality solutions for faster, more efficient, and cheaper payment services. Companies that specialize in money transfer and remittances could also be included in this group. Today, very well-known and large fintech companies such as Square, Ant Financial, Revolut, Stripe, TransferWise, PayPal, Venmo, and many others started from this segment. Some of the most famous fintech companies in this field at the end of 2021 are: Clover Network, SpotOn, Billd, Checkout.com, BillGO, Bigcommerce, Affinipay, Circle, Remitly, the already mentioned Stripe, Braintree, Aeropay, DailyPay, Bolt, PayPal, Ripple, Affirm, etc.

Fintech has significantly influenced the field of banking. The application of information technology in banking has a long tradition, since the appearance of

the first computers and their mass use. As we have seen, the term fintech itself originates in the field of banking. The impact of fintech on banking is multiple. First of all, banks had to react to the growing competition in the field of payment operations by changing their approaches and business systems. Many processes have been automated, and the concepts of electronic (E) and mobile (M) banking have been created. Banks have expanded the range of services from traditional banking operations to online and electronic banking services. This is how 3.0 and 4.0 type banks appeared (King 2019). The development of fintech companies in the field of banking has also had an impact on changes in the banking structure. New small online banks have appeared - bank 4.0. type or neo-banks that have begun to take part in the market share of large banks. That is why they were called "challenging banks." Some of them are, for example, Chime, N26, Monzo, etc. Almost all banks had to react to new technological challenges, changes in processes, the emergence of new and increasingly aggressive and dangerous competition through transformation, restructuring, and acceptance of many fintech innovations.

In parallel with the changes in the field of banking, fintech has brought the development of alternative lending marketplaces. Many companies such as Prosper, LendingClub, OnDeck, Suning Finance, Lufax, ... have started to provide credit approval services, which has led to increased competition in this segment of the financial services offer. If we add online business loan providers such as Lendio, Kabbage, ... we can conclude that the range of services is even more expanded. Finally, specialized fintech companies for mortgage lending have emerged, such as through LendingHome, Better Mortgage, etc.

Fintech has made great changes in the field of insurance. Today, there is more and more talk about Insurance 3.0. or 4.0. (Nicoletti, 2021). It has even established itself as a special term insurance technology (InsurTech) as a kind of subtype of fintech. Innovations in the field of insurance have led to modernize and simplify the insurance industry. Numerous insurtech companies have emerged such as Lemonade, Oscar, Fabric, Bought by Many, Slice Labs, Shift Technology, Cuvva, Steppie, Knip, Insly, Insoore, Inube, and many others. Similar to banking, the emergence of insurtech companies represented a kind of disruption of the insurance industry. Many large and well-known insurance companies have been forced to make major strategic, organizational and technical-technological changes in order to withstand very fast-growing and aggressive competition. All mentioned developments very quickly led to the transformation of the insurance industry from concept from 3.0. to 4.0.

Another important area where fintech has found its application is the area of financial intermediation, i.e., mediation in financial markets. Stock exchanges and over the counter (curb) markets have functioned appropriately for almost centuries, with clearly defined rules and a mechanism of specialized intermediaries in the form of brokers and dealers. Since the early 1970s and the development of Nasdaq, the importance of electronic trading network (ETN) and alternative trading platforms (ATP) has been growing. However, with the advent of fintech companies in this area, the very essence of stockbroking is changing. There is an evolution of financial markets, which some authors also compare with the analogy of 1.0. to 4.0., using the symbol X.0. (in which X symbolizes the dynamism of big and fast changes that are

happening in the financial markets, Erić et al., 2021). Some of the most important fintech companies that have innovated the field of financial intermediation to turn it into an online system in the form of stock trading apps are: Robinhood, TD Ameritrade, Schwab, WeBull, eToro, E-Trade, River Financial, etc.

All the areas analyzed so far in which fintech has been developed are extremely important, but these are more or less classic jobs within the financial services industry (of course, which have started to function in a different way). However, the area in which fintech has brought complete innovation is cryptocurrencies and digital cash. It is one of the most attractive and innovative areas in the field of modern finance, which causes great dilemmas and even controversies. The emergence of electronic money as an alternative to fiat money (coins, paper money) has its roots in the 80s of the twentieth century. It is believed that the first form of electronic money can be linked to 1983, when the American computer expert David Chaum developed an innovation called Ecash as part of the research for his doctoral dissertation. However, it took him almost 12 years for him to practically implement it in 1995. It happened within the company DigiCash, which used it for a micro payment system for the needs of a bank based in St. Louis (USA). The system was used for only 2 years and then withdrawn. At the end of the twentieth century, the development of electronic money was introduced almost simultaneously in several major world banks, such as Credit Suisse, Deutsche Bank, Bank Austria, Posten AB (Sweden), etc. Electronic payments and the first forms of electronic money existed before the fintech revolution. However, it is only with the development of blockchain technology that cryptocurrencies appear, which are experiencing a boom very quickly. The invention of the first cryptocurrency is related to the name of Satoshi Nakamoto, a person whose identity is still unknown, who created a currency known as Bitcoin based on the application of blockchain protocols and appropriate cryptography. Later, a large number of other cryptocurrencies emerged, the most famous of which are Ether (or Ethereum), XRP (Ripple), Tether, Litecoin, and many others.

In terms of technology, blockchain is a new and revolutionary data recording system that makes changes, intrusions, and frauds difficult. An essential blockchain is a digital general ledger of transactions that is copied and distributed throughout a network of computer systems. Each block in the chain contains a certain number of transactions and each new transaction in the chain is recorded and added verified on the general ledger of each participant. As a decentralized database managed by participants, Blockchain is often referred to as distributed ledger technology (DTL). The technology involves electronic recording and signing of each transaction with a fixed cryptographic signature (called hash). The identity of the participants is unknown and often only pseudonyms are listed in the database. Any attempt to break into the base or changes would be visible within each block. If hackers were to try to compromise the system they would have to change every block in the chain across the entire network. All these innovations have led to the development of so-called decentralized finance—DeFi (Bitcome, 2020; Zetzsche et al., 2020). There are very different technological solutions for the development of blockchain and the technology itself is becoming more and more popular in many areas. In addition to the

field of finance, it is increasingly used in the fields of real estate, medicine, R&D, public administration, scientific research, even foreign aid (Blakstad & Allen, 2018), etc.

Blockchain brings a lot of benefits. The biggest benefits come from enabling improved data security and increasing the speed of data. As a significant innovation that is still in development, blockchain in some cases is still a gray area for many businesses. The very fact that the identities of many participants are not known can serve as a basis for suspicion, especially in the area of finance where publicity and transparency are insisted upon. There is a lot of evidence of manipulation, especially in the area of cryptocurrencies related to money laundering. In addition, some cryptocurrencies that were based on the blockchain were pure fraud (a typical example of One Coin), which leaves a big mark on the issue of trust and reinforces the arguments of critics. Many countries have been forced to strengthen regulation and define clear rules for their implementation and development. There are a lot of open questions and challenges regarding the future of this innovative technology.

The advent of cryptocurrency represents a major innovation in the world of finance. Their key feature is that they are still not issued by central banks, but by a decentralized network of "miners." Therefore, they are beyond the control of governments and central banks, which carries a significant dose of risk and skepticism among financial experts. Unlike fiat money, where payment intermediaries are necessary, this is not necessary when using cryptocurrencies. Therefore, the costs of executing transactions are significantly lower compared to payment by payment card or other forms. The execution of money transactions may be stopped by the bank, central bank, recipient bank, or a third party. With cryptocurrencies, the user has full control over the execution of transactions.

Cryptocurrencies as a fintech innovation are still causing great controversy. On the one hand, cryptocurrency enthusiasts glorify this innovation. According to them fiat money in the form of coins, paper money is a thing of the past, i.e., their days are numbered. On the other hand, a large group of economists is still quite reticent and even skeptical about this innovation. The fact is, whatever it is called—electronic, virtual, digital, cryptocurrencies mones already exist. And not just in one form, e.g., Bitcoin. There are hundreds of digital currencies traded on crypto exchanges. The fact is that the number of users of cryptocurrencies, i.e., people who have open "wallets" is growing from year to year. There are big problems with accurate data, but it is assumed that in 2017 there were about 18 million, in 2018 about 35, and at the end of 2021 even over 220 million users.[4] Also, in the middle of 2021, El Salvador became the first country in the world to accept Bitcoin as a legal tender, i.e., in addition to the national currency, official money in circulation.

In addition to cryptocurrencies, a large area of application and strong development of the fintech industry has taken place in the field of digital tokens and coins in several forms. One is the creation of special ecosystems in which coins began to circulate as utility tokens. They could be used to purchase the products or services of

[4] www.statista.com/statistics/1202503/global-cryptocurrency-user-base

ecosystem members as a means of payment but also as a method of raising additional capital. On this basis, a kind of alternative to initial public offerings (IPO) in the form of initial coin offerings (ICO) has emerged. The ICO has brought a lot of new things, but also certain risks and uncertainties, especially in terms of investor protection. In that sense, they went a step further, so fintech companies created not only utility tokens, but securitized tokens that began to be registered with regulatory authorities. On this basis, a new innovation in the way of raising capital was created, called security (or securitized) token offerings (STO). These innovations have laid the foundations for the further development of a kind of token economy, in which new ecosystems with real business models with innovative solutions represent a new step in the development of the fintech industry.

The field of fintech application, which must not be omitted, is related to the field of financial analysis and consulting. It used to be almost inconceivable that highly professional tasks of accounting or financial analysis or investment advising would not be performed by people. However, the development of information technology, quantitative methods, and their application through big date, machine learning (ML), and especially artificial intelligence (AI) have led to almost revolutionary changes (Haenlein & Kaplan, 2019). AI allows computer systems to simulate human intelligence when performing certain tasks and processes. In this way, the field of fintech application has expanded. AI and ML in fintech are used for marketing, risk management, security, customer support, financial analysis, etc.

These changes have caused many financial institutions to change their business strategies. For example, many investment funds, especially hedge fund companies, are increasingly injecting AI into their stock trading operations and trading strategies. A lot of innovations like robo-advisors, chatbots, virtual assistants, and other automated processes have emerged. There are a number of companies that specialize in robo investment analytics and advisors, such as Betterment, Wealthfront, M1 Finance, Interactive Advisors, Personal Capital, Roboanalytics, SigFig, Ellevest, Ally, and many others.

The list of areas in which the fintech industry was developing would not be complete if we did not include financial cybersecurity services. There is a noticeable growth of companies seeking to protect institutions from money laundering, chargeback risk, and cybercrimes. Forter, EverCompliant, CrowdStrike, NsKnox, Palo Alto Network, Auriga, etc. have appeared among some of the most important companies in this segment of the fintech industry. One thing is for sure, there is almost no segment of the financial services industry in which some of the fintech innovations have not found their place.

5 Conclusions

The world of modern finance is full of innovations. Over time, they have become more diverse and the processes of their creation more dynamic. New financial instruments are emerging, new business strategies based on their use, technological

progress has reached almost unreal proportions, the existing ones are changing and new forms of regulations are being created, etc. The impression is that the world of modern finance is at a crossroads. Digitization and the increasing use of IT and communication equipment have led to a revolution called financial technology. The facts speak of the growing importance and role of fintech in many areas of the financial services industry. We are witnessing a rising number of fintech companies, segments where fintech is used, number of customers, investors, volume of turnover, funding and investments, etc.

Fintech can be said to be still in the earliest stages of development. Although there are many new things, such as blockchain, cryptocurrencies, cloud computing, IoT, machine learning, artificial intelligence, decentralized finance (DeFi), it is still difficult to predict further directions of future development. This fact makes this area particularly attractive for research and exciting to follow. One thing is certain about this area—the best is yet to come!

Financial innovation and fintech have led to shifts and changes in the financial structure. New companies have emerged, a kind of "new players" in the form of "challengers" of large and powerful financial institutions. Little by little, the big players' market share became endangered, so they also had to react to new circumstances. Many financial institutions, above all banks, but also insurance companies, investment funds, assets management companies, and brokerage houses, reacted quickly to the new challenges. They started with innovations and the introduction of new services that are digitally friendly or digitally integrated into new products. In this way, there has been an increase in the level of competition in the financial services industry, where in addition to the "classic" new and "pure" fintech players are present. Since digitalization knows no borders, the specificity of fintech development is the development of competition on a global level.

Pure fintech companies try to provide the basis for survival, growth, and development in different ways. Some companies are expanding their field of activity to various operations in the field of financial services while others are trying to reinvent themselves into data organizations and data providers. There are also companies that are diversifying and entering new areas such as the Internet of Things (IoT), green energy, climate change, decarbonization, token, or circular economy. These companies have helped create new business models, innovation in organization, management, organization culture, etc. All of the above has led to major organizational changes in the form of business process reengineering, restructuring, increasing activities in the field of mergers and acquisitions, etc.

A major novelty brought by fintech is related to the need for merging several scientific disciplines and areas of business. In addition to the classic disciplines related to finance, economics, law, information and technical sciences (primarily in the field of information technology), there is a growing need for using quantitative scientific disciplines—mathematics, statistics, econometrics, and even physics, etc. companies imply the need to involve experts from other social sciences, such as psychology, management, organization, marketing, etc. All this leads to changes in the structure of demand for new skillful people who are able to contribute to the development of these new industries. People are expected to be interdisciplinary, and

even more so multidisciplinary, as working in such teams is becoming a new paradigm and requires multifunctional knowledge and skills. In this area, it must be emphasized that there is still a certain gap in the field of education. Namely, the field is developing too fast, and many educational institutions are simply not able to sufficiently follow the dynamism of the changes that are taking place.

In addition to a number of advantages and benefits, innovations, and new opportunities brought by fintech have created new challenges and risks. Hence, there is a large area of change and directions of action aimed at regulating new issues and protecting consumers and investors. There are great differences and different approaches between countries, but it is certain that there is almost no country that has not started changes, improvements, or the adoption of completely new regulations in the field of digital assets or fintech business. As the scope and diversity of new financial products and services in the field of regulation grows, a common feature and general trend is the increasing control of these activities and processes.

In the very end, it must be pointed out that fintech has brought us not only accelerated digitalization but a whole range of innovations. What he introduced are new mental schemes in the way financial services business functions and organizes. New business models, new approaches and methods of business organization, new management techniques in terms of major changes in process reengineering, restructuring, agile transformations, etc. have set new standards, a kind of new paradigm. Without any dilemma, the world of modern finance has entered a completely new phase of development that is appropriate for the time in which we live—the era of the Industrial Revolution 4.0. and the change will be ...

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Central Bank and Fintech: Regulatory Challenges and Framework

Jayaraj Rajaiah, Agamoni Majumder, Kavita Ingale, and Srinivas Subbarao Pasumarti

1 Introduction

Fintech is a relatively recent innovation that transformed in the financial industry of many world economies. Some other revolutionary innovations in the financial sector include transformation of technology into digital technology for the financial services sector, development of Internet and invention of the Automated Teller Machine (ATM) during the late 1960s, Information and Communication Technologies (ICT) investments in the financial sector and introduction of digital currencies or digital electronic money beginning with Bitcoins during 2009. Fintech can be considered as an application of information technology in the financial sector. It encompasses many things like start-ups, financial sector services, financial technologies, and financial companies. The term Fintech indicates all technology-based financial services and business activities supported by the Internet. It encompasses start-ups, ICT-based financial services, and collaboration between start-ups and traditional financial services.

Against the backdrop of rapid proliferation of technology and disruptive innovations, the digital landscape has always remained dynamic. The new products and services have displaced the existing ones by the means of value offerings. A disruptive Fintech operates in areas like insurance and foreign exchange trading services which are traditionally provided by incumbents. These Fintech services use technology to provide fast, convenient, and low-priced financial services to customers. Thus, the expectation of the consumers to get better, faster, and cheaper financial services keep growing thereby forcing the incumbents to stay competitive

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and maintain their market share. On the other hand, an inventive Fintech arises to fill in gaps in financial service market and transforms the entire financial sector in the process. They operate by providing financial services which were non-existent and have been invented by them through use of technology and unconventional business models (Bechara et al. 2021).

According to Li et al. (2020), with the interlinkage between traditional financial institutions and Fintech firms through the presence of the competition services and investments in Fintech businesses by the traditional financial institution, risk of spillover and contagion increases drastically. This poses a big threat to the financial stability (Reserve Bank of India, 2017). The way in which digital ecosystem has evolved over a period of time, it poses many challenges to the regulators. Moreover, the pace at which it is changing makes the existing regulatory mechanism outdated. The reforms are needed in the areas of consumer protection, data security, competition, and network security without compromising consumers' welfare. The involvement of technology companies known as RegTech in monitoring and regulating the activities of Fintech firms will not only impart efficiency in the regulatory mechanism but also result in cost savings through almost, real-time insights into the breaches using artificial intelligence (Arner et al., 2018).

Hence, there is an evident need for monitoring these systematic risk spillovers so that the regulatory authority can ensure the stability of the financial system. This chapter puts forward the Fintech innovations, adoption of Fintech, recent growth of Fintech, and importantly the various regulatory challenges in the Fintech sector and the possible directions for a regulatory framework for the Fintech sector to be undertaken.

1.1 Fintech Innovations

Financial innovation is the act of creating and then popularizing new financial instruments, as well as new financial technologies, institutions, and markets (Lerner and Tufano 2020). Technology-enabled innovation in financial services that could result in new business models, applications, processes, or products with an associated material effect on the provision of financial services (FSB, 2017). The services of Fin Tech companies range from credit, deposit and fund-raising activity, personal finance, investment, and insurance advisory to infrastructure relating to payments, clearing, and settlements (Fig. 1). It encompasses a wide variety of support services like machine learning, blockchain technology, cloud computing, automation in financial services, and advisory. Fintech helps fill the gaps by providing the much-required financial services that are unmet by banks. It improves the efficiency of finical services through ease of borrowing and lower rates of loan default. Fintech attempts to reduce credit risks that an economy faces when credit is provisioned by only leading banks. Another important role that Fintech plays in financial services is financial inclusion by reducing the issue of asymmetric information, reducing the

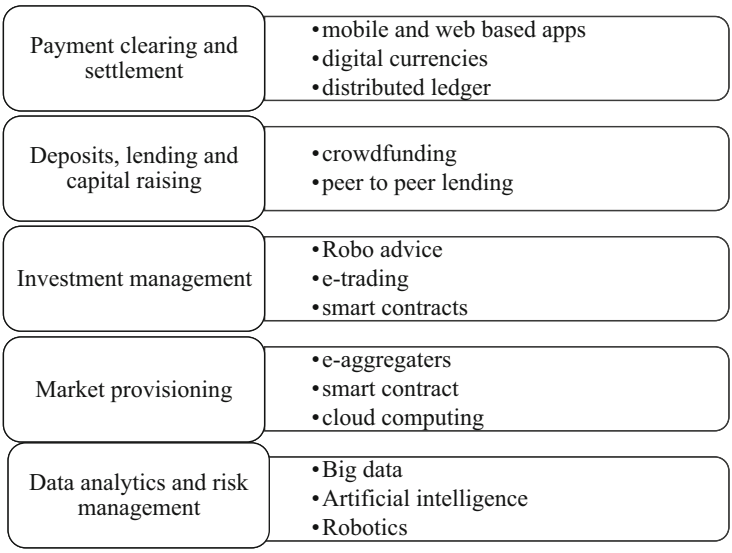

Fig. 1 Fintech innovations. Source: Report of the Working Group on Fintech and Digital Banking, Reserve Bank of India (2017)

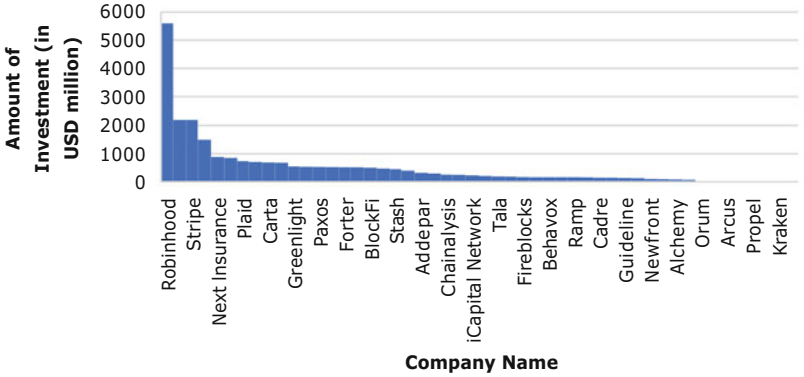

Fig. 2 Most Innovative Fintech Companies in the world, 2021. Source: Abreu et al. (2021)

cost of transaction, reducing human biases, and instances of discrimination while providing financial services.

As per the Abreu et al. 2021 report, almost all of the listed innovative Fintech companies are located in the USA indicating that the USA is the hub of Fintech companies in the world (Fig. 2). The highest number of innovative Fintech companies listed in the table are in the category of Personal finance followed by Payments, blockchain, insurance, investing, real estate, wall street and enterprises, and finally by B2B companies. Figure 2 shows the amount of investment made in various innovative Fintech with the investing company—Robinhood from California, USA

has the highest amount of investment (5600 million USD) followed by Karma (2200 million USD), Stripe (2200 million USD), Chime (1500 million USD), and others.

Fintech companies are the existing financial companies/intermediaries which are offering innovative technology products or the technology companies which offer the infrastructure needed for financial transactions. These are technology start-ups providing innovative solutions in crowdfunding, mobile payments, portfolio management, international financial transfers, and peer-to-peer lending.

1.2 Adoption of Fintech Services

There are a few available studies and reports that use data to examine the spread, adoption, and use of Fintech services among common people as well as businesses. A recent worldwide study done by Ernst & Young Ltd. (EY) in 2019 investigated the global adoption of Fintech among consumers and small and medium businesses. EY conducted online interviews of over 27,000 consumers in 27 markets located across six continents. Ten of these 27 markets are currently considered as emerging markets and play an important role in studying Fintech adoption. This study indicated that the adoption of Fintech across the 27 markets is highest in China (87%) and India (87%) followed by Russia (82%) and South Africa (82%). On the other hand, the Fintech adoption is lowest in countries like France (35%) and Japan (34%) (EY Global Fintech Adoption Index, 2019).

It further showed that the adoption of Fintech has steadily increased among consumers from 16% in 2015 (since the first survey by EY) to 33% in 2017 and 64% in 2019. Even though the trust among consumers on their main bank or insurer remained high, 33% of consumer adopters preferred using Fintech's services first as compared to using the traditional bank services. Sixty-eight percent of the consumers prefer nonfinancial services provider over financial services. Such services include—a digital wallet used for payments with different businesses, digital-only banking, insurance related to smart devices for vehicles, Internet-based tools for accounting and financial planning, peer-to-peer lending, Internet-based tools for investment advice and management, retirement and pension management, peer-to-peer short-term borrowing, cryptocurrency digital wallets, Internet-based stock broking tools, insurance premium comparison sites, app only insurance, etc. As observed from Table 1, the consumer's adoption of various Fintech services has increased considerably over the years with digital payment and services witnessing the highest growth followed by online savings and investment services, insurance services, and lending services (EY Global Fintech Adoption Index, 2019).

The EY report shows that about 46% of consumer adopters are ready to share their bank data with other establishments. Only 4% of global consumers were found to be unaware of online money transfer and payment services provided by Fintech. Despite concerns about personal data security, the adopters of Fintech Services prefer online and app-based financial products. Other reasons for availing these

Table 1 Adaption of Fintech services

Fintech services	2015	2017	2019
Digital payments and money transfers	18	50	75
Online savings and investment	17	24	48
Accounting and financial planning	8	20	34
Insurance	8	10	29
Borrowing	6	10	27

Source: EY Global Fintech Adoption Index (2019)

services include attractive and cheaper rates and ease of setting up an account (EY Global Fintech Adoption Index, 2019).

Adoption of contactless payments in the post-pandemic world has offered a wider scope for digitalization of financial services complemented by the Digital India move by the Government of India. Innovations in financial services industry and advancement of mobile and telecommunications industry have provided the required infrastructure to it. According to Markets and Markets (2021) global market size of digital payments is likely to accelerate at a CAGR of 14.2% by 2025.

Fintech services used by SMEs however differ from those used by consumers. Hence, EY also conducted an online survey of 1000 small and medium enterprises (SMEs) in two developed countries (the UK and the USA) and three emerging economies (China, Mexico, and South Africa). As per this survey, Fintech adoption by SMEs is highest in China (61%) followed by the USA (23%), the UK (18%), South Africa (16%), and Mexico (11%). The SMEs are adaptors of Fintech services like digital payment, transfers and banking, Internet-based foreign exchange services, mobile point of sale payment machines for accepting payments, digital billing and invoice management, digital bookkeeping and payroll, online marketplaces, brokers and aggregators, online equity crowdfunding, online debt securities, dynamic discounting, online invoice financing, insurance premium comparisons, etc. Fintech is quickly becoming a reliable seller for SMEs in these areas of operation which have been underserved by pre-existing financial institutions. Around 25% of SMEs have adopted Fintech globally (EY Global Fintech Adoption Index, 2019).

1.3 Recent Growth Status of Fintech

The KPMG report on the top 100 Fintech Companies during 2018 and 2019 showed that from among the top 100 Fintech companies, payment and transactions sector has the highest number of companies while the lowest proportion is of the neo-banks (Table 2). Neo-banks fall under the category of Challenger banks that may or may not have a banking license. As opposed to the traditional banks, these neo-banks challenge the products, user experience, and business models of traditional banks (KPMG 2021). Comparing the proportion of other types of Fintech services during 2018 and 2019, the proportion of Fintech companies operating in wealth &

Table 2 Top business models

Sectors	No. of companies	
	2018	2019
Payment and transactions	34	27
Lending companies	22	15
Wealth and brokerage	14	19
Insurance companies	12	17
Neo/challenger banks	10	9
Multi companies	3	13
Other companies	5	0

Source: KPMG, (2019)

Table 3 Global Fintech investments

Year	Funds (in Billion US$)	No. of equity funding rounds
2010	5	420
2011	4.39	661
2012	4.62	814
2013	12.41	1188
2014	16.8	1736
2015	42.4	2237
2016	37	2394
2017	39	2532
2018	73.3	2786
2019	78.3	2544
*2020	22	1085

Source: Tracxn (2020)
*Data available up to June 2020

brokerage services, insurance services, and multi companies in top 100 Fintech companies have increased over the period.

The Global Fintech investments have grown rapidly over the years as observed in Table 3. Till June 2020, Fintech funds stood at 22 billion USD as compared to only 5 billion USD in 2010. Similarly, the number of equity funding rounds of the Fintech companies has also gone up over the years.

The first half of 2021 witnessed a massive increase in interest in Fintech worldwide. This trend is expected to continue in the second half of the year as well. However, a significant increase in cyberattacks and ransomware, cyber security is going to be the top priority for investors and most particularly for corporates. Besides, management of frauds, KYC, and security which do not require passwords are drawing most attention among the investors. Business to business-based financial services in payments, Insurtech, Wealthtech, and RegTech are expected to grow. Embedded finance is expected to gain more traction as corporates struggle to consolidate financial services with other environments. Cryptocurrency will continue to be the center of attraction as investors witnessed a massive explosion of

activity in the blockchain and crypto space. Partnership is expected to be the way of business in financial service sector. Merger and acquisition activities will continue to grow as businesses look for expanding operations, capabilities, and offerings. International collaboration activity is likely to be healthy as Fintechs strive at becoming global players or regional leaders (KPMG, 2021).

2 Regulatory Challenges for Fintech

A research report by TransUnion Global Fraud Solutions (2021) has underlined the fact that India stands to be one out of the major countries suffered from cyber frauds in recent periods. As per the data, cyber frauds in India in the context of financial services increased by 88.50 percent from last 4 months of 2020 to first four months of 2021. While the suspected digital fraud attempts across the industries have climbed up by 24.387% during the same period (Table 4).

Owing to the commonality of the market segment and cooperation between traditional financial institutions and Fintech firms and flow of investments from the earlier to the later one, there is a strong likelihood of potential spillover of the inherent risks of the Fintech firms to traditional financial system (Li et al., 2020). Using time series analysis in multivariate framework the authors studied the spillovers and interconnectedness between Fintech, cryptocurrency, and green bonds using frequency dynamics. This study infers the great interconnectedness between technology assets and traditional assets, leading to losses in both during volatile times. Fintech and bitcoin are net contributors while green bonds are net receivers to these shocks and hence act as good hedgers. They proposed that this can serve as a portfolio diversification strategy in industrial revolution 4.0. The KBW Nasdaq Financial Technology Index (KFTX) is an index tracking the performance of publicly traded Fintech companies in the USA.

Table 4 Country-wise data of digital fraud attempts

Country	Digital fraud attempt rate in first 4 months of 2021 in financial services industry (%)
UK	791.34
Brazil	611.95
Colombia	242.95
Canada	217.54
Hongkong	196.24
South Africa	187.34
USA	108.82
India	88.50
Spain	39.63

Source: TransUnion Global Fraud Solutions (2021)

2.1 Challenges for Central Banks

Marqués et al. (2021) highlighted the major issues relating to data gaps for monitoring Fintech relating to monetary policy, financial stability, payment systems, and economic activity in the context of Latin American countries. There are many challenges in incorporating the Fintech data in statistics. There is a wide spectrum of services provided by these companies which are cross-sectional in nature and hence it is difficult to segregate this information. Some of the activities are outside the regulatory boundary of the central bank, about which the information is not received by central banks. The services which are provided in the international territories are not subjected to local jurisdiction. Even though in some cases the information is provided by these companies, it is not sufficient enough to provide the required content to comprehend its impact on the financial system.

2.1.1 Monetary Policy Implementation and Transmission

Traditionally the extent of monetary policy transmission in the real sector was gauged using the financial intermediation process of commercial banks through the payments turnover statistics. However, the Fintech companies offer an alternative to traditional financial intermediation. Fintech facilitates direct financing by providing platform for activities like peer-to-peer lending, crowdfunding, reducing the scope of financial intermediation and it disturbs the process of central banks' assessment of monetary transmission (Marqués et al. 2021). Cryptocurrencies if offered as an alternative to traditional currencies pose a likely threat to this monetary transmission.

2.1.2 Financial Stability

Though Fintech provided alternative sources of finance at ease and facilitate financial inclusion, they pose the risk in terms of mismatch between the investment and credit maturities or information asymmetries that arises out of their low experience with risk mitigation practices. Their high-end technology platform supported with big data makes them vulnerable to miscalibrated models. If their activity is not adequately reported, central banks assessment of interplay between financial growth and economic activity will be incomplete. Interplay between Fintech and regulated financial intermediaries, their vulnerabilities, and the shocks they can transmit to the real economy and amplification of the risk through credit or clients. One needs to look at (a) Scale of activity of these companies, (b) Credit exposure to Fintech companies—main economic sectors, (c) Financial services provided by Fintech companies to other financial intermediaries, and (d) Funding relations with other intermediaries (Marqués et al. 2021).

2.1.3 Payment System-Associated Risk

With the new payments infrastructure, the regulatory authorities need to ensure the safety and efficiency of payment system. Many new entities, different jurisdiction, low survival rates, transversal nature of data in terms of financial and nonfinancial sectors calls for a comprehensive database of Fintech (Le et al. 2021).

2.1.4 Cybersecurity Risk

Risk arising out of mishandling of client data by these technology firms is likely to pose threat to consumers and financial stability (Marqués et al. 2021). Cybersecurity risk is the risk of cyberattacks on account of dependence on third-party service providers. RBI's March 2020 guidelines on the regulation of payment aggregators and payment gateways require these entities to comply with the norm of registration with central bank for organizations providing merchant services. To secure the integrity of financial networks from hackers, money lenders, and terrorists from scams and to ensure well-protected payment system, policy efforts need to be directed. Presently the regulatory authorities' efforts are directed to prevent customer data protection from cyber frauds through tokenization and two-party authentications.

2.1.5 Speculative Risk

Blockchain technology and cryptocurrency have emerged as a major financial disrupter posing threat to the global financial stability as it is neither backed by any government guarantee nor possesses any asset backing (Tan et al., 2020). However, their implications for financial system are vague in terms of the potential to create a speculative bubble.

2.1.6 International Payments Standardization

The Fintech firms interested in tapping the international payments domain resulting from cross border trade are unable to operate efficiently due to lack of global standards for cross border payments and heterogeneous regulatory frameworks. Hence, there is a need for standardization of payments system across interbank and intra-bank networks globally. Regulators can help to encourage the productive use of Fintech innovations. Fintech. While it is important to be thoughtful and cautious, the lack of Fintech regulations could create significant uncertainty in the business environment and put us behind other countries in terms of innovation. Furthermore, the various Fintech regulations, like other financial regulations, may interact with existing financial regulations or with other Fintech-related regulations. Furthermore, the various Fintech regulations, like other financial regulations, may

interact with existing financial regulations or with other Fintech-related regulations. As a result, coordination within the public sector and between the public and private sectors plays an important role. Should regulators decide which alternative data should be permitted or prohibited in credit decisions? To what extent should regulators be held accountable for the cybersecurity of the market infrastructures that they manage and operate? Another relevant question in this respect is, what is the best method for developing and effectively implementing cross-industry, cross-jurisdiction, and cross-country guidance? The numerous benefits of Fintech are accompanied by new types of risk. Regulators all over the world are working hard and carefully to avoid creating an over- or under-regulated environment. Ideally, the Fintech rules should strike the right balance between consumer protection and financial stability, while also providing sufficient incentives for Fintech innovation (Jagtiani & John, 2018).

3 Central Bank

Being the sole monetary authority in a country, Central banks have always been equipped with advanced financial technology and innovation. Starting from the invention of bank notes to interbank transactions and harbinger of Internet-based financial services, central banks have always transformed and improved the financial sector services. However, in the current scenario, the central banks are facing novel and unique challenges owing to the expansion of technological advancements like artificial intelligence and machine learning, cloud computing, and distributed ledger technology in financial services. The private firms and networks (Fintech) have quickly and easily adopted these technologies and are now providing various financial services with much more ease as compared to traditional banks which are still in the process of adopting these technologies. This has a serious implication for the services provided by the central banks. It could weaken the central bank's directives on monetary policy and on the power of the central bank as the sole issuer of money in a country (Bechara et al. 2021).

There are various types and sizes of Fintech firms that meets different requirement of consumers. The risk level associated with the Fintech business also varies from one Fintech firm to another. Hence, "one size fits all" policy cannot be used for Fintech. As the scope and operation of Fintech firms have expanded from national to international arena, regulation on Fintech also has to be applicable and effective irrespective of geographical boundaries where the firms are located. As per the Bank of International Settlements (BIS), most Fintech lending was unregulated while some regulation was present for digital payments and crowdfunding. The existing regulations for Fintech-based insurance services were insufficient. Most commonly used by regulatory bodies for crypto-assets are warnings and clarifications. Therefore, it is observed by BIS that the existing regulatory guidelines are modified to include Fintech-specific regulations. A new development in this context is the crypto-specific licenses. Regulators have been actively taking action through

Application Programming Interfaces (APIs), cloud computing, and biometric identification. However, regulatory actions for artificial intelligence, machine learning, and DLT needs to be improved. At present, regulation in this context is restricted to issuing general guidelines and risk assessments (Ehrentraud et al. 2020).

3.1 Commercial Banks

Fintech lenders, unlike traditional lenders, use big data, alternative data, and complicated AI/ML algorithms to make quick (near-instantaneous) credit determinations. Fintech lenders have joined the shadow banking sector in supplying banking and other financial services, giving convenience and speedier service than regular banks but avoiding the same rules as traditional banks (Jagtiani & Lemieux, 2016). The authors give an example of Lending Club which provides America's largest unsecured personal instalment loans. The customers can receive access to a broad range of financial goods and services through a technology-driven platform, designed to help them pay less when borrowing and earn more when saving. Fintech lenders have brought challenges and opportunities to both traditional financial institutions and customers (Jagtiani & Lemieux, 2016).

3.2 Technology

It is unclear who owns the customers and who owns the customer information as financial organizations exchange their consumer data with an AI vendor or data aggregator. Consumers and regulators are increasingly concerned about the misuse of personal data. Fair lending and financial inclusion are important concerns for consumer protection organizations that want to ensure that disruptive Fintech technologies benefit underserved individuals. A deeper knowledge of the applications of AI/ML and blockchain for supervision and regulation would be beneficial to central banks and other financial authorities (Jagtiani & John, 2018).

Fintech lenders have also been shown to have the ability to undercut established financial rules. Braggion et al. (2021) investigated how regulatory changes in Loan-to-Value ratios affected the supply and demand of P2P lending in China by the lender RenrenDai. They discovered that lending limits in traditional markets enhance demand for P2P lending while credit prices stay stable.

3.3 Learning from International Experience

A recent study by Kharisma (2021) applied normative research with a legal approach to examine the need for Fintech regulation in Indonesia. The author views that the

Fintech industry's great potential and expansion in Indonesia must be backed up by a solid legal framework in the shape of Indonesian law. In terms of Fintech, Indonesia has yet to pass a Fintech-specific law. The Bank of Indonesia Regulations (PBI) and the Indonesia Financial Services Authority Regulations (POJK) only regulate the technical components of the business, giving them little legal jurisdiction. The Bank of Indonesia (BI) and the Indonesia Financial Services Jurisdiction (OJK) have limited regulatory authority, and the regulations they develop cannot include penal provisions. As a result, consumer protection measures are weak. The Investment Alert Task Force discovered 2018 instances of illegal peer-to-peer lending, 472 instances of illegal investment businesses, and 69 instances of illegal pawnbrokers. Fintech regulation in Indonesian law is intended to offer legal certainty and improved legal protection for consumers, investors, and Fintech service providers. With the value of the Indonesian digital economy reaching USD40 billion (roughly IDR586 trillion) in 2019, Indonesia is in desperate need of a Fintech Law from a philosophical, legal, and sociological standpoint.

Payment and settlement are the most prominent Fintech businesses that are actively developing around the world. Korea has a well-developed IT industry and a good existing card payment environment, but its innovative movement in Fintech is significantly slower than that of other countries. A recent study by Seongmin and Do Hyun (2020) compares the cases of the USA, China, and Korea to assess the Fintech regulations and their impacts on the start-up ecosystem. They discovered that both the USA and China have lowered entry barriers for the newly launched Fintech industry, allowing start-ups and IT companies to launch Fintech businesses within the existing financial sector. The implementation of predictable regulations in the USA, as well as the failure to apply financial regulations in China have aided in the growth of start-up companies in the Fintech industry. These findings indicated that the current positive regulations in Korea should gradually be replaced by negative regulations that strictly enforce post-management except for major items rather than pre-approval.

China has accelerated its Fintech development in recent years, establishing itself as a global leader. However, in China, the existing regulatory framework makes it impossible to adequately deal with the potential hazards of Fintech advances, resulting in a high number of risk events. Bu et al. (2021) developed a two-player evolutionary game model to show the evolutionary game behavior of Fintech companies and regulatory agencies, as well as examined the elements that influence their strategic decisions. They discovered that the strategic choices of Fintech companies are primarily influenced by extra benefits from noncompliance innovation, rewards from compliance innovation, and penalty intensity from regulatory authorities, whereas regulatory authorities' strategic choices are primarily influenced by regulatory costs, social evaluation, and negative externalities. China's Fintech is still operating in a relatively unregulated atmosphere when compared to developed countries such as the USA and the UK. At the same time, due to a lack of appropriate regulatory experience and a lack of industry development experience, China's Fintech regulations have traditionally lagged behind the industry's development innovations.

Arner et al. (2018) claimed that RegTech's potential is even greater: it might enable a near-real-time and proportionate regulatory regime that identifies and tackles hazards while also permitting more efficient compliance regulation, according to Buckley. Regulators, according to Magnuson (2018), are frequently focused on mitigating hazards connected with "too large to fail" organizations, while overlooking the conceptually unique concerns associated with small, decentralized financial markets. Buckley et al. (2020) believed that collectively, the rigorous reporting requirements, strict data protection standards, the encouragement of open banking, and a legislative framework for digital identity are underlying and would continue to underlie the creation of a RegTech ecosystem in Europe.

Lu and Ge (2017) proposed that, given the nature of finance and technology, regulatory agencies should follow the notion of progressive and moderate Fintech regulation, striking a balance between preventing risks and promoting innovation. Zhang (2018) stated that a regulatory sandbox system should be established in China to foster Fintech innovations under the premise of effective risk prevention, based on a comparative research of regulatory sandbox systems in various nations and regions. Li and Jian (2017) emphasized that using RegTech to create a progressive regulatory framework that matches Fintech's growth stage and risk level is a viable regulatory method for balancing Fintech innovations and risk management. Yang (2018) claimed that if regulators do not adopt RegTech in response to Fintech advancements, they will face more serious information asymmetry issues, regulatory arbitrage, and more complicated systemic dangers.

4 Regulatory Policies for Fintech

International regulatory organizations, such as the Financial Stability Board (FSB), the European Central Bank (ECB), and others, have paid close attention to the potential risks of Fintech innovations, and have issued a series of policies and regulations or regulatory frameworks to balance Fintech industry development and risk management. Major countries and regions created applicable laws and regulations or implemented appropriate regulatory actions in response to these relevant policies and their current situation in order to preserve the development trend of domestic Fintech and lessen the uncertainty generated by potential Fintech hazards (Table 5). The primary regulatory innovation instruments in this international Fintech legislation include regulatory sandboxes, regulatory technology (RegTech), innovation hubs, and innovation accelerators, among others Bu et al. (2021).

Maja (2018) in his study examined the potential negative consequences of Fintech on the global financial services sector. This study uses arguments and empirical evidence from three geographic and political regions, namely the EU, India, and the USA, to analyze the influence of Fintech companies on traditional financial services providers, as well as the reasons for Fintech's rapid development and expansion. The analysis in this study shows that present Fintech regulation in the aforementioned locations is ineffective and could have negative consequences for

Table 5 Regulatory practices around the world by Central Banks

Year	Institution or State	Regulatory policies
2016	Financial Stability Board, FSB	Fintech: Describing the Landscape and a Framework for Analysis
2017	European Central Bank, ECB	Consultation on Guides Concerning the Assessment of Licence Applications and Fintech Credit Institution Licence Applications
2018	European Commission, EC;	Fintech Action Plan: For a more Competitive and Innovative European Financial Sector
2015	Financial Conduct Authority, FCA	Regulatory Sandbox
2018	Financial Conduct Authority, FCA	Call for Input: Using Technology to Achieve Smarter Regulatory Reporting
2017	U.S. National Economic Council, NEC	A Framework for Fintech
2018	U.S. Department of the Treasury, TD	A Financial System that Creates Economic Opportunities—Nonbank Financials, Fintech, and Innovation
2016	Australian Securities & Investments Commission, ASIC	Regulatory Sandbox Guidelines
2017	Australian Securities & Investments Commission, ASIC	Regulatory Guides 257: Testing Fintech Products and Services without Holding an AFS or Credit licence
2016	The Monetary Authority of Singapore, MAS	Fintech Regulatory Sandbox Guidelines

Source: Bu et al. (2021)

the global financial services sector, such as cybersecurity breaches, data privacy violations, and the use of Fintech services for unlawful reasons. As a result, authorities in the EU, India, and the USA must concentrate on developing appropriate Fintech legislation in order to prevent potential negative consequences.

Changes in regulations and rules have always accompanied the growth of China's Fintech industry (Table 6). From the standpoint of policy formulation, the People's Bank of China (PBOC), along with 10 other government ministries, issued the Guidance on Promoting the Healthy Development of Internet Finance in July 2015, signalling the start of Chinese Fintech regulation. The State Council introduced a special rectification of online finance in 2016 which was thereafter implemented across the country. Following frequent malicious incidents of P2P lending, in 2018, the People's Bank of China (PBOC) and the relevant departments introduced a special rectification of internet finance risks, and China's Fintech entered a strict regulation stage. To further promote a healthy and sustainable development of Fintech in China, the People's Bank of China (PBOC) officially released the Financial Technology (Fintech) Development Plan (2019–2021) in 2019. This plan clearly defined the guiding ideology, basic principles, development goals, key tasks, and safeguard measures for China's Fintech over the next 3 years and proposed to further improve the Fintech industry's application capabilities and realize the deep integration of finance and technology. This reflects the gradual construction of the Fintech industry's regulatory regime in China.

Table 6 Fintech regulatory policies in China

Year	Institution	Regulatory policies
2015	The People's Bank of China, PBOC and other departments	Guidance on Promoting the Healthy Development of Internet Finance
2016	General Office of the State Council, GOSC;	Implementation Plan for the Special Rectification of Internet Financial Risks
2016	The People's Bank of China, PBOC and other departments	Implementation Plan for the Special Rectification of Non-bank Payment Institutions
2016	China Banking and Insurance Regulatory Commission, CBIRC and other departments	Implementation Plan for the Special Rectification of P2P Lending Risks
2017	PBOC and other departments	Notice on further doing a good job of Internet Financial Risk Special Rectification and Rectification Work
2017	China Banking and Insurance Regulatory Commission, CBIRC	Guidance on Information Disclosure of Business Activities of P2P Lending Information Intermediaries
2018	National Internet Finance Association of China, NIFA	Tips on Preventing Overseas ICO and Virtual Currency Trading Risks
2018	PBOC and other departments	Guidance on Standardizing Asset Management Business of Financial Institutions
2018	CBIRC and other departments	Risk Tips on the Prevention of Illegal Fundraising in the Name of Virtual Currency and Blockchain
2019	The People's Bank of China, PBOC	Financial Technology (Fintech) Development Plan (2019–2021)

Source: Bu et al. (2021)

4.1 Assessing the Suggestions of Previous Studies

From the literatures around the world on regulation of Fintech given its challenges and concerns, various studies have suggested policies as discussed below.

4.1.1 Use of RegTech

Bu et al. (2021) suggested to use RegTech to reduce the costs of regulation and compliance, to change the way regulations are done and establish the concept of incentive regulation, to improve the regulatory rule system, and reduce the profit space of noncompliance innovation. Further, it recommends drawing the bottom line of regulation and increasing the penalty intensity of noncompliance innovation, and to give social evaluation more weight. In India, the Reserve Bank of India has already begun the process of legitimization of Fintech. It has established a "Working Group on Fintech and Digital Banking," whose goal is to closely monitor Fintech's development and suggest legislative solutions that would allow Fintech companies to be regulated while also reducing the risk of data privacy breaches and mitigating

cybersecurity risks (RBI, 2017). Furthermore, due to security, financial, and legal concerns, the RBI has barred the use of cryptocurrencies as a form of payment (Deloitte, 2017). In India, no other formal Fintech rule has been issued or implemented (Deloitte, 2017). A working group on Fintech by Reserve Bank of India (2017) has proposed various solutions:

- Understand the interplay between financial sector and Fintech.
- Identify risks relating to platform-based Fintech.
- Regulatory authorities in finance sector need to identify and assess sector-specific Fintech products.
- Implement stepwise regulatory reforms—disclosures, from light to tight regulatory norms.
- Brand and product managers should work together with the technical and analytical experts for Innovation hubs.
- Activity relating to Fintech products in the securities market should be closely monitored.
- A dedicated organizational structure needs to be created within each financial market regulator. Each of these structures needs to design standalone data protection and privacy laws.
- Collaboration between Fintech companies and regulatory bodies to be encouraged for both demand and supply-side measures.

4.1.2 Regulatory Changes in the EU

The EU's regulatory organizations have taken a more specific course of action. Changes to the EU's financial institution legislation, as outlined by the Commissioner, were agreed upon and went into effect at the start of 2018 (Arnold & Brunsden, 2017). "PSD2" (Second Payment Service Directive) is a new piece of law that is supposed to enhance competition in the name of 'open banking,' by mandating banks to allow third parties, such as innovative financial technology companies, access to the data of consumers who authorize it (Arnold & Brunsden, 2017). Finally, both the PSD2 and the MiFID II guidelines went into effect in January 2018. The European Banking Authority (EBA) enacted PSD2 legislation, which establishes criteria for which types of organizations are permitted to provide payment services within the European Economic Area (EEA), as well as transparency requirements for those institutions (EBA 2017). The European Securities and Markets Authority (ESMA) drafted the guidelines for MiFID II implementation, and the main goal of this legislative framework is to make investing more safe, transparent, and fair by establishing requirements for investment institutions on how to conduct business and report, as well as rules on which financial instruments can be admitted for trading on EU and EEA financial markets (ESMA, 2018).

4.1.3 Regulatory Landscape

In terms of the USA, their regulatory agencies have not yet made a clear statement on their plans for Fintech regulation, although they have stated that they intend to go a different path than the EU (Federal Reserve, 2016). Furthermore, Fintech firms are neither controlled nor monitored by any government agency, with the exception of payment and lending Fintechs, which are subject to a restricted set of federal restrictions (Deloitte, 2017). These rules primarily concern consumer protection (Deloitte, 2017). Nonetheless, no more information on the regulatory plans for Fintech companies in the USA is accessible. This is not surprising given that the USA has historically been more open when it comes to financial market and financial services regulation (Denk & Gomes, 2017).

4.1.4 Joint Ventures with Financial Intermediaries

One of the measures suggested by Marqués et al. (2021) includes forming a joint venture with financial intermediaries which are under the regulatory framework. The establishment of a link between Fintech companies and financial service providers will further enhance data integration. Besides that, there is a need to create a cyber secure environment. Measures to detect any anomalies and prevent their possibilities in future needs to devise.

4.1.5 Need for Entry Barriers to Avoid the Concentration

Though SME credit and better financial inclusion were the positive outcomes of Fintech companies, they have enabled credit delivery to those who did not have a bank account or access to formal lending without any collateral. Rapid expansion of this sector especially in peer-to-peer lending implies low entry barriers. Moreover, in Indonesia these companies need to be registered with the Financial Services Authority of Indonesia (Utami & Ekaputra, 2021). In this regard, the entry into Fintech sector can be subjected to certain norms limiting the concentration in the sector.

4.1.6 Central Bank Digital Currency (CBDC) in Cross Border Payments

Central bank digital currency involvement in cross border payments can overcome the issues relating to diverse regulatory cultures Marqués et al. (2021). Platform-based solutions can facilitate price discovery in international payments transactions through CBDC. It will eliminate the time zone distinction by the way of currency delivery instead of bank settlements for cross border payments. Recently RBI and monetary authority of Singapore collaborated for linking their payment systems,

Unified Payment Interface (UPI) and Paynow, respectively, is a major development in cross border payments.

4.1.7 Functionality-Based Regulatory Framework

According to Jeffrey & Soria, (2016) report, the regulations should be based on the functionality of the firms rather than on the basis of technology of industry nature and they should be dynamic in nature to align with the rapid pace of growth of the industry. This would ensure immunity from possible harm to the consumer as the functionality-based approach appreciates the technology-specific regulatory treatment.

5 Need for Regulatory Framework in the Indian Context

Recently, the RBI has taken measures to reduce digital transaction costs by imposing charges on banks for all transactions made through debit cards, credit cards, wallets, and UPI. Such measures have made digital transactions affordable. Financial innovations have improved the ease and efficiency of financial transactions and fostered better financial inclusion, yet it has thrown several challenges.

The regulatory authorities have created a regulatory sandbox—new incubation model which enables the Fintech firms to experiment with new financial products within a secured environment, which replicates the real-time basis. There is a temporary relaxation in regulatory norms for enabling the proposed product. This sandbox provides the indicative list of products and technologies which are acceptable as well as negative list of products that will not be accepted for testing such as cryptocurrency.

This leads us to ponder upon the questions like:

- Can Fintech innovation expose economy to the vulnerability and shocks due to nonadherence to prudential norms?
- Is there a structured regulatory framework in place which defines the ambit or purview of these regulatory guidelines?

With growing number of Fintech firms and the resultant disruptions, regulators across the world are concerned about the vulnerabilities the consumers are exposed to. At the same time, it has to ensure that technological and economic value continues to be delivered to consumers. To foster the financial innovation worldwide various initiatives are undertaken in the form of regulatory sandboxes, incubation, and innovation hubs (Reserve Bank of India, 2017). A comprehensive regulatory framework requires a sound understanding of the risk implications of these innovations. Since the services provided by these firms range from payment systems to insurance and investment advisory, all regulators including RBI, SEBI, IRDAI, and PFRDA. Indian regulatory framework for Fintech industry is highly fragmented at

Table 7 Present regulatory infrastructure

Regulatory framework/infrastructure	Functionality/importance
Payments and Settlement systems act (2000)	Mandates RBI approval for initiation and operation of payment system
National Payments Corporation of India	Provides a list of authorized payment system operators
P2P lending platform directions 2017	Prescribes exposure norms for lenders and limits for borrowers
UPI Payment guidelines	Ensures money transfers through UPI are generated by banks by engaging technology providers under norms prescribed by NPCI
Payment banks guidelines	Prohibits payment banks to involve engage in deposit or credit business and instructs these banks to be registered as private limited companies
Anti-money laundering regulations Act 2002	Enforces anti-money laundering regulations for entities offering financial products
NBFC regulations by RBI act 1934	Mandates entities providing Fintech services to be registered under RBI
Information Technology Act 2000 and IT rules 2011	Oversees data privacy and ensures common minimum standards for security control
Ombudsman scheme for digital transactions	Addresses customers' complaints in digital transactions
UIDAI	Prescribes framework governing the use of Aadhar by Fintech players for onboarding and verification of customers
Guidelines of Regulation of payment aggregators and payment gateway 2020	Stipulates technology-related recommendations given that they do not engage in funds handling

Source: Prepared by authors

present (Table 7). It suffers from a lack of comprehensive set of rules and legal provisions. Yet, the data protection laws in India are in close alignment with international framework wherein draft personal data protection bill follows general data protection regulations and adopts major principles from it.

According to Li et al. (2020), with the interlinkage between traditional financial institutions and Fintech firms through the presence of the competing services and investments in Fintech businesses by the traditions FIs, risk of spillover and contagion increases multi-fold. This poses a big threat to the financial stability, (RBI FSB, 2017). Hence, there is an evident need of monitoring these systematic risk spillovers so that the regulatory authority can ensure the stability of the financial system.

6 Bank–Fintech Cooperation

Fintech can adapt, innovate, and evolve to meet the customer demand for a variety of financial services within a short period of time as compared to traditional banks (KPMG, 2017). Thus, the traditional banks can sustain in the long run-in financial

sector through greater digitization and technological innovations. Collaboration and cooperation among companies are essential for innovation (Economist Intelligence Unit, 2015). It is important to understand that the challenges faced by the banking sector during the present era were nonexistent earlier. The incumbents are dependent on Fintech companies for advanced, faster, and cheaper financial services. The Fintech companies are not deterred by the presence of already established institutions. Rather, these Fintech carefully select many such established institutions as partners. The innovative and inventive nature of Fintech companies is the driving force behind consumer satisfaction besides challenging and changing the business models in the banking and financial sector (Williams et al., 2008). If Fintech companies collaborate and cooperates with banks, then monitoring the Fintech companies and regulating them will become much easier as it will give the banks a better understanding of the nature and operations of Fintech companies.

7 International Regulatory Landscape

BIS committee on Global Financial System underscored the Fintech benefits in the form of efficiency improvement, better financial inclusion, and risk minimization. Nevertheless, challenges it posed to the existing business model of banks due to platform-based lending cannot be ignored. Risks arising out of disruptive business models need to be assessed by understanding the Fintech innovation and how banks are adopting new technologies through scenario analysis and case studies.

Financial Standards Board through its financial innovation network has pointed to the major concern relating to decentralization of financial system owing to disintermediating role of Fintech companies. This is likely to pose threat to overall financial stability, emanating from novel ideas like peer-to-peer lending.

Committee on Payments and Market Infrastructure (CPMI) addressed issues relating to digital innovation in the area of digital currencies, payment system infrastructures such as distributed ledgers and blockchain technology.

European Union Taskforce on financial technology is working on developing a compressive plan to study challenges while World Bank Group is creating a framework for the activities of the SMEs operating in this domain. Irving Fisher Committee (IFC) Working Group (2020) on Fintech Data Issues deliberated on various issues relating to monitoring this financial innovation. The committee recommended setting up of systematic statistical information system. The regulatory reform process is likely to slow down the pace of Fintech evolution through continuous mutation of financial ecosystem. It will impart the required time for the financial systems to adopt to the digitalization in a nondisruptive way. However, this process demand reduced resistance to change and opposition to consumer-centric reforms and priority for long-term gains over short-term convenience.

8 Shift from Activity-Based Regulation to Entity-Based Regulation

With big technology companies entering financial space, the distinction between finance and nonfinance companies has started disappearing. According to RBI governor's speech at Global Fintech Festival 2021, these Fintech companies in credit and deposit domain though can address the spatial gap, but they cannot bridge the temporal gap in deposit mobilization and credit creation. Hence, they need to be subjected to same regulatory regime as banks. These companies can be identified as enablers or partners and banks can leverage upon these functionalities of Fintech companies. Reserve Bank of India (2017) working group report underlines the risks to the profitability of the existing market players. It is likely to create tough competition with lesser entry barriers in this industry. Further, the IT risk events arising from high degree of interdependence between IT firms and financial service providers can culminate into a full blown systematic crisis. Hence, there is a need for further upscaling of supporting infrastructure like NEFT and RTGS apart from basic infrastructure provided through IDRBT and NPCI.

9 Conclusion

Economic theory of regulation has two schools of thoughts namely, theory of public interest and theory of regulatory capture. According to these theories, regulation stems from the need to check anticompetitive practices, market failures and promote public interest. Regulation is a tool to control human/societal behavior through the framing of rules or issuance of orders by regulatory bodies to control the activities detrimental to societal wellbeing, Richard & Posner (2004).

According to Sankar (2021), diversity in the services provided by Fintech companies demands for widening the regulatory boundaries. As the financial value chain is continuously evolving, the legal system has to adapt to this pace. With the rapidly evolving Fintech ecosystem and a strong interplay between financial system and economy, financial innovations have posed many challenges to the economic systems all over the world. The 2008 subprime crisis has exposed the weak links between the financial intermediation through the innovative way of bundling subprime loans into collateralized debt obligations (CDOs) (Chambers et al. 2011). This jeopardized the stability across global financial system.

Fintech is a boon as well as a bane for the modern world economy. On one hand, it facilitates financial services that are innovative, cheaper, and easier, improved access to financial services and better financial inclusion on positive side. On the other side, the Fintech companies disrupt the services of the traditional financial institutions and bring forth new threats like digital frauds, leakage of sensitive information, credit risk and large-scale cyberattacks, threat to monetary transmission mechanism in cryptocurrency-based payments. This chapter focused on identifying

the challenges faced by the regulators in regulating Fintech companies. Fintech services have become inevitable and indispensable part of everyone's life in the form of digital wallets and transactions, easy credit and debt activities, insurance services, P2P lending, and investment services. However, the evolving nature of financial services industry amidst technological innovation has several spillover risks and threats to the financial stability of an economy.

The key challenge with regulating Fintech companies is that "one size fit all" policy cannot be taken by regulators. Another issue is with Fintech services provided across international boundaries and lack of uniform regulation across countries to tackle any fraudulent activities and malpractices occurring beyond jurisdictions of various regulators. There is a huge gap in data availability on Fintech activities relating to monetary policy transmission, payments, and settlements. Besides, segregation of information related to Fintech services becomes very difficult as to diverse nature of services. There is also a difficulty in tracking the financing activities parallel to those of traditional financial intermediaries. Hence, the regulators face several impediments in regulating the Fintech companies effectively.

The Fintech companies were initially not regulated since they were not considered a threat to the financial sector of world economies. Given the current global scenario wherein Fintech services have become very popular among the consumers of these services as well as the producers and SMEs. There has been an increased adoption of financial services by emerging economies led by the USA, India, and China where majority of the Fintech companies are located. In order to tackle various challenges, a comprehensive regulatory framework is the need of the hour. Besides, same set of regulatory practices may not work for all Fintech companies since there are various types of Fintech based on the nature of financial services they provide. In this context, a progressive and moderate regulatory measure ensuring the balance between innovation and risk mitigation is required. Other ways include incentive-based regulation and imposing different intensities of penalties for noncompliance. However, for this to work the product managers should collaborate with the innovators to ensure regulatory compliance. A dedicated organizational structure has to be set up for designing stepwise regulatory reforms. Collaboration between regulatory bodies and Fintech companies can also provide an effective monitoring of Fintech companies and regulating them. There is an urgent requirement for data integration by linking the Fintech companies and financial intermediaries.

To summarize, experts in the USA and overseas have undertaken several studies on the development, hazards, and regulations of Fintech, creating a solid framework for this study, but further research is needed. Most of the current research focuses on qualitative analysis and analyzing the behavior of significant Fintech industry participants is insufficient.

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The Dematerialization of Money in the Age of COVID-19 Pandemic: A New Future for Digital Finance?

António Portugal Duarte

1 Introduction

The last 20 years have been marked by very important events in the functioning of the international monetary and financial system. On the positive side, Europe witnessed the creation of the Economic and Monetary Union and the introduction into circulation of the European single currency, which facilitated exchanges within the European space and eliminated the possibility of issuing currency by European central banks, leaving this responsibility in the hands of a supranational monetary authority, the European Central Bank (ECB). On the negative side, the world experienced the financial crisis of 2007–2008, the sovereign debt crisis and, more recently, the brutal economic and social shocks caused by the SARS-CoV-2 coronavirus. The disease was defined as COVID-19 pandemic by the World Health Organization (WHO) on February 11, 2020.

This chapter aims to analyze one of the most important developments in the international payment systems in the age of COVID-19 pandemic crisis, the so-called dematerialization of money. This phenomenon takes place when the traditional physical coins and banknotes issued by the central banks are replaced by noncash transactions carried out by centralized or decentralized electronic and digital means of payment.

Our main purpose in writing this chapter is to investigate to what extent the recent context of COVID-19 pandemic crisis contributed decisively to accelerate the course of money dematerialization in the last few years, namely following the introduction of new technologies arising from the use of modern electronic and digital payment systems, such as cryptocurrencies.

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For this purpose, some behavioral dynamics are analyzed regarding different forms of noncash payments used in the last 20 years, such as credit transfers, direct debits, e-money, cheques, and card payments. A closer examination of electronic transactions in the European Union stock exchanges will be also carried out. Both investigations will be complemented by a descriptive statistical analysis in the more particular scope of the functioning of cryptocurrency market.

From this research, we believe that we can draw some prospective implications for the future of digital finance, specifically in the context of the European integration process that is expected to be reinforced by the emergence of new digital payment systems.

We refer specifically to the so-called Central Bank Digital Currency (CBDC), an expedient still in a pilot phase, but which in the short term could represent an alternative innovation for international financial markets. In addition to allowing less costly and more generalized exchanges in relation to physical currencies, the CBDC is also backed by monetary authority or government, thus ensuring greater transparency, supervision, and the maintenance of the monetary policy instrument. Undoubtedly remarkable advantages when compared to other forms of digital payments, namely cryptocurrencies.

Similar to other studies recently developed to analyze the impact of COVID-19 pandemic on financial markets and on the process of dematerialization of money (see, e.g., Hadad & Bratianu, 2019, Guzmán et al., 2021, and Samut & Yamak, 2021), it is our expectation that the pandemic crisis has accelerated this process.

However, to some surprise, our results seem to point in the opposite direction. If it is true that following the COVID-19 pandemic electronic transactions have seen a gain in importance, a more particular analysis of the cryptocurrency market has also shown that the daily trading volumes of the major cryptocurrencies suffered a negative impact as a result of the pandemic.

Despite the negative impact of COVID-19 pandemic on cryptocurrency market, digital payments seem to be the future for international capital markets, namely through the introduction of CBDCs. The recent pilot project announced by the ECB in July 2021 to launch a digital euro in the euro area is a good indication of this reality. As mentioned by the ECB, a digital euro will guarantee that economic agents in the euro area can maintain costless access to a simple, universally accepted, safe, and trusted means of payment. It should be noted that the digital euro would still be a euro, like banknotes and coins of the central bank, but digital. The Euro system would continue to ensure that economic agents would have access to cash across the euro area but giving an additional choice about how to pay and make it easier to do so, thus contributing to more accessibility and inclusion in the European digital payment system.

The remainder of this chapter is organized as follows. Section 2 briefly describes the dematerialization of money since commodity currency to digital means of payment, such as cryptocurrencies. Section 3 analyzes the impact of COVID-19 pandemic on the cryptocurrency market. Section 4 provides a prospective analysis of what the future of digital finance will look like. Finally, Section 5 draws some conclusions.

2 The Dematerialization of Money

The emergence of money scripts the end of primitive economies, characterized by the direct exchange of goods, allowing the growth of transactions, and the development of modern societies. Money has come to be at the heart of payment systems, but over the years it has not always taken the same form. As exchanges developed, due to their characteristics of utility, durability, divisibility, and transportability, various goods were being used as money, namely skins, shells, cattle, rice, gold, metal, paper, cheques, credit and debit cards, and more recently, "virtual and digital goods," such as e-money and cryptocurrencies.[1] From regular cash transactions to wire transfers and QR code links, payment systems have been recently evolving both online and offline, but mainly online.

We are in the presence of an authentic monetary revolution characterized by a successive dematerialization of money and an increasing use of digital payments that the COVID-19 pandemic seems to have boosted, namely through the rise of contactless payments and online transactions. The outbreak of SARS-CoV-2 was declared a pandemic by the World Health Organization (WHO) on March 11, 2020, after being initially reported in December 2019 in Wuhan—China's seventh largest city—following its rapid widespread, and since then several changes have taken place in the way in which economic agents began to carry out transactions. The desire for a cashless society capable of solving many of our current transaction problems is such that at the beginning of the COVID-19 pandemic, the use of financial applications in Europe increased by 72% in just a week (European Commission, 2020).

The dematerialization of money occurs when banknotes and coins are replaced by electronic payment transactions. We move to a society where the mean of payment has lost its physical shape, and is represented virtually by a number or digital code. Digital innovation is currently the main driver of the process of dematerialization of money and the main reason why many economic agents imagine a society where there is no cash (Hadad & Bratianu, 2019).

Although this process has become more visible in the daily lives of citizens following the COVID-19 pandemic, the dematerialization of money is not a new phenomenon. Over time, the so-called "real" money, i.e., coins whose value is tied to the weight of the precious metal that is present on them, usually gold for the highest value transactions, and silver, bronze, and copper for the remaining transactions, was turned into fiduciary (fiat) money, whose value is declared by law or government regulation and not intrinsically. This monetary form or payment system is therefore supported by the trust of economic agents in the face (nominal) value of the material that supports the currency, for example, a banknote.

A new step in the dematerialization of money was taken with the end of the classical gold standard system. When this payment system was instituted, the

[1] Eichengreen (2019) presents an excellent historical perspective of the different evolutionary forms of money from commodities to fiat money, and currently to cryptocurrencies.

amount of money countries put in circulation was based on the gold reserves held by their central banks. Each currency had its value fixed in terms of ounces of gold, making this precious metal the main reserve asset of central banks. The monetary authorities undertook to keep the price of their currencies fixed in terms of gold, except, e.g., following a war, a financial crisis or a shock in the terms of trade. In the event of a war, governments could suspend gold convertibility and issue paper money to finance their expenses. On the other hand, in the event of a financial crisis or a shock to the terms of trade, the application of the so-called "escape clause" could give rise to a suspicion that discretionary actions were being taken by monetary authorities (Duarte, 2015). However, following the collapse of the classical gold standard, minting money no longer depends on holding a material good. At the same time, bank current account balances, whose value is determined by bank scripts, led to the emergence of scriptural money, devoid of any physical existence.

Scriptural money is the name given to bank deposits that can be used as a means of payment by cheques, debit and credit cards, or by transfer between deposit accounts, not corresponding to any physical transfer of money, involving simply a shift of credit from one bank to another through scripts. It is important to note that scriptural money is also fiat money, as its acceptance and circulation depend on agents' confidence in its value. However, unlike fiat money, this payment system does not have legal tender.

The dematerialization of money continued during the Bretton Woods international monetary system, stimulated by the growing need for new forms of payment, not only to cope with the growth of international exchanges and the increasing debt of the United States, but also to respond to the need for reconstruction of European and Japanese economies in the aftermath of World War II. The European integration process that followed, and the desire to create the European single currency, issued and supervised by a supranational central bank, accelerated this course. If initially, the discovery of the steam technique contributed decisively to the improvement of the minting of new coins, more secure and divisible, but also to the extraction of the precious metal that sustained them, the dematerialization of money was strongly encouraged with the development of the telephone industry and the increasing use of prepaid telephone cards.

New technological innovations followed, not only in the telecommunications and banking sector, but above all in financial system, especially in developed countries, with an enormous impact on the growth of electronic transactions within the scope of capital markets, namely with the invention of the first digital pricing system that marked the transition from traditional systems based on shouting, the telephone or telegraph transactions, to automated systems founded on electronic means of communication, of which the most important example is the Internet.

The Internet and the new electronic and digital devices such as mobile phones, websites, microprocessors, tablet computers, flash drives, Random Access Memory, machine learning, cloud computing, or big data analytics have in fact deeply transformed transactions, allowing economic agents to use more alternative forms of payments, like cryptocurrencies or virtual wallets, but at the same time they also raised new problems, namely related to cybersecurity and the possibility of using

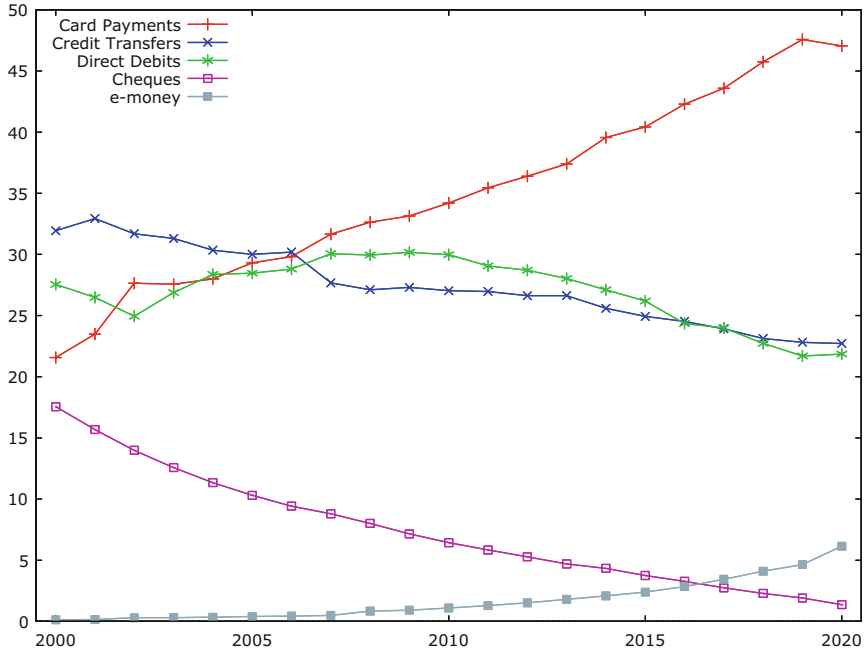

Fig. 1 Number of noncash transactions in euro area (billions of euros). *Note.* Author, using data from the European Central Bank (https://www.ecb.europa.eu) and Statista (https://www.statista.com/)

these payment systems in criminal activities (Aldridge & Askew, 2017; Durrant, 2018; Cuervo et al., 2019; Swammy et al., 2019, and Choi et al., 2020).

If those new payment systems started as a tentative way to make transactions both online and offline easier, they surely have grown to become an essential service. New consumer habits and behaviors related to money and payment systems emerged, but the adoption of noncash transactions seems to have come to stay or even accelerate following the COVID-19 pandemic.

Figure 1 shows the number of noncash transactions (payments) per year in billions of euros in the euro area from 2000 to 2020, year of the outbreak of SARS-CoV-2 disease. These transactions comprise the main types of noncash payment services used in euro area, like card payments, credit transfers, direct debits, cheques, and e-money issued by resident Payment Service Provides (PSPs).

As can be seen from the figure, in line with the process of dematerialization of money that has been operating in the last few decades, transactions with cheques have gradually lost importance over time. Some relative loss of importance can also be observed in credit transfers and direct debits, although they continue to be two of the main forms of noncash transactions in the euro area. In the opposite direction, there has been a successive increase in the relative weight of card payments and e-money transactions, with the latter even surpassing the use of cheques. Although the availability of data does not allow us to assess with a high degree of certainty the

impact that the COVID-19 pandemic had on this type of transactions, with the exception of e-money payments and direct debits, the figure shows that all the other (more traditional) forms of payment services were relatively less used as a result of the pandemic.

Table 1, which documents the electronic transactions (millions of euros) in 24 European Union stock exchanges in the period 2016–2018, helps us to better understand the importance of e-money transactions following the dematerialization of banking products and services that happened in European capital markets some years before the outbreak of the COVID-19 pandemic.

As can be seen, the importance of electronic transactions in the 24 European Union stock exchanges increased on average by 22% from 2016 to 2018, and the total volume of transactions also increased on average by 19.3% per year is clear evidence of the widespread process of dematerialization of physical central bank currencies following the increasing use of electronic payment instruments. More particularly, in what concerns the number of transactions, the highest average growth rates were recorded for the Hungarian stock exchange (11.5%), the Swiss stock exchange (13.2%), the Norwegian stock market (17.1%), and the Aquis Exchange stock market (67.2%), the pan-European independent company based in London. With regard to the total trading volume, the highest average growth rates were recorded for the Norwegian stock exchange (12.4%) the Romanian stock exchange (14%), the German stock market (14%), and the Aquis Exchange stock market (56.5%).

Some of these European stock exchanges have also experienced a loss of importance in electronic transactions. However, in most cases, these are stock exchanges with lesser activity in the context of the European capital markets, so, despite having registered negative average growth rates both in the number of transactions and in the trading volumes, their performance does not invalidate the general conclusion of successive gain in importance from electronic transactions instead of the transactions using the so-called "traditional" currencies.

Currently, along with the increasing use of electronic (e-money) transactions, as a resilient reaction to the restrictive policy measures taken to respond to the COVID-19 pandemic (lockdown, quarantine, testing, etc.), and the consequent disturbances occurring in the international value chains,[2] the dematerialization of money also operates through other types of dematerialized money, the so-called virtual money, and digital money, namely in the context of the increased popularity of cryptocurrency market.

The following section is precisely dedicated to the analysis of the impact of the COVID-19 pandemic on cryptocurrency market in order to assess the extent to which the dematerialization of money has accelerated due to the pandemic or, on the contrary, like what happened with transactions using central bank currencies,

[2] Using a counterfactual analysis, Duarte and Murta (2022) examine in detail the macroeconomic impacts of the COVID-19 pandemic in the European Union (27 countries) and, particularly, in four of its economies: Germany, Spain, Italy, and Portugal.

Table 1 Electronic transactions in European Union stock exchanges

	2016		2017		2018		AGR 16–18 (%)	
Market	T	V	T	V	T	V	T	V
Athens SE	4,639,181	12,879,1	4,329,400	11,387,1	4,997,273	10,774,5	3,8	−8.5
BME	54,135,347	618,930	50,726,794	619,121,2	44,027,990	548,576,7	−9,8	−5,9
Boerse Stuttgart	1,392,773	16,859,7	1,668,538	18,310,2	1,647,235	16,192,1	8,8	−2
Bucharest SE	650,161	1640,9	797,687	2006,1	534,245	2132,7	−9,4	14
Budapest SE	1,346,828	7347,5	1,743,560	8688	1,675,559	8673,7	11,5	8,7
Bulgarian SE	53,936	176,3	75,636	315,7	49,322	183,7	−4,4	2.1
CEESEG - Prague	895,979	6213,2	776,574	5269,4	705,619	5551,4	−11,3	−5,5
CEESEG - Vienna	6,625,672	27,975,7	6,766,881	33,376,9	5,565,691	35,220,1	−8,3	12.2
Cyprus SE	31,893	78,2	26,533	57,7	24,238	48,7	−12,8	−21,1
Deutsche Börse	137,827,209	1,184,365,5	140,309,311	1,300,956,4	133,379,663	1,538,059,9	−1,6	14
Equiduct	10,071,313	57,041,2	8,155,569	50,366,6	6,302,306	41,896,4	−20,9	−14,3
Euronext	222,889,417	1,601,434	234,549,334	1,707,503	224,413,457	1,864,832	0,3	7.9
Irish SE	3,217,679	23,543,2	3,208,095	24,142,8	3,681,557	28,063,3	7	9.2
Ljubljana SE	81,629	322,2	49,189	334,5	30286.335	327,682	−39,1	0,9
LSE group	322,394,903	2,070,377,9	326,186,000	2,051,513	340,371,000	2,142,651	2,8	1,7
Luxembourg SE	9006	74	10,129	78,2	7786	81,6	−7	5
Malta SE	10,092	77,8	10,249	88	10,401	86,2	1,5	5,3
Nasdaq N & B	115,437,788	643,951,1	135,534,625	704,425,3	152,687,281	718,564,9	15	5,6
Oslo Børs	22,908,399	98,041,5	24,573,226	103,311,8	31,436,761	123,861,2	17,1	12.4
SIX Swiss SE	44,668,529	782,500,6	48,273,205	835,178,5	57,250,643	814,829,6	13,2	2
Warsaw SE	18,433,081	43,664,8	20,888,240	55,819,4	18,807,486	48,310,7	1	5.2
TASE	12,440,273	47,297,5	15,566,299	59,016	15,203,796	55,181	10,6	8
Aquis SE	17,435,889	105,704,1	29,950,776	168,355,2	48,731,116	258,947,6	67,2	56.5

(continued)

Table 1 (continued)

	2016		2017		2018		AGR 16–18 (%)	
Market	T	V	T	V	T	V	T	V
Turquoise	288,275,651	1,223,924	195,764,176	809,669,0	147,314,485	621,097	−28,5	−28,8
Total	1,223,654,402	7,916,586,4	1,758,009,931	10,688,479,2	1,822,724,861	11,261,536,6	22	19,3

Note. Adapted from Hadad and Bratianu (2019). "AGR" is the average growth rate; "T" is the transactions; "SE" is the Stock Exchange, and "V" is the volume (millions of euros)

also ended up negatively affected by the economic crisis that took place, in such a way that similar to what was observed by Umar and Gubareva (2020), Majdoub et al. (2021), and Umar et al. (2021) it is possible to conjecture the existence of a negative interdependence and transmissibility between fiat currencies and cryptocurrency markets from the perspective of contagion, reducing consequently the role of cryptocurrencies as safe havens during periods of economic turbulence, such as the SARS-CoV-2 outbreak.

3 The Impact of COVID-19 Pandemic in Cryptocurrency Market

In line with other forms of digital payments such as mobile wallets (cell phones and smartwatches), money transfers through mobile payment service apps and QR codes (e.g., PayPal, Venmo, and Zelle), and online-based purchases (e.g., browsers or apps), the growing activity of cryptocurrency market is also well illustrative of the dematerialization process of money. The cryptocurrency market trades around the clock 24/7, being exchanged thousands of units of the more than 6500 cryptocurrencies that currently exist in digital financial markets.

The growing total market capitalization value and the increased use of cryptocurrencies have attracted the attention of several economic agents, who in reaction to the growing financial regulation following the international financial crisis of 2007–8 showed a great interest in the development of new services provided by technological innovations inherent to the use of cryptocurrencies. Many saw the technology and anonymous and decentralized nature associated with cryptocurrencies as an opportunity to obtain alternative financing to traditional capital markets. At the same time, this new form of payment could also mean replacing the "old" fiat money by other more flexible and lower-cost payment alternatives, thus revolutionizing the dematerialization process of money and the way in which the international financial system works.

However, despite the great popularity of cryptocurrencies among economic agents, everything seems to indicate that the growing trend toward the use of this type of digital currency has been reversed with the emergence of the COVID-19 pandemic, as this health crisis represents the largest episode of global turmoil since the 2007–8 international financial crisis. Similar to what happened with the so-called "real" currencies, the supply and demand shocks caused by the pandemic context have also contributed to a reduction in the volume of transactions using cryptocurrencies, creating naturally new challenges and uncertainties for digital finance.

The cryptocurrency market suffered a collapse on March 8, 2020, caused by the massive sale of cryptocurrencies, resulting in a loss of $21 billion in the total capitalization value of cryptocurrency market in just 1 day and led to the so-call "Black Monday" in the stock market on March 9 (Umar et al., 2021). Certainly, one

of the main reasons for the collapse of this market was that many of the European countries and various cities in China were already in quarantine, and the rest of the world was considering similar policy measures. Just 2 days later, on March 11, 2020, the situation in cryptocurrency market worsened further when the Director General of the WHO considered the COVID-19 outbreak as a worldwide pandemic. This further alarmed the markets, including the cryptocurrency market, which on March 13, 2020, lost almost half of its total market capitalization value, thus leading to a sharp fall in the capitalization value, prices, and trading volumes of the major cryptocurrencies. The total market capitalization only recovered at the end of May, however, since then there has still been strong instability in its trading volumes.

Figure 2 presents the evolution of daily trading volumes for six major cryptocurrencies (Bitcoin—BTC; Dogecoin—DOGE; Ethereum—ETH; BitcoinCash—BCH; Ripple—XRP, and Litecoin—LTC) from February 2, 2019, to November 5, 2021.

Because all the series of cryptocurrencies are denominated in US dollar (USD), volumes are also a function of the cryptocurrencies' prices. To take out the price effect, daily volume was divided by the daily price. Therefore, volumes were measured in units of cryptocurrencies. It should be noted that this procedure introduces a measurement error because trading is done at different prices during the day. Even so, the trading volume in cryptocurrency units can be interpreted as a proxy for overall cryptocurrency market activity.

In this context, as can be seen from the previous figure, for most of the selected cryptocurrencies, everything seems to suggest the existence of a reversal of the growing trend in trading volumes following the COVID-19 pandemic, with particular emphasis on the sharp drop in the volume of transactions using the Bitcoin, Dogecoin, and Ethereum.

This reversal behavior in trading volumes of the major cryptocurrencies can be explained by the fact that the COVID-19 outbreak may lead to investors liquidating their positions, resulting in massive demand for cash. It should be noted that cryptocurrencies still exhibit high price volatility, being often sought only for reasons of speculative nature (see, e.g., Cheah & Fry, 2015, Dyhrberg, 2016, Blau, 2017, Katsiampa, 2019, López-Cabarcos et al., 2019 and Tiwari et al., 2020).[3] For these reasons, they are hardly able to fulfill one of the functions of the so-called "real" currencies, the function of storing value. Therefore, in periods of crisis or strong turmoil in financial markets, such as the SARS-CoV-2 pandemic crisis, economic agents tend to take refuge in more stable and secure applications with the aim of reducing economic uncertainty, namely seeking to hold cash or gold. Moreover, firms without ample cash at hand may have also sought cash to continue their operations during the pandemic crisis. Under these circumstances, policymakers proposed a series of stimulus measures, such as fiscal packages,

[3] The European central bank president Christine Lagarde described cryptocurrency as high speculative asset (Bloomberg, 2021). It is argued, e.g., that Bitcoin should be considered as a speculative commodity compared to "real" currencies.

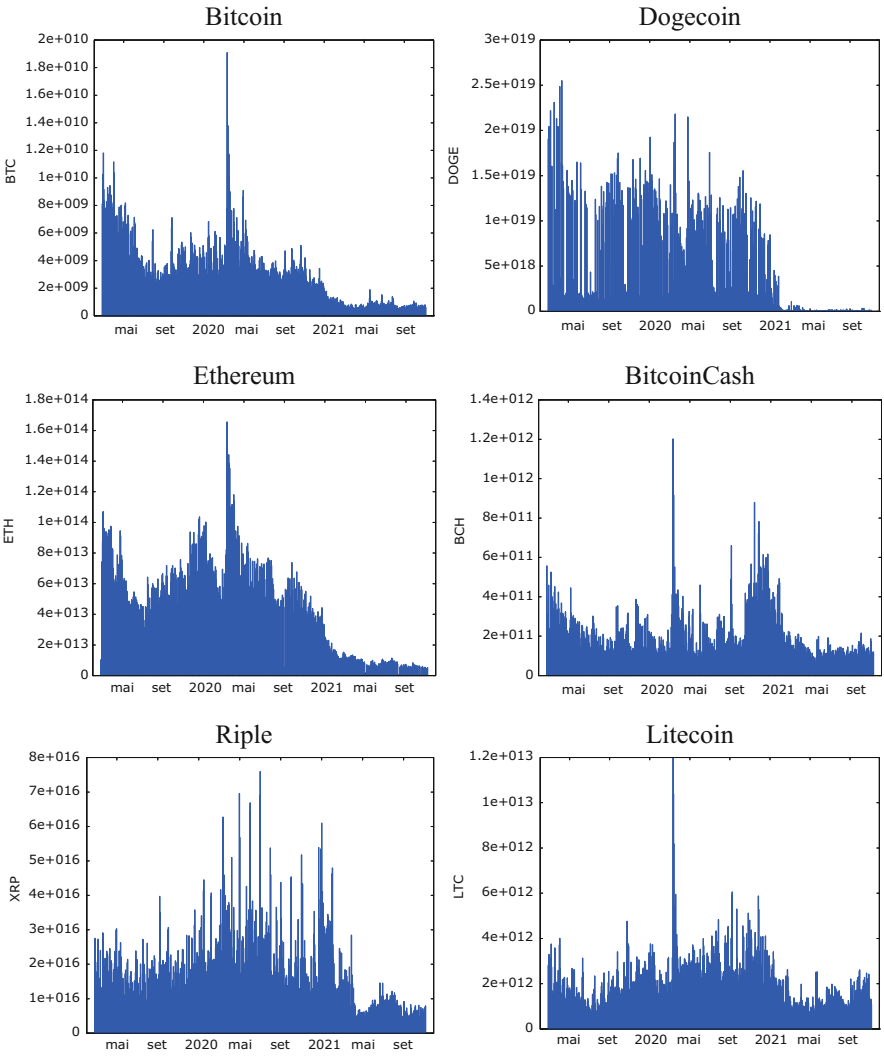

Fig. 2 Daily trading volumes for six major cryptocurrencies (27/02/2019—05/11/2021). *Note.* Author, using data from CoinDesk (https://www.coindesk.com/). Trading volumes are "1 Day Active Supply" of cryptocurrencies

adjustments to labor laws, and public sector backstops to private businesses to reduce the potential contagion effects between financial markets.

An analysis of some descriptive statistics of the logarithmic rates of change (first differences of log values) of daily trading volumes for the same set of cryptocurrencies and the same period certainly helps us to better understand these behavioral dynamics in the age of the COVID-19 pandemic. For this we will consider three different samples: (a) Pre-pandemic period (27/02/2019–11/03/

Table 2 Descriptive statistics of the daily trading volumes of cryptocurrencies

	BTC	DOGE	ETH	BCH	XRP	LTC
Pre-pandemic						
Mean (%)	−0.012	−0.581	0.540	−0.077	0.038	0.029
Median (%)	0.465	−1.581	−2.201	1.172	1.544	−1.924
Minimum (%)	−481.88	−649.91	−684.60	−307.68	−515.41	−687.55
Maximum (%)	482.80	701.11	467.09	298.78	503.28	730.33
Std. dev. (%)	107.89	190.35	158.91	105.07	120.34	132.30
C.V.	9223.9	327.38	294.70	1364.0	3162.5	4492.2
Skewness	−0.067	−0.164	−0.064	−0.092	−0.035	0.064
Exc. Kur.	6.571	0.653	2.111	1.913	4.515	6.675
Pandemic						
Mean (%)	−0.570	−0.906	−0.575	−0.387	0.406	−0.398
Median (%)	0.346	0.287	−0.076	0.404	−1.296	−2.284
Minimum (%)	−487.63	−910.92	−693.09	−925.75	−497.59	−473.99
Maximum (%)	478.31	696.98	700.78	870.22	572.36	459.36
Std. dev. (%)	100.83	189.19	189.94	113.40	117.23	110.50
C.V.	176.88	208.90	330.59	293.39	288.56	277.97
Skewness	0.001	−0.314	0.020	−0.250	0.217	−0.059
Exc. Kur.	4.502	1.863	0.860	15.971	6.029	2.544
Full sample						
Mean (%)	−0.263	−0.775	−0.070	−0.159	−0.126	−0.097
Median (%)	0.459	−0.763	−0.832	0.943	−0.313	−2.2147
Minimum (%)	−487.63	−910.92	−693.09	−925.75	−515.41	−687.55
Maximum (%)	482.80	701.11	700.78	870.22	572.36	730.33
Std. dev. (%)	103.54	189.44	178.47	110.21	118.95	119.32
C.V.	393.76	244.40	2565.3	693.39	940.56	1228.8
Skewness	−0.030	−0.256	−0.005	−0.200	0.089	0.004
Exc. Kur.	5.467	1.3951	1.269	11.602	5.357	5.113

Note. Author, using data from CoinDesk (https://www.coindesk.com/). "Std. Dev." is the standard deviation. "C.V." is the coefficient of variation. "Exc. Kur." is the Excess Kurtosis

2020); (b) Pandemic period (12/03/2020–05/11/2021), and (c) Full sample (27/02/2019–05/11/2021).

Table 2 shows the descriptive statistics of daily trading volumes of the six cryptocurrencies considered in our analysis.

As it can be observed, the differences across samples are clear, namely in the mean of the series. The comparison between the pre-pandemic and the pandemic period shows that the mean growth rates of daily trading volumes are considerably lower in the pandemic context. With the exception of Riple (XRP), which registered a higher mean growth rate in its trading volumes, in the pandemic all other cryptocurrencies have relatively more negative means, which is illustrative that the pandemic negatively affected the digital currency markets, namely cryptocurrencies, whose number of units transacted fell sharply. This situation is particularly evident in the case of Ethereum (ETH), which from a mean growth rate of trading volumes of

0.54% in the pre-pandemic period, recorded during the pandemic period a decrease of −0,575%. A significant drop in the mean of daily trading volumes was also observed in Bitcoin (BTC), Dogecoin (DOGE), and Litcoin (LTC), with the latter going from a mean growth rate of 0.029% in the pre-pandemic period, to a negative mean growth rate of −0.398% in pandemic.

Looking now at the minimum values, it can be seen, once more with the exception of Riple (XRP), but also of Litcoin (LTC), that in the pandemic period these values are relatively more extreme, again highlighting the negative impact of the COVID-19 pandemic on digital finance. The loss of importance of digital finance during the pandemic is also evident in the lower maximum of trading volumes observed in Bitcoin (BTC), Dogecoin (DOGE), and Litecoin (LTC) during the pandemic. In turn, regarding the maximum trading volumes recorded exceptionally by Ethereum (ETH), BitcoinCash (BCH), and Riple (XRP) in the pandemic period, we believe them to be simple outliers if we look once more at their behavioral dynamics in Fig. 2, but can also be explained by their relatively longer sample (of 603 observations compared to 378 observations from the pre-pandemic period).

It is also important to mention that, with the exception of Ethereum (ETH) and BitcoinCash (BCH), the remaining cryptocurrencies recorded lower volatility in the pandemic period, which naturally seems to suggest that the digital financial markets were relatively less active when compared to the pre-pandemic period, demonstrating this minor activity that similarly to what happened with some forms of payments using fiat currencies, the cryptocurrencies were also negatively affected by the COVID-19 pandemic despite its decentralized nature.[4]

These results have necessarily policy implications since these behaviors between the major cryptocurrencies and fiat currencies may require the implementation of alternative policy measures to provide greater confidence to economic agents, but above all new strategies on the part of central banks, namely to give more stability to capital markets, and to control them in periods of economic turbulence, such as the COVID-19 pandemic crisis. A good example of this reality is the recent development of the so-called Central Bank Digital Currency, a topic that we will briefly analyze in a prospective way in the following section.

4 Which Future for Digital Finance?

Digital payment systems, namely the cryptocurrencies, rapidly revolutionized international financial markets creating a world of opportunities for investors, entrepreneurs, and countries with financing difficulties. However, new technology brings also new challenges. In the absence of a supervisory regulatory framework or any central monetary authority, as well as any mechanisms to prevent fraud, digital theft, money laundering, or financing of illicit activities, the "opportunities" created by the

[4] Similar analysis can be found, e.g., in Guzmán et al. (2021) and Samut and Yamak (2021).

development of cryptocurrency market are numerous, but these are also associated with immeasurable risks and uncertainties. It is not just about the high volatility of cryptocurrency prices, but also the enormous difficulty in knowing the fundamental value of digital currencies. Its volatility and uncertainty are such that the demand for a digital currency can quickly shift to another currency, completely eroding the market value attributed to the former.

In this context, in order to reduce uncertainty and provide greater stability to digital finance, several central banks, including the European Central Bank (ECB), have recently committed to launching a digital form of fiat currency backed and issued by the central bank, the so-called Central Bank Digital Currency (CBDC). It should be noted that, if central banks did not launch their own versions of digital currency, they risk seeing tech giants, e.g., the Diem Association, which counts on Facebook as its main supporter, take over the international financial sector in the near future. Instead of printing money, through this new form of digital currency, the central bank issues electronic coins or accounts backed by the full faith and credit of the government, thus providing digital finance with alternative stablecoins.

In addition to the greater stability, these centralized digital currencies are also more cost efficient than physical central bank currencies as they have lower transaction costs. There are, however, several challenges that must be taken into consideration before a country launches a CBDC. Economic agents could pull too much money out of banks at once and purchase CBDCs, triggering a run on banks. Centralizing, through the government, a payment system designed to be private may produce backlash from users and create cybersecurity risks. Even so, CBDCs can promote financial inclusion by enabling easier and safer access to money through electronic devices, and can also help monetary policy flow more quickly and seamlessly, a possibility excluded in the world of cryptocurrencies.[5]

As we have already mentioned, there are currently more than 6500 cryptocurrencies in global digital financial markets. Some of them are also centralized, but they are not from any government. The first pilot project of government-backed stable digital currency was undertaken in January 2019 by the United Arab Emirates and Saudi Arabia that announced a bilateral CBDC called Project Aber, from which the central banks of both countries concluded that the Distributed Ledger Technology (DLT) can successfully facilitate cross-border transactions.

Notwithstanding the announcement of this pilot project, the Bahamas was the first country to effectively launch, in October 2020, a global CBDC called the "Sand dollar." In February 2021, the United Arab Emirates joined China, Hong Kong, and Thailand in a joint CBDC cross-border to test the use of DLT for foreign currency payments.

Sweden has also been testing the digital currency "eKrona" since February 2021. The goal was that "eKrona" could work as a complement to physical money and have a system of use accessible to the entire population. This happened in September 2021 when this digital currency backed by the Sveriges Riksbank became available

[5] See https://www.atlanticcouncil.org/cbdctracker/.

on a trial basis with external clients on the official website created by the Swedish government so that economic agents can buy and sell within the country or in stores abroad. It should be noted that the launch of this project was driven by the increasing dematerialization of physical money in Sweden, a fact that the central bank believes could result in situations of marginalization, with a user wanting to pay in physical money and the seller no longer accepting it. It is yet another challenge for the future of digital finance to which the COVID-19 pandemic has given a huge boost.

The UK, Japan, and the ECB are also considering their entry into digital currencies. The digitization of central bank currencies is in fact a rapidly growing process at a global level and, in particular, in the euro area. It is expected that the launch of a digital euro will revolutionize the lives of all European economic agents through the changes it will introduce in their lives, and especially in the form of how payments will be made in the future.

The digital euro project was announced by the ECB in July 2021, that is, in the midst of the COVID-19 pandemic. Nevertheless, this does not mean that the ECB will necessarily issue a digital euro immediately, but rather that it will get ready to possibly issue it in the near future, taking into account any changes in the European legislation that may have to be made. As mentioned by the ECB,[6] a digital euro will guarantee that economic agents in the euro area can maintain costless access to a simple, universally accepted, safe, and trusted means of payment. The digital euro will still be a euro, like banknotes and coins, but digital, turning the euro area into a global digital player. It will be an electronic form of money issued by the ECB and national central banks and accessible to all economic agents. A digital euro will not replace cash, but rather complement it.

The Eurosystem will continue to ensure that European citizens would have access to cash across the euro area, giving an additional choice about how to pay and make it easier to do so, thus contributing to more accessibility and inclusion in the European financial space. Using a digital euro, agents could have the same level of confidence than with physical central bank currencies, since they would be both backed by the monetary authority. A digital euro would be consequently a digital symbol of progress and integration in Europe.

Once the digital euro project is implemented, given that it is a digital finance innovation carried out by a large dominant monetary area, we want to believe that in an authentic chain reaction or by "domino effect" other central banks belonging to other monetary areas and different geographical spaces will also create their own digital currencies, continuing along this path to the global process of dematerialization of money. Consequently, in the near future, physical central bank currencies, as we know them today and with the functions they currently perform, will certainly become part of our historical memory or will only have value for more committed collectors or numismatics.

[6] See https://www.ecb.europa.eu/paym/digital_euro/html/index.en.html.

5 Conclusion

This chapter was dedicated to the analysis of the dematerialization of money in the context of the COVID-19 pandemic crisis. The dematerialization of money takes place when physical coins and banknotes issued by the central bank are replaced by noncash transactions carried out by centralized or decentralized electronic and digital means of payment.

Over the years, this process occurs naturally as a result of technological innovations in payment systems, as it happened during the gold standard system, with the introduction of the steam technique, or during the Bretton Woods system, with the development of information and communication technologies in the banking sector, but above all in financial system. Recently, the dematerialization of money become more visible following the development and popularity of cryptocurrency market, but also as a reaction to the negative demand and supply shocks caused by the COVID-19 pandemic, which led not only to the loss of importance of cash transactions, but above all to a loss of considerable importance of payments through credit transfers, direct debits, and cheques. In the opposite direction, there was an increase in the number of e-money transactions and card payments using, e.g., the new technology of contactless.

However, when particularly analyzed the impact of the COVID-19 pandemic crisis on cryptocurrency market, with some surprise it was observed that the growing trend toward the use of cryptocurrencies which had been registered since the emergence of Bitcoin in 2008 turned out to be reversed when the outbreak of SARS-CoV-2 was declared a pandemic by the WHO on March 11, 2020.

The comparison of the number of transactions in six of the major cryptocurrencies (Bitcoin, Dogecoin, Ethereum, BitcoinCash, Ripple, and Litecoin) between the pre-pandemic and the pandemic periods shows that the mean growth rates of daily trading volumes are considerably lower during the pandemic. This situation is particularly evident for Ethereum, which from a mean growth rate of 0.54% in the pre-pandemic period, recorded during the pandemic a decrease of −0,575%. A significant drop was also observed in Bitcoin, Dogecoin, and Litcoin, with this latter cryptocurrency going from a mean growth rate of 0.029% in the pre-pandemic period to a negative mean growth rate of −0.398% in pandemic.

Despite this apparent loss of importance for the cryptocurrency market, digital payments seem to be the future for international capital markets, namely through the launch of the Central Bank Digital Currencies. The recent pilot project of the ECB to launch a digital euro in the euro area is a good example of this reality, with the advantage relative to other existing digital forms of payment that these Central Bank Digital Currencies are backed by the monetary authority, thus ensuring more stability, supervision and the maintenance of monetary policy instrument, which can be fundamental in periods of economic turbulence, such as the COVID-19 pandemic crisis.

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International Financial Markets in the Digital Era

Michael Frömmel

It seems likely, then, that . . . a stock exchange can be embodied in a network of computers and the costs of trading can be sharply reduced, without introducing any additional instability in stock prices, and without being unfair to small investors or large investors.—Black (1971a, b, p87)

1 Introduction

Although financial assets have been traded for ages, they evolved to the form they have today only during the last decades. Permanent exchanges only came up during the renaissance, before to those fairs had been the dominant trading place in Europe. Those fairs, periodic meeting places for traders, were mostly concerned with real goods, but also with currencies and money. Famous fairs were held in the French Champagne in several cities (Provins, Troyes, Lagny, Bar-sur-Aube) in a rotating system. Well organized and under the protection by the Earls of Champagne they had their golden age between 1150 and 1300 (Lo & Hasanhodzic, 2010, p.25). Clough and Cole (1952) describe how financial assets were traded as a division of those fairs: *"At the beginning of the fair eight days were allowed for unpacking. Then in regular order came special divisions as they were called. . . . Then began the fair of the money changers and brokers, who sat behind their tables weighing gold and silver, examining strange coins, making loans, and collecting their debts."*

Besides those general fairs few pure currency fairs existed in Italy. The most important one took place every 3 months in Genoa (actually in Novi Ligure, north of

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Genoa), and lasted for 8 days each between 1532 and 1763 (Rime, 2003). Another one took place in Piacenza since 1622 and since 1631 the Venetians held a separate fair in Verona, and since 1633 there was one in Bolzano/Bozen (Marsilio, 2015).

The fairs were subsequently replaced by permanent exchanges or bourses. In the beginning meetings took place at the houses of rich families. The word bourse can be traced back to the Latin word bursa, meaning a leather bag for coins or wallet. Since 1409 there was a regular exchange in Bruges, and in 1453 the bourse in Bruges became its own building. The name bourse is derived from the wealthy family Van der Beurze in Bruges, which hosted traders in their house. The house still exists. In 1460, an exchange for spices was founded in Antwerp. But the bourse in Amsterdam became the region's most important one very soon. Bourses also emerged in the neighboring countries: around 1540 in Augsburg and Nuremberg, and 1585 in Frankfurt (all in Germany), and The Royal Exchange in London in 1554. Around 1602 the first shares were traded in Amsterdam, issued by the United East Indies Company (in old Dutch spelling: Vereenigde Oostindische Compagnie, VOC). The VOC raised about 6.5 million guilders, equivalent to now about 100 million US dollars. At the same time, the first banks (Bank of Amsterdam 1609, Bank of England 1694) and exchanges occurred in Europe. In 1792, traders met in New York and carried out their trades in a coffeehouse in Manhattan, which is the origin of the New York Exchange (Roll, 2006).

Since then, the trading activities at exchanges remained almost the same for the next centuries. Floor trading was the dominant trading form for equity and bonds, whereas currencies were traded as a direct trade between brokers and customers through an "open outcry" system, a mechanism matching buyers and sellers through the use of verbal bids and offer prices. Exchanges were located in many cities with usually one of them being the dominant one in the country, for the currency market London became the global trading center, using telephone brokers instead of the open outcry system.

This changed in the second half of the twentieth century. Computers were already used in the 1960s and the first automated trading system was Instinet. Introduced in 1969 and building on digital exchange-based streaming quote technology, the Instinet trading system targeted large institutional investors, who could trade pink sheet securities directly with one another in a purely electronic over-the-counter system. One of the first markets on which physical, analogous trading was replaced by electronic trading was the NASDAQ, where in 1971 fully automated over-the-counter (OTC) trading became a reality. Similar to Instinet's earlier system, the NASDAQ created a strictly digital trading arena. As a reaction the New York Stock Exchange introduced the designated order turnaround system (DOT) in 1976, which allowed customers and brokers to directly send their orders to a designated market maker instead of employing a broker. However, the DOT was restricted to small volumes with a maximum of 500 shares. Once the order was executed, the user received a confirmation report of the transaction in real time. The main advantage of the system was the increase in speed. In 1984, the system was extended to the SuperDOT system, which increased both speed and accuracy of trades. It allowed orders of up to 99,999 shares (if limit orders) and limit orders were on average

executed within 28 s (Siebers & Weigert, 1998). In 2009, the system was completely replaced by the Super Display Book (SDBK) for displaying, recording, and executing orders for securities. The SDBK is a sophisticated computer program that facilitates the transmission of both market and limit orders directly to the trading post, and designated market makers. As such it increases speed and accuracy and helps control risk. In 2012, it was followed by the Unified Trading Platform.

In the 1990s Electronic Communication Networks (ECN) emerged, which allow customers to trade with each other. Customers transmit their orders to the system, and if possible, these are matched with orders by other customers outside the exchange, or if there is no matching order transferred to the exchange. ECN led to a substantial decrease in execution time and costs and enabled automated trading for institutional investors (Lhabitant & Gregoriou, 2015).

Subsequently, electronic trading became the dominant trading system for most exchanges over the world, with the London Stock Exchange being the pioneer on the European continent. This was part of a large-scale program including deregulation and restructuring in 1986, the so-called "big Bang" (Poser, 2001). Electronic Trading quickly gained ground. The Borsa Italiana introduced electronic trading in 1994, in 1997 followed by the Toronto Stock Exchange and the Frankfurt Stock Exchange. A milestone was 2020 when the New York Stock Exchange closed their trading floor temporarily due to the COVID-19 pandemic. Even if that remained a temporary step, it would further increase the acceptance of electronic trading.

This leads to the question of what the term "electronic trading" means. As the Bank for International Settlements [BIS] (2001) points out, electronic trading comprises a huge range of potential activities, starting from electronic order routing, i.e., the delivery of orders from users to the execution system (or dealer as in the New York Stock Exchanges Designated Order Turnaround System—DOT—of 1976), automated trade execution, i.e., the step from orders into trades, electronic dissemination of pre-order (such as information on the order book, including the bid-ask-spread and the depth and breadth of the limit order book) and post-order information (such as availability of transaction prices and volumes and market impact). Markets can, therefore, be electronic at increasing levels, which may substantially differ between asset classes, but also marketplaces within one asset class, which refers to a broad definition of electronic trading. A narrower definition is limited to systems that include all of the above aspects, in particular the trade execution itself.

The BIS (2016) assessed the degree of electronification for various market segments between 2012 and 2015. For all asset classes the electronification substantially increased but to different degrees. As a general guideline, we can state that markets with high liquidity and fungible assets, which are standardized and interchangeable, are those who most quickly and easily adapted to electronic trading. Accordingly, forerunners have been derivatives, CDS, equity, and the foreign exchange spot market (on which we will focus later in this chapter). With degrees of electronification in the range of 70–90% the BIS refers to them as fully electronic markets. Many other markets, such as the markets for US treasury bills, European government and covered bonds, and other FX market segments (forwards, options,

and swaps) are regarded as significantly electronic with an electronification of more than 50%.

Electronic trading has changed markets substantially, the effect of its introduction was "not merely to build a better telephone" but creating a new way of trading (BIS, 2001), whose impact on the market is manifold and will be discussed in the following section.

2 Impact of Electronic Trading on the Market

2.1 Impact on the Market Structure

The impact on infrastructure comprises *speed, liquidity,* and *accuracy*. The main effect of electronic trading on the trading process itself is an enormous increase in speed. The NYSE's DOT system allowed trades to be executed within 28 s on average (Siebers & Weigert, 1998), which was an extraordinary increase in speed. Hendershott (2003) reports execution times of slightly more than 20 s through an exchange and 2–3 s through an ECN. In the meantime, trade execution has been reduced to less than 300 microseconds (Ding et al., 2014), nowadays trading platforms advertise execution times measured in milliseconds. Trading speed is crucial for automated trading, or high-frequency trading, hereafter HFT (Menkveld, 2016). HFT does not necessarily require highly sophisticated models, but rather relies on speed (Virgilio, 2019), or as Arnoldi (2016, p46) states: *"priority is granted to speed rather than sophisticated data processing … algos get faster but not smarter."*

HFT has gained ground since the turn of the century and now is responsible for a large fraction of the total trading volume. Estimates, however, differ substantially. Kaya (2016) estimates that in 2014 HFT accounted for about 50% of the trading volume in the USA and 35% in Europe (after a maximum of 60/40% in 2009/2010). Similar values have been estimated by the Bank of England (Haldane, 2010), which finds a lower share of 5–10% for Asia, and the SEC (2010) or Miller and Shorter (2016). Few authors estimate the share of HFT to be in a range of 70% to more than 80% (Adamska, 2021), reflecting not only trading algorithms but also algorithms executing customer orders (Glantz & Kissell, 2014).

However, the profits from HFT have been eroding since their peak around 2008–2010: While in the earlier days an HFT could state that they never experienced a negative daily return for a period of 4 years (Patterson, 2012a, b), Cookson (2013) reports for the USA a decline from 5 billion USD in 2009 to 1.25 billion USD in 2012, while Kaya (2016) estimates profits in the USA of 7.2 billion USD in 2009 and 1.3 billion USD in 2013. One reason may be the increased competition in this sector (Boehmer et al., 2018), which expelled smaller and less powerful competitors from the market. Profits in HFT rarely exceed a few cents per trade and only get significant, when millions of trades are performed per day. In a segment that lives from small price differences or price movements, a market with more advanced

technology is harder to beat and profit opportunities become scarcer. At the same time, small differences in speed become increasingly important: when the execution time is in the range of milliseconds, few delays matter, which may occur due to physical limitations. Distance from the trading place starts to matter, and a *"costly arms race has begun for telecommunications and networks links that can give traders a competitive edge as small as a few tens of microseconds"* (Schneider, 2011). Based on the observation that traders far away from the (electronic) exchange are at a disadvantage (Garvey & Wu, 2010), traders engaged in HFT are ready to pay for proximity and aim at placing their computers close to the exchanges' data centers. When the NYSE moved its data center to Mahwah, N.J., they also let space for trading forms and could ask premium prices for that (Schneider, 2011).

The rise and (partial) fall of HFT is pretty much in line with Andrew Lo's (2004) adaptive market hypothesis: the introduction of electronic trading was the technical innovation that changed the environment and allowed traders to evolve into a new species—high-frequency traders—whose population exploited this nutritious food source, grew, and competed. The best-fitted firms survived whereas the profit opportunity eroded.

While costs for HFT increased during the last years due to increased competition, electronic trading led to falling trading costs in general due to labor-intensive processes by computers (Allen et al., 2001). The reduction in costs is estimated to be in the range of 50–75% (Domowitz & Steil, 2002). Besides those direct cost effects, implicit costs decrease. These are reflected in the bid-ask spread, which—besides a component covering the trading costs—covers the inventory risk component (the risk that the fundamental value changes into an unfavorable direction during the holding period), and the adverse selection component (the risk that the counterpart in the trade has private information). While electronic trading reduces the trading cost component directly, see above, the inventory cost component is reduced by the additional liquidity provided by high-frequency liquidity providers. The adverse selection component may decrease due to higher transparency.

Therefore, all the aspects of electronic trading—*electronic order routing, automated trade execution, electronic dissemination of pre- and post-order information*—have the potential to reduce trading costs.

2.2 Impact on Price Quality

Besides the cost-reducing effect of electronic trading, one may also expect an increase in the accuracy of the trading process. As accuracy, we understand the ability to avoid mistakes that inevitably occur as long as humans are involved in the process. Such mistakes led to a few spectacular cases of price distortions (all examples are taken from Bremser, 2012):

- In October 2002, a market maker confused euro and pound sterling when trading Ryanair shares. As a result, the share price jumped by 61 percent.

- A trainee at Mizuho (Japan) intended to sell 1 share of the Japanese telecom firm J-Com at 610,000 yen, but instead he sold 610,000 shares at the price of 1 yen each. What is remarkable is the market impact: Because it was too late to stop the deal, he caused a loss of 224 million US dollars while the Nikkei fell by 2%.
- In May 2001, a dealer of Lehmann Brothers in London sold blue chips. By mistake and for whatever reason he always sold 100 times as many as intended. As a consequence, the FTSE100 fell by 120 points, which was equivalent to (although temporary) loss in market capitalization of 30 billion pounds sterling. In the aftermath, the supervisory authorities sentenced Lehman Brothers to a penalty of 20,000 pounds.

Summing up, positive effects of electronic trading include an increase in market liquidity and smaller bid-ask spreads through reduced costs, less adverse selection due to higher transparency and a faster price discovery (Hendershott et al., 2011; Hendershott & Riordan, 2013). HFT may particularly contribute to the increase in liquidity.

However, it turned out that mistakes still occur in an electronic trading environment. While this is no longer related to "fat fingers" (Bremser, 2012), they rather occur due to errors in the (mostly) trading algorithms (Adamska, 2021).

As Perez (2013) reports, on August 1, 2012, an erroneous algorithm occurred at the US firm Knight Capital Group, which was active at the New York Stock Exchange as well as at the NASDAQ and which at that time had a market share of 17%. As the largest US equity trader Knight Capital engaged in market making, electronic execution, and institutional sales and trading, their daily trading volume was more than 3.3 billion trades with a volume of more than 21 billion USD. Dolfing (2019) describes what happened on August 1, 2012:

On that morning, a new trading software was installed which contained a flaw, that only became apparent after the opening of trading at the New York Stock Exchange. The algorithm caused purchases of a wide variety of 150 different stocks at a total cost of around 7 billion USD. Knight capital now had the option to cancel the orders or to sell the purchased stocks immediately. The first option, cancellation, failed for most stocks, because the SEC chair Mary Schapiro declined the request based on the SEC's rules. So, the second alternative was the only remaining option. In order to avoid the prices to be massively forced down, Knight Capital decided to sell all the acquired stocks to Goldman Sachs, who offered to pay a price that left Knight with a loss of 440 million USD. Although Knight received a capital infusion of 400 million USD one week later, Knight Capital was acquired one year later by their competitor Getco LLC.

This was not the only incident of that kind: Following a similar pattern, the Chinese state-owned broker Everbright Securities C. caused price jumps at the Shanghai Stock Exchange when design flaws in their trading system had triggered huge buy orders of 23.4 billion CNY, equivalent to 3.82 billion USD. The Shanghai Composite Index jumped up by more than 5% within 3 min on August 16, 2013. As a result, China's supervisory authorities slapped fines totaling 523 million CNY

(84.75 million USD) on Everbright. Besides the fine the company lost the equivalent of 31.7 million USD in the trades (Kauffmann et al., 2015).

Turning to HFT again, negative effects of HFT that are found in the literature are increased volatility (Lewis, 2014) and the risk of mispricing (Jarrow & Protter, 2012). Automated and high-frequency trading also enables market participants to apply sophisticated methods of price manipulation, such as spoofing and order stuffing (Lee et al., 2013) and may increase the danger of flash crashes (Patterson, 2012a, b). Kirilenko et al. (2017) analyze the flash crash on the e-mini S&P 500 stock index futures market of May 6, 2010, and concluded that during that flash crashes non-designated high-frequency market makers did not adjust their behavior to liquidity imbalances. They refer to flash crashes as the *"new normal."* However, the latter point is disputed in the economic literature without a clear consensus (see the extensive discussion in Menkveld, 2016). Jacob Leal et al. (2016) find both a crucial role in the occurrence of flash crashes and also in the fast market recoveries after such crashes.

2.3 Impact on Market Stability

Efficiency, liquidity, order, and resiliency enhance financial stability (BIS, 2001). We already discussed some of these aspects, in particular, liquidity and efficiency: electronic trading increases liquidity on financial markets and also has the potential to do the same for efficiency because the higher transparency increases access to and supports the dissemination of information. The same applies to lower costs, which allow to adjust prices to even smaller changes in fundamentals. However, this line of argument has some caveats:

First, increased efficiency may go along with higher, undesired volatility, although one could argue that slower reaction may then lead to bigger movements. More important, traders need time to react to changes in the order book and order flows. If this is not the case the segmentation of the market into slow and fast traders may be worsened. In other words, the speed of the trading process is no longer in line with the reaction time of traders to price information. This may prevent orders from being executed at the intended price and lead to overshooting (BIS, 2001).

Second, and being a consequence of the first point, while the general liquidity on markets increases due to electronic trading, around market events there is a trade-off between liquidity and efficiency. This means in such a situation the price adjusts more efficiently and moves toward its new destination with a higher *"order intensity"* (Jiang & Lo, 2014). But this happens at the cost of worse liquidity because high-frequency traders process news faster and more efficiently but consume the available liquidity in the market for doing so (Jiang et al., 2014). This can be associated with price jumps (BIS, 2016). The benefit of this ultra-fast price discovery is doubted. Nobel laureate confesses his inability to understand the benefit of price adjustments in the range of micro- or milliseconds (Stiglitz, 2014), confirming Krugman (2009) who states that *"it is hard to imagine a better illustration*

[of social uselessness] than high-frequency trading." Most empirical papers confirm that HFT increases volatility (see Virgilio, 2019, Table 1).

The effect of HFT on market efficiency is mostly seen as positive (Virgilio, 2019, Table 5). Brogaard et al. (2014a, b) find that HFT in tendency to trade in the direction of permanent price changes, but also take contrarian positions during temporary mispricing. Their results corroborate with the findings by Foresight (2012) and Manahov and Hudson (2014) and most empirical papers. Only a few authors, such as Hasbrouck and Saar (2013) or Benos and Sagade (2016) take a less optimistic view.

Financial stability is of particular importance during times of crises and market distress. As BIS (2001) states in the early times of electronic trading crises led to a "flight" of trading from electronic marketplaces to more traditional ones, like phone- and floor-based systems. This has changed since the turn of the century. A potential explanation is that during market stress traders move to the systems with the highest market share, which is nowadays electronic markets. Hasbrouck and Saar (2013) confirm that HFT lowers short-term volatility during both, quiet markets and markets under stress. Another positive impact on financial stability may stem from giving more heterogeneous players market access.

Another danger to financial stability is a crowding effect or unintended herding, which may fuel mispricing and exacerbating prices. Due to the "faster but not smarter" approach (Arnoldi, 2016) algorithms are kept simple and do most likely not differ a lot between individual high-frequency traders, which inevitably leads to a high correlation between traders. The empirical literature largely confirms this correlation (Chaboud et al., 2014). Brogaard (2010) finds that high-frequency traders employ less diversified strategies than low-frequency traders. Kirilenko et al. (2017) analyze the flash crash of May 6, 2010, and find that after a clear price signal HFT follows the trend in the 4 s afterward, and takes a contrarian position later (after 10 s).

3 The Case of the Foreign Exchange Market

3.1 Technical Innovations

The foreign exchange (FX) market is the world's largest and oldest financial market. Currency exchange was, however, less formal in the beginning, although it started as soon as international trade connected regions with different currencies in the ancient world. Besides the informal exchange of foreign coins, currencies were sometimes traded at regular fairs. There has been a currency fair in Genoa, every 3 months that lasted for 8 days each between 1532 and 1763 (see Rime, 2003). While telephones were used for communication in the foreign exchange market since the Belle Epoque (Van den Berg, 2010), since the 1930s telephone brokers were the standard. They gave quotes via telephone which could be accepted, or not. A first, major innovation was the introduction of direct, private telephone networks in 1960: the brokers installed intercoms free of charge in the banks, so-called squawk boxes, allowing

for real-time dissemination of quotes to interested parties. The dealer at the bank could then pick up the phone and accept the quote with the words *"mine"* to buy at the ask price or *"yours"* to sell at the bid price. In other words, the broker place limited orders, and the dealer could place a market order (Rime, 2003). Besides those voice brokers (indirect trading), direct trading was also possible via telephone or telex. The latter made a step forward with the introduction of Reuter's RMDS (Reuters Market Data Service), which was introduced in 1981, and followed by the advanced communication system Reuters D2000–1 in 1987. This was rather a kind of chat, which allowed the dealers to easily communicate with other dealers and gave direct trading an advantage over indirect trading via voice brokers. Accordingly, direct trading gained market shares until the early 1990s.

The next important step in electronic trading on foreign exchange markets happened in 1992, when Reuters launched the new Reuters D2000-2 system. While D2000-1 targeted the direct trades, D2000-2 targeted the voice brokers, by being able to match buy and sell orders from a set of dealers (Van den Berg, 2010). Dealers could enter buy- or sell-orders directly into the system and avoid the need for a human broker. In 1993, two competing systems emerged, the Japanese Minex platform and the EBS platform, Electronic Brokering Service, which was launched by large trading banks and took over Minex in 1997. Until now, these are dominating trading platforms, although some smaller local solutions exist, such as the Moscow Interbank Currency Exchange (MICEX) trading platform, now integrated into the Moscow Exchange (MOEX). Both EBS and Reuters (now in the advanced version D3000) still exist but serve different market segments: EBS dominates EUR/USD, USD/JPY, EUR/JPY, USD/CHF, EUR/CHF, and USD/CNH, whereas Reuters is the trading venue for most commonwealth currencies and emerging markets (Sercu, 2009).

3.2 Market Size and Structure

It is remarkable that the emergence of electronic trading platforms made the foreign exchange market much more centralized after its introduction, since they gained a dominant market share for different currencies.

Electronic trading together with an increasing globalization led to a huge increase in trading volume on foreign exchange markets. The Triennial Central Bank Survey (BIS, 2019), carried out by the Bank for International, reports a daily turnover of almost 6.6 trillion USD, compared to slightly more than 500 billion USD in 1989, see Fig. 1. Spot transactions, which are mostly done by electronic trading, account for about 30% of the market in 2019, whereas FX swaps amount to another 50% (BIS, 2019).

What makes the FX market different from other markets is its pronounced two-tier structure. Customers do not have direct access to the core market, which is a pure interdealer market. The dealers take orders from the customers and deal on the interbank market. Dealers may also trade on the interdealer market without

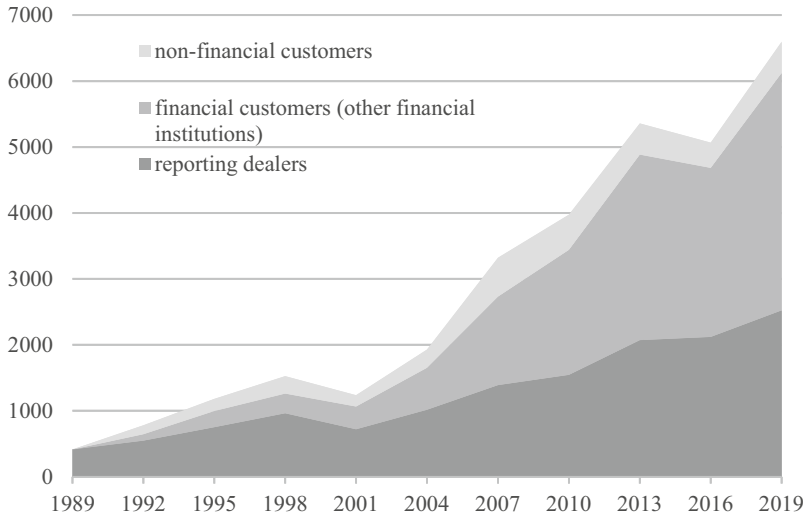

Fig. 1 Evolution of the daily trading volume on the foreign exchange market, in billion USD. Source: BIS (2019)

customer orders. The inner circle, the interbank market, accounts for less than half of the turnover. Customers may be financial institutions, or nonfinancial customers.

The BIS distinguishes three types of counterparties (BIS 2010, p33):

> *'Reporting dealers' are .. financial institutions that actively participate in local and global foreign exchange and derivative markets. These are mainly large commercial and investment banks and security houses that (i) participate in the interdealer market and/or (ii) have active business with large customers, such as large corporate firms, governments, and other non-reporting financial institutions.*
>
> *'Other financial institutions' are defined as those financial institutions that are not classified as reporting dealers. Thus, the term mainly covers all other financial institutions, such as smaller commercial banks, investment banks and securities houses, and in addition mutual funds, pension funds, hedge funds, currency funds, money market funds, building societies, leasing companies, insurance companies, financial subsidiaries of corporate firms and central banks.*
>
> *"Non-financial customers" are defined as any counterparty other than those described above, i.e. mainly non-financial end users, such as corporations and governments.*

The share of reporting dealers trading with each other in the total trading volume is declining for some decades now and recently dropped to 38% (BIS, 2019), see Fig. 2. In 1992, this was the dominant category with a share of 70% of the total trading volume. The largest fraction of trades now involves reporting dealers with financial customers and accounts for 55% of all trades (compared to 12% in 1992).

This reflects the deepening of the financial markets, but also the increasing competition and concentration in the interdealer markets, see the discussion below. In total numbers, the volume of trades with financial customers increased by a factor

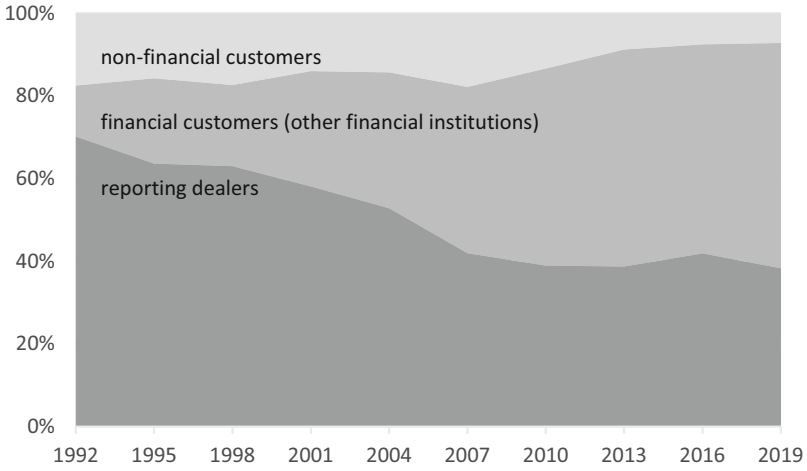

Fig. 2 Share of counterparties for registered traders, in % of total trading volume. Source: BIS (2019)

37.5 from 96 billion USD (1992) to 3600 billion USD in 2019. The rest are trades with nonfinancial customers, whose share declined from 18% (1992) to 7% (2019).

Electronic trading was one of the main reasons for this change in the market structure, which is now mostly dominated by financial institutions. King and Rime (2010, p29ff) see four main factors:

First, electronic trading gained importance. In line with what we observed on other markets, this led to higher market liquidity together with low transaction costs. Electronic trading was a prerequisite for the fast growth in trading volume.

Second, and again similar to other markets algorithmic trading and HFT have become widely used on the FX market. This cannot be separated from electronic communication networks (where they also locate EBS and Reuters), see the brief discussion below.

Third, there is a strong tendency toward concentration in currency markets. London is the most important trading center for foreign exchange trading. In 1998, 24% of banks accounted for 75% of the turnover. The number declined to 9 in 2010. In 2019, the share of London in global FX trading was 43% and increasing (US 17%, BIS, 2019). This is at the same time a consequence of the rise of electronic trading, but also fueling the further growth of electronic trading. Many smaller banks have left this increasingly competitive market, which is also reflected in the share of trades between reporting dealers and financial customers increasing at the cost of the interdealer market (smaller banks who had previously been dealing themselves became clients of the top dealers and are now categorized as financial customers). A fourth reason (and consequence) for electronic trading is that FX trading by retail investors via trading platforms such as Oanda FXTrade, FXConnect, or Currenex has significantly increased during the last years (see Nolte & Nolte, 2012).

3.3 How FX Is Traded in the Dealer–Customer Market?

Since customers (i.e., "other financial institutions" and "non-financial customers") do not have direct access to the "inner circle" of the market—the interbank foreign exchange market—they have to place their orders via dealers. Prior to the advent of the Internet, customers exclusively did so via direct communication channels, mostly telephone, leading to high loyalty of customers to their banks. Note that it is always the customer who becomes active and calls the dealer, the dealer never takes the initiative. The spreads given to customers are much larger than those given to other banks in the interbank market. As a consequence, most of the banks' revenues originated (and still originate) from trades with customers (see, e.g., Mende & Menkhoff, 2006).

This has recently changed with the introduction of electronic communication networks (ECN), of which some target small corporative customers, whereas others focus on retail investors (Rime, 2003). ECNs are no stand-alone marketplaces but crossing networks. This means they obtain their prices from the interbank market, so there is no price discovery on the ECN. As such they extend the existing trading platforms rather than replacing them. Nevertheless, there is some competition between them, since orders at the ECN are matched and executed against each other. Therefore, trades executed at the ECN lower the transaction volume in the traditional market segments.

However, the importance of ECNs in practice is still low (see Rime, 2003), so several ECNs have already closed down. See Fig. 3 for the structure of the foreign exchange market.

Lyons (2002) suggests three potential scenarios for the future evolution in the customer market:

(i) Internet trading gains further importance and banks lose their customer trading to it.
(ii) Banks hold their position and electronic customer trading platforms remain a niche product.
(iii) Traditional interbank electronic brokers like EBS open their platforms to retail customers.

Lyons (2002) assigned the highest probability to (ii), followed by (iii). In fact, we can observe that internet trading gains importance, thus (i) (Schrimpf & Sushko, 2019): electronic interdealer trading now accounts for less than a third of the market, to a large extent due to internalization, where dealers now more and more net client flow with the help of electronification, at the expense of inventory risk. This also led to a decline in order book depth at the electronic interdealer market. In other words, the centralization we could observe with the introduction of electronic trading since the 1990s has reverted. However, electronic trading platforms in the interdealer segment still remain the source for price discovery (Markets Committee 2018). Indeed, their importance is time varying and increases under high volatility conditions (Moore et al., 2016).

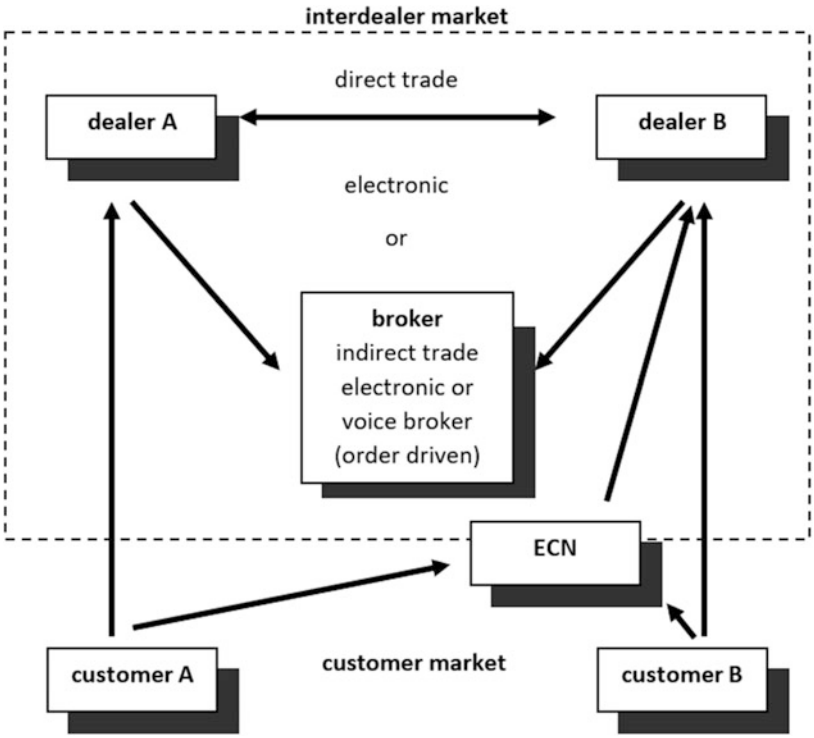

Fig. 3 Structure of the foreign exchange market. Source: Frömmel (2017)

At the same time, there seems to be a peak in electronification, stemming from market fragmentation which creates the need for customers and traders to be connected to a large number of ECNs, which can easily reach 40–50 different systems (Schrimpf & Sushko, 2019).

4 Summary

Since the introduction of electronic trading started in 1970 financial markets have changed their face significantly. Floor trading has mostly disappeared, also voice brokers have lost importance. As a result, trading costs, both direct and indirect decreased, whereas trading volumes and execution speed rocketed. Accuracy of the trading process increased in the sense that "fat fingers" became less frequent, but the danger of flash crashes due to erroneous algorithms and homogeneous trading strategies seems to be higher.

New market players emerged with high-frequency traders, which exploit their speed advantage and have gained substantial market shares. However, both market share and profitability have decreased during the last 10–15 years due to high

competition. There is now a race for time advantages in the region of milliseconds. The effect of high-frequency trading on markets is ambiguous: While they further increase liquidity and volatility, there also seems to be a positive effect on market efficiency, although they increase the probability of flash crashes. Furthermore, the benefit of the increased efficiency may be low, since it concerns improvements on ultra-short horizons.

Electronic trading seems to have a little negative impact on liquidity during crises. The flight from electronic to more traditional markets, which could be observed in the early times of electronification is no longer observed nowadays, when electronic trading has become the dominant trading segment.

The impact of electronic trading has become particularly pronounced on foreign exchange markets, which were characterized by direct telephone-based trading and voice brokers. While electronic trading first replaced telephone trading to a large extent, voice brokers have lost volume to electronic trading platforms since 1990. As a result, the foreign exchange market became more centralized and concentrated. The share of reporting dealers is decreasing for more than two decades. In the dealer–customer segment electronic communication networks have gained ground and led to a decline in electronic interdealer trading. Customers and traders increasingly question the need to connecting to a large number of ECNs, due to the high costs and potential settlement risks during times of stress.

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Response of BTC Market to Social Media Sentiment: Application of Cross-Quantilogram with Bootstrap

Kazi Sohag and Mirzat Ullah

1 Introduction

Since the inception of Nakamoto in 2008, Bitcoin has gotten a lot of attention in the recent digital currency age. In the media, on social media, in the IT business, and among financial investors, Bitcoin has caused waves (Urquhart, 2018). Due to its structure, Bitcoin offers various distinct features, including a peer-to-peer system, government-free architecture, and minimal transaction fees. This allows for electronic payments to be transmitted from one party to another directly without the involvement of any third-party like government or banks (Atsalakis et al., 2019). Bitcoin has several unique features in compression with other financial assets, as it is unaffiliated with any higher authority, such as a government, financial institution, or underlying commodity. Bitcoin has no physical form, and its value relies on the security of computer programming that allows it to track all buyer and seller transactions. As any governments, banks or any other organizations do not issue it, it provides investors with security and anonymity (Wook, 2020). As a result, Bitcoin is not guaranteed or controlled by a central authority; this distinguishes Bitcoin from other financial instruments.

Bitcoin prices began to surge in 2013, after 3 years in 2009 when they were below $680 by the end of 2019. Bitcoin was valued at nearly $40,000 per coin with the record highest value science invention. The price of Bitcoin got more interest after the COVID-19 outbreak, and it is currently at $42,377 at the time of this writing. This signifies that this asset has a high level of volatility. Economists, investors, and politicians face various issues in price determination, return, and volume due to

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Bitcoin's gain revolutionary features, simplicity, transparency, and growing popularity. Their social media popularity influences individual investors' feelings (Aharon et al., 2022; Caferra, 2022; Khan, 2021; Sohag et al., 2021). The Bitcoin market grows in popularity due to high price fluctuation it becomes speculative in nature. Investor mood is boosted by the number of active Internet users and the number of online searches, which predicts Bitcoin prices and returns (Tandon et al., 2021). Similarly, searching on digital platforms such as Google has an impact on Bitcoin pricing (Guégan & Renault, 2021).

The volume of tweets related to Bitcoin and Twitter trends is a stronger indicator of investor interest. The link between Twitter user sentiment and financial markets was examined by Cary (2021). Bitcoin returns, volatility, and trading volume can be predicted by the number of tweets using the term "Bitcoin." The rising number of tweets is regarded as a factor in price volatility, which can impact Bitcoin profits (Philippas et al., 2019). As a result, it is possible to assume that social media users' attention and Bitcoin returns are linked. Bitcoin returns may be affected by the increased media attention, and Twitter trends are partial drivers of users' sentiment to Bitcoin returns during moments of higher uncertainty. Huynh (2022) looks at how famous tweets like Elon Musk's and Trump's tweets affect Bitcoin price. Other investors may be lured to invest more than they can afford because they are unaware of the market's volatility, which can alter rapidly and result in the loss of an investor's savings (Huynh, 2021).

As previously stated, Bitcoin has grown in popularity due to its rapid adoption and skyrocketing price since its inception in 2013. Due to its widespread use, it has spawned a slew of trading and investment opportunities. There have been recent research studies on the impact of the pandemic (COVID-19) on the financial market, including the Bitcoin market. Bitcoin has been a risky investment vehicle (Conlon & McGee 2020). A correlation has also been found between US stock market and Bitcoin; the authors used a dynamic correlation analysis to show that Bitcoin has the potential to hedge the extreme tail risk associated to US stocks (Grobys et al., 2020). Yarovaya et al. (2020) explored Bitcoin market herding behavior. They looked into the link between stock market volatility and policy reactions to public sentiment on social media.

Yadav et al. (2021) looked into the potential to predict Bitcoin prices based on current tweet sentiments; they investigated the social influences on Bitcoin values. They forecasted average pricing using a Multiple Linear Regression model based on the number of good, neutral, and negative tweets collected hourly. Similarly, Symeonidis et al. (2018) evaluated the importance of several preprocessing strategies for Twitter sentiment analysis. None of the previous studies looked into Bitcoin-related emotions expressed on social media sites like Twitter. Bitcoin price changes are always influenced by sentiment, especially during moments of significant volatility (Guégan & Renault, 2021). In order to provide and improve an acute prediction model, tweet preprocessing is a crucial difficulty. When text data is fed into a prediction model that does not correlate well with Bitcoin, accurately forecasts Bitcoin's behavior.

The consequences of economic uncertainty, anxiety, and investor skepticism on the future economy have been highlighted by shifting global economic conditions such as pandemics and financial crises. When there is uncertainty in the financial market, the requirement for a stable ground is crucial for market participants (Aharon et al., 2022). In particular, Bitcoin is largely considered a viable alternative investment choice. This study uses a novel approach based on Twitter-based economic uncertainty to look at the influence of such unique uncertainty on Bitcoin returns. Financial investors' tastes have altered due to the Internet's adaption for information analysis and how investors react to such information. Investors with real-time data are more successful (Ma & Hao, 2022). Investors are interest in online trading platforms, for example, Google search increased during periods of higher market uncertainty, according to (Aharon & Qadan 2020).

Social media is one of the essential sources of information in today's digital age. Twitter, in particular, delivers the most up-to-date information and provides facts about current and ongoing subjects as "Trends" any topic due to its familiarity and popularity. Twitter has evolved into a modern newspaper that serves as a conduit for information between providers and customers and a potential tool for gauging a person's mood. A long line of research papers has sought to assess the level of risk to the virtual cryptocurrency market by looking at the impact of social media sentiment. The volatility index was used in most studies, such as the Bitcoin hedge global economic policy uncertainty index by Naeem et al. (2021), the crude oil volatility index by (Demir et al., 2018, Fang et al. 2019), the index for geopolitical risk used by Al-Yahyaee et al. (2019), and other similar studies such as Caferra (2022), Khan (2021), Mokni et al. (2022), and Ortu et al. (2022). While there has been research on the relationship between Twitter and cryptocurrency, most of them have focused on Bitcoin. Few studies explored the relationship between Twitter based economic uncertainty and cryptocurrency returns, and those who have done so have generally concentrated on a particular digital currency, such as (Béjaoui et al., 2021; Lucey et al., 2022; Mai et al., 2018; Smuts, 2019; Verma & Sharma, 2020). According to these studies, the quantity of tweets is a substantial driver of realized volatility and the next day's trading volume, but it does not predict future prices and returns.

Wu et al. (2021) also discovered strong Granger-causality from Twitter-based uncertainty metrics to several cryptocurrencies the Bitcoin, Litecoin, Ethereum, and Ripple. Similarly, multiple studies have discovered that the volume of tweets is a strong driver of cryptocurrency realized volatility and the trading volume for the next day (Khalfaoui et al., 2022; Philippas et al., 2019). We investigate the influence of a recently released uncertainty metric, Twitter-based economic uncertainty (TEU), on high-market-capitalized cryptocurrency "the Bitcoin." The idea of Baker et al.'s (2021) Twitter-based Economic Uncertainty (TEU), in which they used sentiment estimation generated from Twitter, is closely followed in the design of this assessment. "How and why Twitter-based economic uncertainty (TEU) influence the Bitcoin returns?" asks this study. First, all cryptocurrencies, but particularly Bitcoin, have the potential to be affected by uncertainty. Following the global financial crisis of 2008, the cryptocurrency market arose, resulting in unprecedented levels of loss for individuals (Sohail et al., 2021). The cryptocurrency market has gained in

popularity due to its unique properties, such as its decentralized nature, independence from traditional financial systems, and propelled evolution mechanism for investors. As a result, investors are turning to Bitcoin as an alternative investment to offset the present financial system's instability (Aharon et al., 2022). Second, we hypothesize that Twitter may influence cryptocurrency behavior. We anticipate that Twitter-based economic sentiment will play a central role in cryptocurrency price formation, based on the arguments above about price formation, return dissemination, and trading mechanisms. Additionally, we expected the relationship between Twitter-based economic uncertainty and Bitcoin return at lower and higher quantiles of the return distribution, which reflect different outcomes during the higher and lower uncertainty (See Khalfaoui et al., 2022; Mensi et al., 2021; Song et al., 2022). In other words, based on this research, it is plausible to deduce that TEU and Bitcoin returns have a nonlinear connection.

This research study contributes to the current body of knowledge in several ways. Earlier studies typically measured uncertainty using the economic policy uncertainty (EPU) proxy and attempted to explore its impact on Bitcoin (Demir et al., 2018, Bouri et al., 2017, Fang et al. 2019). Because monthly data was readily available, they attempted to quantify uncertainty by counting the number of tweets on the most popular social media platforms. On the other hand, we use daily high-frequency data from Twitter-based economic uncertainty, which can better capture investors' uncertainty in very short time frames, such as 1 day. Second, unlike any other social media platform, the TEU is based on the volume of tweets, which better reflects investors' level of uncertainty. Third, we follow previous research by taking different quantiles into account when considering the impact of uncertainty (Demir et al., 2018, Wang et al. 2020). To investigate bivariate causal relationships between the two series directional predictability tests, we used the Cross-quantilogram technique, which was first introduced by Han et al. (2016).

1.1 Twitter-Based Uncertainty

To capture the rapid changes in the financial market, real-time tracking of (perceptions of) economic uncertainty can be useful inputs into policy formulation and assessments of whether policy actions reduce or amplify perceived uncertainty, especially during a crisis. To respond to these observations, Baker et al. (2021) used text messages sent through the Twitter social network to build perception measures of economic uncertainty. Twitter-based uncertainty has a potential to represent a large number of adults users. Twitter provides a broad cross-section of social media users, the tweets come with a precise timestamp explaining a specific market behavior. The high-frequency indicators are constructed using tweet-based measurements, and these measures are correlated to near real-time developments and financial market responses. Social media users' views on Bitcoin share returns were clearly depicted in this study by segmenting user tweets from Twitter into three separate panels:

1. Twitter-based economic uncertainty index to Bitcoin returns (BTC to TEU).
2. Twitter-based economic uncertainty-weighted (retweets) index to Bitcoin returns (BTC to Wgt.).
3. Twitter-based uncertainty scaled index to Bitcoin (BTC to Sc.).
4. Twitter-based economic uncertainty originated from tweets in English index to Bitcoin (BTC to Eng.).

To have a better understanding of how significant a certain tweet is, it is important to know how many retweets it has received. This information can be used to create a weighted indicator for uncertainty. According to Baker et al. (2021), a country-level index (geotagged tweets) is constructed using an inference method. Twitter Economic Uncertainty (TEU-USA) for the United States is constructed by tracking the amount of tweets that include both a term connected to the economy and a keyword related to uncertainty. Using the number of retweets of each message, Baker et al. (2021) suggest a weighted TEU index based on the logarithm of the number of retweets. Retweets can be used as a proxy for a message's level of influence (Park & Cha 2019). Finally, the indexes are presented by analyzing all English language communications (and not only messages from users located in the USA). TEU-SCA (Scaled Index), TEUWGT (Weighted Index), and TEU-Eng. (English Index) are the names of these indexes (index based on all English tweets). Please visit our website: https://www.policyuncertainty.com/ to access all indexes.

2 Literature Review

Uncertainty in the current study stream is an important stand faced by the fast-growing market of cryptocurrency, more especially to Bitcoin. One of the basic studies examined the effect of the volatility index of Bitcoin returns attempted by Bouri et al. (2017). They examined 14 developing and developed stock markets. They studied the negative relationship between uncertainty and Bitcoin returns by employing the OLS estimation. At the same time, the quantile regressions showed that Bitcoin could use as a hedge shield to face minimum uncertainty, especially in higher quantiles. Similarly, our study also reveals that the uncertainty is higher in daily and weekly estimations in comparison with monthly and quarterly estimations.

A similar study conducted by Demir et al. (2018) used the economic policy uncertainty as a proxy to measure the uncertainty for Bitcoin and showed that the economic policy uncertainty could predict Bitcoin returns by using the Bayesian graphical structure VAR model and OLS estimations. They conclude a negative association among uncertainty, economic policy, and Bitcoin returns and reveal that if this effect changes and becomes positive at higher and lower quantiles. Accourding to the findings of (Gozgor et al., 2019) which is accord with the findings of (Bouri et al., 2017) that the Bitcoin has a capabilities of hedging at higher and lower quantiles. Gozgor et al. (2019) used wavelet analysis methods and the trade policy uncertainty as a proxy to study the effect of Bitcoin returns in the US

economy. They documented a significant and positive relationship between Bitcoin return and trade policy uncertainty. They studied the regime change considering the change in trade policy and reported a significant negative correlation. The economic policy is considered an important driver of spillover for Bitcoin returns. Caviggioli et al. (2020) studied the connectedness among different cryptocurrencies and find out that the global economic policy uncertainty is an important element which affects Bitcoin returns. Similarly, Cary (2021) documented that Bitcoin and gold are strong hedges when there is the average level of economic policy uncertainty by using GARCG and the quantile regression model. Cheng and Yen (2020) examined that China's economic policy uncertainty could predict the monthly returns of Bitcoin using monthly data. Moreover, Asia, China, United States' economic policy uncertainty is not at the same level while some other developing economies do not predict the return of Bitcoin.

Khalfaoui et al. (2022) used monthly frequency data using the GARCH model; they examined China's economic policy uncertainty and revealed that it was negatively associated with Bitcoin returns. Finally, Wang et al. (2020) examined the effect of the economic policy uncertainty on Bitcoin return considering local currencies, the US dollar (USD) and the British pound (GBP). The Bitcoin returns are significantly higher in comparison with the lowest uncertainty days on the highest uncertainty days. They employed the dynamic conditional correlation DGCC-GARCG estimations and documented that the impact of the US economic policy uncertainty on the association among USD and Bitcoin return is greater than the effect of the UK economic policy uncertainty on the relationship among British pound and Bitcoin.

By concluding the above research studies, we are expecting that Bitcoin can be use to hedge the market uncertainty at some level, like in short time intervals as daily and weekly but this momentum can change while considering investment in monthly and quarterly. This study uses a unique approach in this regard. This study examines the relationship between Twitter-based economic uncertainty disseminate from social media users and Bitcoin returns.

3 Methodology and Data

3.1 Data and Sources

To predict the returns of Bitcoin, we used price and returns indexes. Daily prices are considered in USD. The data relating to cryptocurrency are downloaded from major crypto databases (www.investing.com and www.Bitcoinchart.com). The Twitter-based economic uncertainty is derived from the leading database that manages the social media sentiments to the Bitcoin returns. We examine weekly frequency data (5 days in a week) sample timeframe from March 2017 to March 2022.

3.2 Cross-Quantilogram

To investigate bivariate causal relationships between two series, the contemporary cross-quantilogram (CQ) technique was developed by Han et al. (2016). In this study we adopted the Cryptocurrency and social media sentiment, which are two high-frequency data series. First, because CQ is based on quantile hits, it does not necessitate momentary conditions and hence works well for fat-tailed distributions, which is one of its key advantages. Also, shocks can be assessed in terms of their duration and direction by using extended lag lengths, which are possible with this technique (Sohag et al., 2021). CQs are able to capture shocks between markets in different quantiles of the observation, which is another strength of the technique. Lastly, this method is that it is able to examine the volatility spillovers between series even when there are extreme observations and irregular distributions.

We applied a recently introduced technique and the Cross-quantilogram introduced by Han et al. (2016) to investigate the bivariate causal linkages between TEU and Bitcoin returns series. In addition to being based on quantile hits and not necessitating immediate conditions, this methodology offers other advantages. The fat-tailed distributions are well served by this method. Cross-quantilograms also allow the use of lag lengths to capture the structural estimations and to measure the duration or direction of shocks (Sohag et al., 2021). It is also possible to measure the magnitude of shocks between markets in different parts of the observation. Thus, when extreme observations and anomalous distributions are present, the cross-quantilogram technique is able to accurately anticipate the volatility spillovers between TEU and Bitcoin return series.

The Eq. (1) indicates the cross-quantilogram between TUE and Bitcoin, which are strict stationary time series $\{(y_t, x_t) : t \in Z\}$ comprising $y_t = (y_{1t}, y_{2t})^{'} \in R^2$ and $x_t = (x_{1t}, x_{2t}) \in R^{d1} \times R^{d2}$, where $x_{it} = \left[x_{it}^1, , , , , , , x_{it}^{di}\right]$\hskip3\vskip-7\rot180{\rm $\therefore \perp$}$\in R^{di}$with $d_i \in \mathbb{N}$. The conditional distribution between two series follows the function $F_{y_i|x_i}(.|x_{it})$ indicating the fiscal stance given the TEU, corresponding to $q_{i,t}(\tau_i) = \inf\left\{v : F_{y_i|x_i}(v|x_{it}) \geq \tau_i\right\}$ for $\tau_i \in (0, 1)$, *for* $i = 1, 2$. The framework considers $\mathcal{T}$ as a Cartesian product of two closed intervals in (0, 1), that is, $\mathcal{T} \equiv \mathcal{T}_1 \times \mathcal{T}_2$, where $\mathcal{T}_i = [\underline{\tau}_i, \overline{\tau}_i]$ *for some* $0 < \underline{\tau}_i < \overline{\tau}_i < 1$. The CQ framework incorporates serial dependence between two shocks $\{y_{1t} \leq q_1, t(\tau_1)\}$ and $\{y_{2,\, t\, -\, k} \leq q_2, t - k(\tau_2)\}$ for a particular pair of (τ_1, τ_2)\hskip3\vskip-7\rot180{\rm $\therefore \perp$}$\in \mathcal{T}$ for lag order k. Cross-quantilogram can be estimated by the following Eq. (1).

$$\rho_\tau(k) = \frac{E\left[\psi_{\tau_1}(y_{1t} \leq q_{1t}(\tau_1))\psi_{\tau_2}(y_{2t-k} \leq q_{2t-k}(\tau_2))\right]}{\sqrt{E\left[\psi_{\tau_1}^2(y_{1t} \leq q_{1t}(\tau_1))\right]}\sqrt{E\left[\psi_{\tau_2}^2(y_{2t-k} \leq q_{2t-k}(\tau_2))\right]}} \tag{1}$$

The CQ approach is invariant to any monotonic transformations in both series and captures serial dependence between TEU and Bitcoin returns. In studying two events $\{y_{1t} \leq q_{1t}(\tau_1)\}$ and $\{y_{2t-k} \leq q_{2t-k}(\tau_2)\}$, $\rho_\tau(k) = 0$ indicates no cross-sectional dependence from event $\{y_{2t-k} \leq q_{2t-k}(\tau_2)\}$ to event $\{y_{1t} \leq q_{1t}(\tau_1)\}$. While considering dependence in terms of the direction of deviation from conditional quantiles, as $\rho_\tau(k)$ changes with respect to lag length k, the directional predictability from one variable to another can be measured. We consider $k = 1, 5, 22$, and 66 in the current study, where $\widehat{\rho}_\tau(k)$ is cross-quantilogram obtained as follows:

$$\widehat{\rho}_\tau(\mathrm{k}) = \frac{\sum_{t-k+1}^{T} \psi_{\tau_1}(y_{1t} - \widehat{q}_{1t}(\tau_1))\psi_{\tau_2}(y_{2t-k} - \widehat{q}_{2t-k}(\tau_2))}{\sqrt{\sum_{t-k+1}^{T} \psi_{\tau_1}^2(y_{1t} - \widehat{q}_{1t}(\tau_1)}\sqrt{\sum_{t-k+1}^{T} \psi_{\tau_2}^2(y_{2t-k} - \widehat{q}_{2t-k}(\tau_2))}} \tag{2}$$

where $\widehat{q}_{it}(\tau_i)(i = 1, 2)$ represents the estimated quantile function. The null distribution of the cross-quantilograms (1) and the Q-statistic (2) is approximated via applying stationary bootstrap. To account for the effect of uncertainties, partial-cross-quantilograms between TEU and Bitcoin returns are calculated. Let $z_t = [\psi_{\tau_3}(y_{3t} - q_{3t}(\tau_3)), \ldots, \psi_{\tau_l}(y_{lt} - q_{lt}(\tau_l))$.

We define the correlation matrix of the hit processes and its inverse matrix as: $R_{\overline{\tau}} = E\left[h_t(\overline{\tau})h_t(\overline{\tau})^T\right]; P_{\overline{\tau}} = R_{\overline{\tau}}^{-1}$, where $h_t(\overline{\tau}) = \psi_{\tau_1}(y_{1t} - q_{1t}(\tau_1)), \ldots, \psi_{\tau_l}(y_{lt} - q_{lt}(\tau_l))$ be an $l \times 1$ vector of the quantile hit process. For $i, j \in [1, \ldots, l]$, let $r_{\underline{\tau}ij}$ and $p_{\underline{\tau}ij}$ be the (i,j) element of $R_{\overline{\tau}}$ and $P_{\overline{\tau}}$. Note that the cross-quantilogram is $r_{\overline{\tau}12}/\sqrt{r_{\overline{\tau}11}r_{\overline{\tau}22}}$. The partial cross-quantilogram is defined as follows:

$$\rho_{\overline{\tau}|z} = -\frac{p_{\overline{\tau}12}}{\sqrt{p_{\overline{\tau}11}p_{\overline{\tau}22}}}$$

$\rho_{\overline{\tau}|z}$ can be viewed as the cross-quantilogram between y_{1t} and y_{2t} conditional on the control variable z.

4 Results and Discussion

The results of the Cross-Quantilogram are presented using several heatmap matrix. We consider the lags order for daily, weekly, monthly, and quarterly intervals, these are the stock trading days as 5 days in a week. We are examining the high-frequency data for 5 year long period of observation with considerable volatility by using quantile splitting at a 5% confidence interval level into 19x19 quantiles matrix.

4.1 *Twitter-Based Economic Uncertainty Index to Bitcoin Returns*

Figure 1 demonstrates volatility Spillovers from Twitter-based economic uncertainty to the returns of Bitcoin. The blue (from dark-blue to yellow-green) squares on the given heatmap which indicate 0 or very lower degrees, and the squares area with red color indicates the highest (1) degrees of spillover effect. Additionally, the (*) star sign indicates the significance level 10%.

Based on the panels in Fig. 1, we could infer that volatility of Twitter-based economic uncertainty only significantly affects the returns of Bitcoin in the lag 1 and lag 5 periods, most specifically at the lower quantile of both variables while insignificant in the lag 22 and lag 66 of the periods. This may imply that the news effect from the Twitter-based economic uncertainty dies off over time as the market

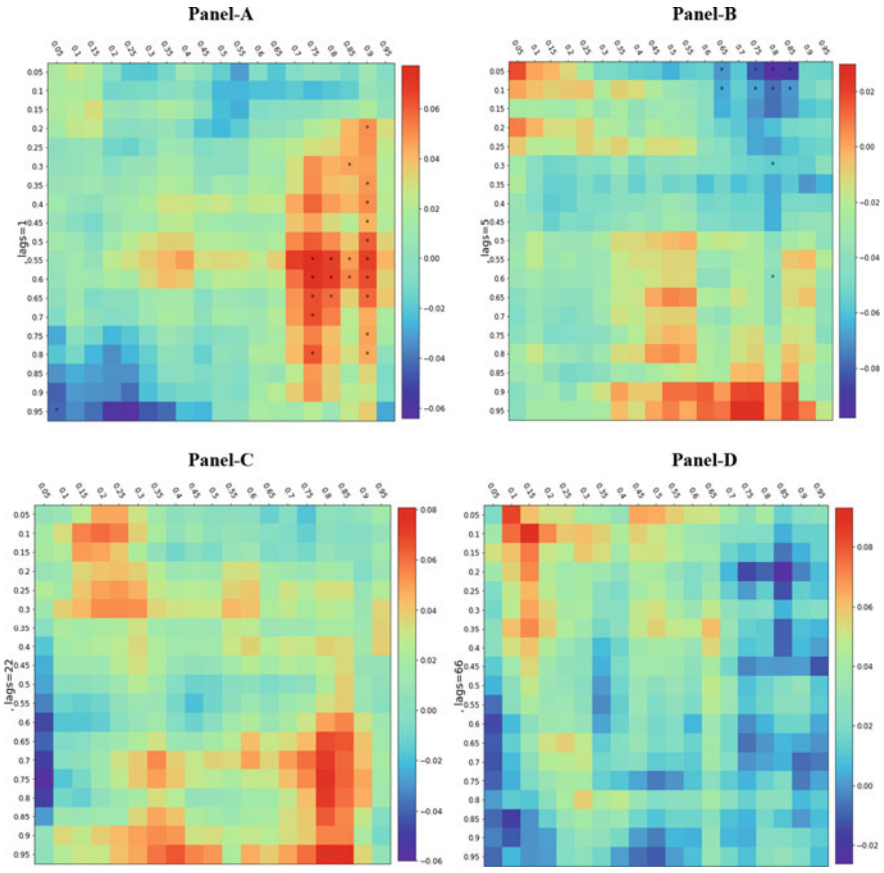

Fig. 1 Volatility spillovers from Twitter-based economic uncertainty index to Bitcoin returns, a cross-quantile dependence matrix. Source: Authors' calculation

adjusts itself with the momentum effect. Also, this may signify that the market is highly responsive to the news in the first period, as indicated in lag 1. Similarly, the volatility Spillovers from Twitter-based economic uncertainty to Bitcoin returns become more noticeable under higher quantile. All panels indicates that the results are highly and significantly sensitive with lag orders. It can be viewed among the panels, i.e., in Fig. 1, especially from a day to a week. The heatmaps turn less significant when 66 days lag is considered.

4.2 Twitter-Based Economic Uncertainty -Weighted Index to Bitcoin Returns

According to Fig. 2, the volatility of Twitter-based economic uncertainty-weighted index significantly impacts Bitcoin returns at both the lowest, and the highest quantiles, which is unusual. As quantiles of both variables rise, the volatility of spillovers from Twitter-based economic uncertainty-weighted (retweets) index to Bitcoin returns rises in lockstep with them. Increasing the quantile size in weekly

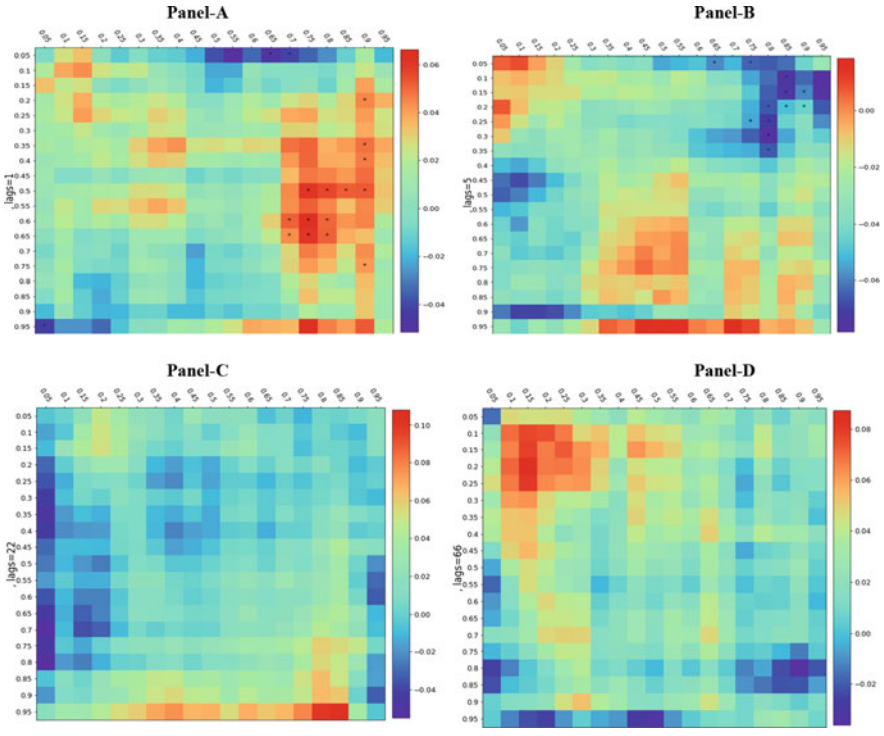

Fig. 2 Volatility spillovers from Twitter-based Economic Uncertainty-weighted Index to Bitcoin returns, a cross-quantile dependence matrix. Source: Authors' calculation

lags causes spillovers from Twitter-based economic uncertainty-weighted (retweets) index to Bitcoin returns to become more volatile. Additionally, when the lag period was increased from a monthly or quarterly interval to daily or even hourly intervals, there was an increase in the number of notable heatmaps. The effectiveness of retweets reduces over time, in a manner similar to the theoretical effect of retweeting.

4.3 Twitter-Based Economic Uncertainty Scaled Index to Bitcoin Returns

In Fig. 3, the findings demonstrate that Twitter-based economic uncertainty scaled index significantly impacts returns of Bitcoin at the highest quantiles, particularly at the lower quantiles. With respect to lags 22 and 66, Twitter-based economic uncertainty scaled index under the lowest quantile does not have any significant impact on Bitcoin returns under either the lowest or highest quantiles. Lags 1 and

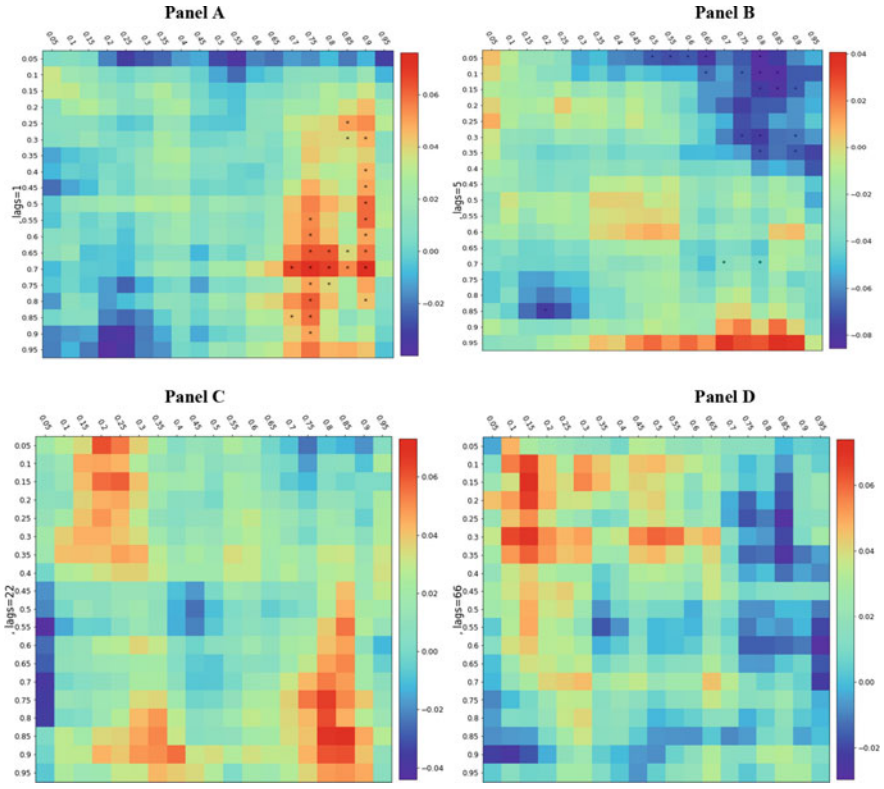

Fig. 3 Volatility spillovers from Twitter-based Economic Uncertainty Scaled Index to Bitcoin returns, a cross-quantile dependence matrix: Source: Authors' calculation

5 demonstrate stronger importance at the highest quantiles of both variables. The insignificance is visible in the heatmap matrix with 22 and 60 lags ordered, as shown in Fig. 3.

4.4 *Twitter-Based Economic Uncertainty Originated from Tweets in English Index to Bitcoin Returns*

Figure 4 clearly showed that the cross-quantile relationship between Twitter-based economic uncertainty originated from tweets in English index to Bitcoin returns. The Twitter-based economic uncertainty originated from tweets in English significantly impact the Bitcoin returns when the quantiles are at their highest levels. This is in line with previous findings, which show that the significance of both variables increases with rising quantiles while decreasing with increasing lag duration.

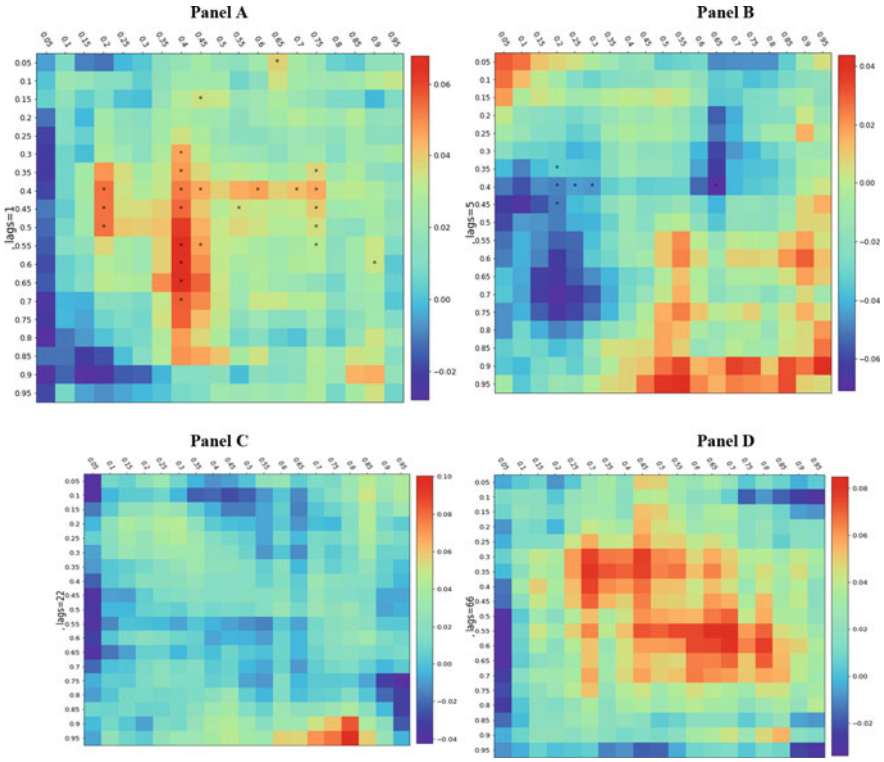

Fig. 4 Volatility spillovers from Twitter-based economic uncertainty originated from tweets in English index to Bitcoin returns, a cross-quantile dependence matrix. Source: Authors' calculation

5 Empirical Findings

The general results show a consistent simultaneous lag relationship between Twitter-based economic uncertainty and Bitcoin returns. In all given cases, the results show exhibit significance. The findings of this study generally accord with the literature supporting significant associations between returns of Bitcoin and uncertainty in normal market conditions (Mokni et al., 2022; Sohag et al., 2021; Suardi et al., 2022). On the other hand, Aysan et al. (2019) documented that there is no lag relation between with Bitcoin by considering geopolitical risks.

In the results, we followed the methodology used by Aharon et al. (2022). They used an innovative approach a "cross-quantilogram" to explore the relationship between Bitcoin returns and Twitter-based sentiment metrics. The static (*) sign refers to the 90% bootstrap confidence. Our results are reported in Figs. 1, 2, 3, and 4, respectively. As the findings in Fig. 1, which reports the concomitant results, indicate that the returns of Bitcoin have a significantly positive contemporaneous relationship in the higher quantile. In other words, considering Bitcoin trading in an efficient and bull market, the Twitter-based economic uncertainty drives the return of Bitcoin upward with a positive effect on returns of Bitcoin. As Fig. 2 indicates, when the volatility of the Twitter-based economic uncertainty-weighted index significantly impacts Bitcoin at both the highest and lowest quantiles, which is unusual likewise (Aharon et al., 2022). As the quantiles of both variables rise, the volatility of spillovers from Twitter-based economic uncertainty-weighted index to Bitcoin returns rises in lockstep with them. Increasing the quantile size in weekly lags causes spillovers from Twitter-based economic uncertainty-weighted index to Bitcoin returns to become more volatile.

Additionally, when the lag period was increased from a monthly or quarterly interval to daily or even hourly intervals, there was an increase in the number of notable heatmaps. The effectiveness of retweets reduces over time, in a manner similar to the theoretical effect of retweeting. We can say that investors in Bitcoin can face a large loss at this stage. The results represented in Fig. 3 are prospective to those in Fig. 4, when the lags interval increases from the TEU the sentiments setup at their previous position the return of Bitcoin is again starting their stream in positive direction. It indicates the momentum effect and gets up from the previous position.

The overall findings of this study have implications of better risk management for fund managers and investors with respect to their decision-making and asset allocations for their portfolio management. The changes in Twitter-based uncertainty significantly impact the changes in Bitcoin returns. Understanding this lead–lag relationship may help stakeholders to consider the investment in Bitcoin as a hedging strategy against increased market uncertainty at the time of making investment portfolio. Additionally, for the investors who wanted to invest for short time, we are highly recommending considering Bitcoin as an investment asset.

6 Conclusion

In this research study, we take the novel method of utilizing the measurement of Twitter-based economic uncertainty to determine really TEU effect; if yes, then how much do sentiments affect the return of Bitcoin. Here, the financial market is facing an uncertain geo-economics situation and pandemic; at this point, the results of our study are important in helping the fund portfolio managers and Individual Bitcoin investors to limit their risk exposure in setting their portfolio management. We documented here that Bitcoin investment is significantly affecting the information disseminated from social media. We selected the most reliable unit from the social media network, "Twitter," and used the historical data extracted for Twitter-based economic uncertainty proposed by Baker et al. (2021) using a newly introduced statistical technique cross-quantilogram proposed by Han et al. (2016).

We further studied the effect of TEU and Bitcoin at four different lags, i.e., the daily effect represents the high correlation, and TEU has more effect on the returns of Bitcoin. Similarly, the weekly effect follows the trend as a daily stream. However, when considering the monthly and quarterly affection, the TEU becomes insignificant to Bitcoin returns. Future research study may conduct to examine the relationship between different cryptocurrencies during the different markets and certain level of uncertainty.

Our study focuses on the high-frequency time series daily data of Bitcoin returns. Nonetheless, some studies concentrate only on the cross-sectional data and examine its effects in the cryptocurrency market. For a future study to examine the social media sentiment can be extended to cross-sectional tests and additional to include other cryptocurrencies. Moreover, our data set (2017–2022) covers the current Bitcoin situation in a limited time span, and focusing on a single crypto asset could be considered a limitation for this study. For the future direction, a study can conduct that extends the analysis to an extensive range of historical data and considers major cryptocurrencies to study that how the impact of fluctuations in the Twitter-based economic uncertainty with market capitalizations like high and low capitalizations.

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The Impact of Digitalization on the Introduction of Innovations into BFSI Activities

Elena M. Grigorieva

1 Introduction

Technological development and the rebirth of already applied technologies in the field of banking, financial services, and insurance (BFSI) will help to form a new view of the role of the financial sector in the global economy as a whole and in individual national economies. BFSI business model is also undergoing a major transformation. There are three main areas that form the specifics of the use of digital technologies in the financial sector: FinTech, RegTech, and SupTech. In addition, value chains are being transformed, opening up opportunities to shape customers' perceptions of financial organizations in a new, better light. Separately, we need to focus on the trend of embedded finance, when digital technologies allow the formation of ecosystems. The complexity of building business models in BFSI has created the need to revise standards in supervisory practice. In this regard, a lot of work is currently underway to develop new supervisory standards in order to prevent the occurrence of risks of loss of financial stability in BSFI. BSFI's close cooperation with the regulator and central banks comes to the fore here. The coordination of applied technologies and software and the provision of unhindered access to performance indicators in finance ensure maximum efficiency in the implementation of SupTech goals. Now it is very important to study the most successful experience of digital activity and new BSFI business models. Replication of the most successful business models, and their effective interaction with supervisory authorities, will make a significant contribution to ensuring financial stability in economic systems.

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1.1 Overview of Financial Innovations and Their Impact on Changing the Business Model of BFSI

Banking, Financial Services, and Insurance (BFSI) is a broad term for companies that provide financial products and services. This includes universal banks that provide a range of financial services, or companies operating in one or more of these financial sectors. BFSI includes commercial banks, insurance companies, nonbanking financial companies, cooperatives, pension funds, mutual funds, and other smaller financial entities (BFSI, 2022).

Banking, financial services, and insurance play a significant role in a market economy, as they participate in the efficient distribution of investment and savings and are important for the stability of the global financial system. BFSI is a growing sector in many countries around the world, in particular through the introduction of new products, innovations in technology, expansion of distribution, networking, and increasing customer awareness of financial products.

Almost everywhere in the world, the financial services sector in financial institutions in general, and banking in particular, is undergoing technological change. The reason is twofold: on the one hand, changing customer expectations and improvements in technological capabilities. On the other hand, growing competition from fintech startups using technology to create unique customer experiences in banking and other financial services has forced large financial institutions, particularly banks, to innovate in response. In addition, the threat of cybersecurity breaches means banks need to be more flexible than ever before (Technology in Banking, 2022).

In recent years, the banking and financial services space has undergone many changes as a result of changing regulations and the rapid development of new digital technologies. While technological advances are not new to finance, digital innovation has resulted in significant improvements in system connectivity, CPU power, and cost, as well as in newly created and usable data. The improvements have reduced transaction costs and led to new business models and investors entering the financial markets (Feyen et al., 2021).

It is crucial to emphasize three key areas of the use of digital technologies in the financial sector, detailed in Fig. 1. These areas are FinTech, RegTech, and SupTech. One of the important areas for introducing innovations in the financial services sector is the spread of financial technologies (Fintech). In a general sense, financial technology is used to describe new technologies that aim to improve and automate the provision and use of financial services. At its core, fintech is used by both companies and consumers to improve the efficiency of financial management. Currently, fintech includes various sectors and industries related to the use of finance. In general, innovations related to financial technologies have become the basis of rapid digitalization in the financial sector (PWC, 2016).

According to the Financial Stability Board (FSB), a working definition of fintech is technologically sound financial innovations that can result in new business models, applications, processes, or products with corresponding significant impacts

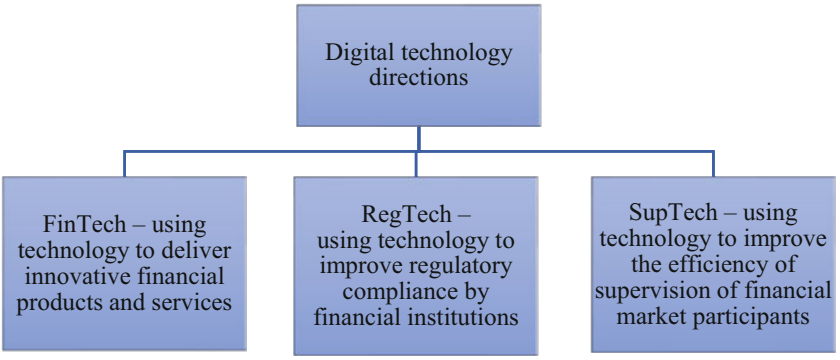

Fig. 1 Digital technology directions in the financial sector. Source: Compiled by the author based on the monograph (Zhdanovich, 2021)

on financial markets and institutions, as well as financial services (BCBS, 2018). FinTech is advancing rapidly along with RegTech.

Technological innovations are not only fundamentally changing banking business models, but also enabling banks to better comply with the requirements of dynamically changing banking regulations. The term "RegTech"(stands for regulatory technology) in a general sense refers to new categories of technologies that provide easier, faster, and more efficient compliance with regulatory requirements by financial market participants (Zhdanovich, 2019). Process automation can provide better and more effective risk identification and regulatory compliance than what currently exists. RegTech could disrupt traditional banking and finance practices by advancing a more robust and efficient regulatory compliance system (Solms, 2021).

The scientific literature often describes RegTech as a type of financial technology, and in some sources, it is interpreted as a way of improving financial regulation. However, this description is more appropriate for a SupTech whose purpose is to improve regulatory compliance oversight. RegTech's place within the direction of using digital technologies to easily respond to regulatory requirements is confirmed by international organizations. Basel Committee on Banking Supervision defines RegTech as the use of innovative technologies by financial institutions to comply with regulatory requirements and objectives. The development and application of regulatory technology can, for example, enhance regulatory reporting and compliance requirements, in addition to facilitating cross-sectoral and cross-jurisdictional collaborations to improve compliance (BCBS, 2018).

Supervision technology (SupTech) is the use of innovative technologies by regulators to support supervision. This helps regulators digitize their reporting and regulatory processes, leading to more effective and proactive monitoring of risk and compliance across financial institutions. The same technologies that offer efficiencies and opportunities for fintech companies and banks, such as AI/ML/advanced data analytics, DLT, cloud computing, and APIs, also have the potential to improve the efficiency and effectiveness of supervision (BCBS, 2018). The spread of

financial technologies (Fintech) is the main component of innovation in the financial services sector. Digital technological innovation is transforming financial services. A technological innovation in the provision of financial services can be defined as artificial intelligence (for example, when creating bots and algorithms), machine learning (for data processing, in scoring), distributed data technologies (for example, blockchain), cloud technologies (to reduce data storage costs and IT infrastructure maintenance), etc.

Various financial technology innovations have emerged around the world, including mobile money, peer-to-peer or market lending, robotic advice, insurance technology (insurtech), and crypto assets. Over the past decade, fintech has already brought greater access and convenience to retail users of financial services. In the meantime, artificial intelligence (AI), cloud services, and distributed ledger technology (DLT) are transforming wholesale markets in fields as diverse as financial market trading and regulatory and supervisory technologies (RegTech and SupTech). A number of new firms have emerged to meet consumer demands using new technologies, and most existing firms have indicated that digital transformation is a strategic priority (BCBS, 2021).

In the first decade of the twenty-first century, innovation has been focused on creating and disseminating new financial products such as collateralized debt and credit default swaps, which rose to prominence during the global financial crisis. In contrast, today's innovations include not only new products, but also new processes, new interactions between financial firms and their clients, and new forms of collaboration (Eichengreen, 2021). As the global economy undergoes a profound transformation, the COVID-19 coronavirus pandemic has accelerated it. COVID-19 came at a time when the financial services industry was already growing rapidly due to changing customer expectations, increased competition from entrants and existing players, changing regulations, and technological advancements. Despite these trends, however, the willingness of consumers to adopt digital technologies and the willingness of companies to invest in them has remained inconsistent across players, markets, and continents. In a matter of weeks, COVID-19 has changed customer behavior, shifted a substantial part of the economy online, and improved customer comfort and digital readiness (Deloitte, 2020).

Modern digital technologies are changing payments, lending, insurance, and wealth management. In general, the development of innovative technologies in the financial sector, the intensive introduction of digital platforms, systems, cloud solutions, distributive registry systems, and other technologies have affected the change and transformation of global BFSI business models. Through digital technologies, financial institutions can create, deliver, and realize value to their clients in new ways.

By and large, a traditional universal bank operates as an assembly line model, where it manages everything from production to sales and distribution in-house. The vertically integrated pipeline business model is disintegrating, giving way to fragmented value chains and new business models (Sanat Rao, 2021). The financial services value chain consists of four broad components: front-end, back-office functions, infrastructure, and balance sheet. The first three are included in financial

services "production." Before fintech, the combination of transaction costs and economies of scale and scope resulted in large financial intermediaries that were vertically and horizontally integrated, providing all four components (and many subcomponents) within a single firm:

1. Client interface. It consists of physical networks such as branches, ATMs, and points of sale to distribute basic financial products and services. Traditionally, opening an account, making a purchase, completing a transaction, and getting advice required physical presence. In many cases, the process was paper-intensive and cumbersome. Even though online banking and mobile banking arose from the advent of the Internet, they were owned and operated by specific financial institutions (BIS Papers 2021).
2. Back and middle office. It consists of all departments, processes, and internal systems for working with the bank's products and balance sheets. These functions include risk management, compliance, credit decision-making, fraud detection, call centers, trade reconciliation, process operations, and record keeping. Until the advent of fintech, these processes required manual intervention and required interagency coordination. Organizational complexity and outdated legacy IT systems have driven up transaction costs, left customer data unused, hindered innovation, and degraded customer experience even further.
3. Infrastructure. This links the different participants in the financial sector (including the central bank) so that they together make up the financial system. This includes payment and settlement systems (retail and wholesale) as well as other financial infrastructures such as credit bureaus and facilities facilitating cross-border transactions. Many of these frameworks are still inefficient because they have limited runtimes or compatibility restrictions. Furthermore, until recently, nonbanks were unable to access these infrastructures directly and were therefore dependent on banks.
4. Balance sheet. Customer deposits (or another source of funds) are turned into productive loans (and other uses of funds) through balance sheet intermediation, which is among the oldest functions of finance. Modern balance sheets are more complex and are optimized to attract mixed retail and wholesale funds, to match assets and liabilities across multiple dimensions (terms, currencies, etc.), and to maintain adequate capital and liquidity levels. A wide range of requirements and restrictions apply to the balance sheets of regulated financial institutions. Most financial institutions, such as payment service providers, mutual fund managers, and more recently P2P or market lenders, do not create customer liabilities and assets on their own balance sheets. However, balance sheet financing remains dominant (BIS Papers 2021).

As technology has decreased transaction costs, firm boundaries have changed, and the financial services value chain has become more disaggregated (vertical disintegration). The rise of information and communication has also resulted in a split in the consumption of financial services (horizontal disintegration).

A typical example of a consumer archetype is the financial sector, where consumers drive innovation. Consumers primarily desire the reduction of time for

financial transactions, a more convenient use of financial products and services, the ability to perform banking transactions at a convenient time, and the ability to combine the receipt of financial services with other types of services. It was these needs that became the basis for implementation of innovations in the financial sector (McKinsey, 2020).

If we consider innovation in the management and operation of organizations in the BFSI sector, then the main categories of innovation are the ability to change business models, transform banking operations, create financial ecosystems, form partnerships with other companies, and also create fundamentally new directions in financial operations (Kosinova & Atova, 2020). In particular, in light of the intensive process of digitization in the financial sector, several concepts have emerged, including the process of changing the business models of banks as key players in the marketplace. The innovative business models include the concept of the digital bank, open banking (Open Banking), the model of the bank as a service (Bank-as-a-Service, BaaS), banking marketplaces (Marketplace Banking), and embedded finance.

A digital bank is a business model where a bank operates only digitally, providing all (or almost all) of its services through digital touchpoints. One of their key competitive advantages is a high-quality self-service experience and much lower transaction costs than traditional banks. While digital banks target primarily digital/technical consumers and small businesses, some begin with narrower segments and gradually expand to other groups. In addition to offering some online banking services, digital banks offer a customer service system that relies largely on chatbots with limited human assistance. Some international examples are Marcus by Goldman Sachs, Liv. by Emirates NBD, Digibank, Monzo, and Kakao Bank (Bubnova, 2019). Tinkoff Bank is a prime example of a Russian bank leading the way as a digital bank.

The concept of Open Banking underlies many fundamentally new models of banks and other financial institutions. Open Banking is a set of solutions and processes that enable banks and third-party service providers to securely exchange financial information and services electronically and with the consent of customers. Through this concept, software developers are able to create products and services for financial institutions and combine them within a single digital ecosystem (Reuters, 2021). Bank-as-a-Service is an end-to-end model that allows digital banks and other third parties to connect directly to banking systems via APIs in order to build banking offerings on top of a regulated provider infrastructure, as well as unlocking opportunities for open banking and global financial services (Shelagh Dolan, 2021).

The Banking as a Service (BaaS) platforms has become a vital component of open banking, which provides account holders with more options for financial transparency by opening their APIs up to the development of new services by third parties.

The BaaS model involves a fintech, digital bank, or another third-party provider (TPP) paying a fee to access the BaaS platform. The financial institution exposes its APIs to TPP, thus giving TPP access to the systems and information needed to create new banking products or offer white-label services.

Through BaaS, the bank actually leases out its infrastructure (licensing, payment processing, card issuance, compliance) to the client (legal entity). The bank's financial services can, for example, be integrated with the customer's business processes, including external end-user applications and an enterprise resource planning (ERP) system. At the same time, the number and speed of financial transactions increase dramatically. An almost seamless connection between company and bank information systems is provided with BaaS using open APIs, and in some cases smart contracts and distributed ledgers. Data is transmitted via standard secure protocols in real time (Abdrakhmanova et al., 2021).

The development of new technologies and the emergence of a wide range of companies that use FinTech technology increases competition in the market and negatively affects the traditional business models of financial institutions, especially banks. With the Bank-as-a-Service business model, however, traditional financial companies and banks can fend off the threat of fintech companies by moving to the BaaS arena to share data and infrastructure.

Bank as a Service (BaaS): In this model, banks provide complete banking functions around their financial products, such as payments, loans, or deposits, as a service that third parties can integrate into their own products and services. Through BaaS, financial products can be seamlessly integrated into mainstream customer journeys, such as instant auto loans from dealers. Usually delivered through well-defined APIs and business partnerships, BaaS is growing in popularity around the globe. A wide range of banks of all sizes and profiles, including Goldman Sachs, BBVA, Sutton Bank, ICICI Bank, and Solaris Bank, are actively developing their businesses with this approach. Furthermore, specialized BaaS resellers such as Galileo, Marqeta, and Setu are getting significant support. Leading BaaS platform providers are divided into fintech players with only BaaS platforms and retail banks that have launched their own BaaS platforms (Global finance, 2021).

Emerging banks are changing their mindset to include third-party products and services in order to meet the growing needs of their customers. There was a beginning for the development of banking marketplaces that combine a variety of products and services into an ecosystem designed to meet the specific needs of customers. Typically, these products and services are provided by a number of ecosystem providers, including retailers and healthcare providers, as well as financial offerings from banks. This approach can ensure transparency, competitive prices, and the alignment of financial services to the needs of consumers.

For many years now, open platforms have been at the heart of the success of players such as eBay, Amazon, Etsy, and Alibaba as they meet customer expectations for a one-stop-shop, convenience, and can offer new and targeted products that make customers' lives easier. These business models were also seen as having value by banks. The development of PSD2 also contributed to the development of this business model, which made it possible to achieve a balance between security in the financial sphere and convenience for users.

Bank platform creation relies on the technological infrastructure of Open Banking, but it is much more than that. There are three types of Marketplace Banking platforms, which are most often found in international practice:

1. Banking as an Open Platform. This model proposes a plug-and-play architecture that allows third parties (e.g., competitors and developer communities) to connect, develop, and manage client interfaces, interact, and exchange value.
2. Banking Platform as a Complement. Third parties will expand their value proposition by integrating additional banking services (e.g., banking, e-ID, credit scoring, and AML/KYC), improving customer data analytics (e.g., customer behavior and understanding), and facilitating community access (e.g., cross-selling) supported by related banks.
3. Banking Platform as a Marketplace. The banks will develop marketplaces that will complement their own core value proposition with services and products of their choice, likely coming from third parties that provide financial and nonfinancial services.

All three platform models can have valid business logic, but the platform-as-marketplace model solves a key disintermediation problem for banks, since customers access the platform primarily through the banking interface. Marketplace platforms give the bank control and ownership of customer data and partnerships (Deloitte, 2021). Marketplaces are becoming increasingly attractive to banks seeking to improve their customers' experience by using matchmaking. Additionally, marketplaces enable banks to leverage their corporate networks and collaborate with ecosystem providers to create new revenue streams and add value, such as addressing complex challenges like regulatory compliance, credit decision making, and credit servicing. The building of financial ecosystems by BFSI firms to serve all clients, including private and corporate, means paying attention to consumer needs and partnering with other companies to meet all those needs (Christian Rupp et al., n.d.).

In the future, financial ecosystems will play an important role in interacting with customers. The integration of financial and nonfinancial services via ecosystems becomes a prerequisite for competing for clients (Kosarev & Iarajuli, 2020).

The modern banking ecosystem is characterized by:

– Combined effect of using a number of services, products, and services.
– Single digital platform that allows flexible (seamless) integration with banking partners.
– Positioning an ecosystem as a lifestyle partner for clients.
– Using a wide range of different services and products based on a single platform.

The embedded finance is another form of change in the usual business models of companies under the influence of new technologies. Customers who actively interact with companies and deeply understand their needs are integrating banking and payments into nonfinancial products and services. The interest in embedded finance is growing across all industries. E-commerce companies, retailers, travel companies, and companies of all kinds are actively incorporating financial products into their customers' journeys. For example, providing suppliers with cash flow-based credit products in collaboration with banks, such as "buy now, pay later" during checkout. Shopify offers a good example of this. It offers consumers a Buy Now, Pay Later

option, a business debit card for merchants, and has plans to open business bank accounts with Stripe Treasury (McKinsey 2020).

A new phase in the digital transformation of the financial sector occurred during COVID-19. Various financial institutions in European and Asian countries have begun to shift focus toward delivering their services entirely digitally.

The following five directions represent the evolution of interaction between financial institutions and their clients through innovative technologies:

1. Personalized and distinctive products and services.
2. Active use of automation and new technologies that enhance the client's capabilities.
3. Reliable quality of services and fast processing.
4. Process and offer management using big data analytics.
5. Simplify organizational processes by eliminating fragmentation.

Thus, new technologies, particularly digital ones, have a significant impact on the financial, banking, and insurance industries. The role of strategic choice and the search for new priority business development models for companies in the BFSI sector in the context of digitalization is becoming increasingly important. The use of advanced technologies is helping companies to increase revenue, lower costs, and provide better customer service.

1.2 Aspects of the Transformation of Regulatory Practice and the Development of Digital Technologies

Innovative digital finance has had a huge impact on business and society as it has been widely adopted by businesses and consumers (e.g., digital payments, crowdfunding, digital lending, supply chain finance, and robotic consulting). However, innovative technologies used in the financial sector not only provide new growth potentials, but also create significant risks, which attract the attention of regulatory authorities.

The regulation and supervision of financial markets and financial activities have always been essential to the efficient functioning of financial markets and their stability. This becomes especially relevant in the framework of the rapid development of new technologies and the changing conditions for the functioning of financial markets. At the same time, the transformation of banking business models is also taking place and the transformation of banking regulation. The introduction of digital technologies directly affects the activities of regulators, new accounting rules are being created, recommendations are being developed for data management, IT outsourcing, projects are being implemented to regulate fintech, and rules for the openness of financial services.

The transformation of regulatory practices in the financial sector in light of the development of digital technologies partly addresses the challenges and risks related both to the development of the sector itself and the introduction of new technologies.

It is vital to consider the risks associated with digital currencies, the decentralization of money, and the emergence of new technologies like blockchain, the Internet of Things, and machine learning have brought about new opportunities and challenges for the banking and finance industry, as well as e-commerce clients using these services.

Risks include decreasing profitability, coming too late to the emergence of new innovations in business processes, for instance, during their implementation, as well as risks of insufficient protection of consumers and data, risks of being used in the legalization of criminal proceeds, etc. There is also the risk that new business models for financial institutions could shift critical banking functions to an unregulated industry (www.rbc.ru, 2017). Banking and financial technologies can increase operational efficiency, risk management, compliance, and customer satisfaction, but they can also reduce barriers and create new ones, such as cybersecurity threats (Mohd Naved et al., 2022).

Increasing use of software and digital processes in the financial sector means that information and communication technology (ICT) risks are also common within organizations in the BFSI sector. In banking and finance, where organizations often handle sensitive customer data, security is a priority. It is unquestionable that constant changes and the introduction of new digital technologies into financial institutions create certain problems for regulators. As a result of new forms of interaction between financial firms and their clients, there are implications for consumer protection, primarily data protection, but also for other types of protection, such as fraud protection. The new forms of collaboration between banks and fintech companies, as well as the anticipated entry into the financial sector of major technology firms such as Amazon, Google, Ant, and Tencent, will force regulators to reevaluate the impact on competition (Eichengreen, 2021).

During the transformation of the regulatory practice in the financial sector, it is crucial to examine changes in the traditional areas of regulation of the financial sector and the banking sector, in particular. One of the key areas of legal support for the transformation of banking regulation was the introduction of international standards by the Basel Committee on Banking Supervision, which gradually evolved from Basel I to Basel III (Larionova, 2018). In addition, the transformation continues as part of the implementation and development of Basel IV. According to the Basel Committee, the main objective of Basel III was the introduction of bank-level regulation or macroprudential regulation, which enables banks to be more resilient during times of stress. Furthermore, the new standards are intended to minimize macroprudential and system-wide risks that may accumulate in the banking sector, as well as their potential to increase over time (BCBS, 2011).

Although Basel III addressed the problems and shortcomings of Basel II, a number of issues related to risk management and regulation remained. In this regard, Basel IV is slated for introduction. Basel IV is an informal name for a set of proposed international banking reforms set to come into effect on January 1, 2023, and will

take 5 years to fully implement. A major goal of the agreements is to strengthen the international banking system by standardizing rules among countries, including those related to risks (BCBS, 2022).

Considering the response of regulatory bodies of different countries to the development of innovations, we can also analyze the experiences of the European Union. Open Banking has been implemented in the European Union to open up banking services to more competition by allowing third-party firms to make payments and to offer other financial services directly from a customer's account. The Payment Services Directive 2, or PSD2, revamped block payment rules to reflect the rapid development of technology such as smart phones to access financial services (Reuters, 2018). In response to the growing number of fintech companies in the financial industry, a second Payment Services Directive (PSD2) came into force in 2016 and opened the door to Open Banking. The Second Payment Services Directive (PSD2) aims to regulate payment services and payment service providers in the European Union (EU) and the European Economic Area (EEA). The directive came into force in January 2018. It includes provisions to:

- Make it easier and safer to use Internet payment services.
- Better protect customers against fraud abuse and payment problems.
- Promote innovative mobile and Internet payment services.
- Strengthen consumer rights.
- Strengthen they are all of the European Banking Authority (EBA) to coordinate supervisory authorities in draft technical standards (European Commission, 2018).

The existing regulatory perimeter may not fully cover new financial service providers, and new players could create challenges for day-to-day financial oversight. We need to find the right balance between consumer protection, privacy concerns, and the stability and integrity of financial systems. The consumer may not be well informed about financial products and services, which can be complex and opaque. Regulations set standards for such products and mandate that suppliers adhere to them to prevent exploitation of consumers. The FinTech sector can attract customers by offering low interest rates on loans with additional hidden restrictions. Regulators should therefore require a minimum acceptable level of transparency. A regulator should require fintech companies to inform customers that the financial services are still in trial mode, which creates unforeseen risks.

The concept of market integrity refers to keeping a level playing field for financial service providers and preventing the manipulation of results by participants that have market power. We are familiar with cases where large investors have sought to dominate the markets for financial assets, taking advantage of other participants due to their size. Regulators should prevent market manipulation, or in other words, ensure fair competition (Eichengreen, 2021). Systemic financial stability refers to preventing the collapse of systemically important financial institutions, market crashes, and other crisis-like events that threaten to disrupt the financial system. It is a fragile system due to a combination of information asymmetries, leverage, and network effects, along with the externalities they produce (FSI Insights, 2020).

Table 1 Implementing innovative technology to meet regulatory requirements

Innovative technology	Ability to use technology to comply with regulatory requirements.
Biometrics	Automates the customer identification process (KYC), thereby improving efficiency and security.
Cryptography	Enables safer, faster, more efficient, and more effective data exchange within financial institutions, primarily for risk data aggregation.
Blockchain and other distributed ledger technologies	Ensure the creation of more efficient trading platforms, payment systems, and information exchange mechanisms within and between financial institutions. Combined with biometrics, they can provide timely, cost-effective, and reliable customer verification.
Application Programming Interfaces (APIs)	Using APIs, financial institutions can retrieve machine-readable reporting rules and data models straight from regulators, improving the quality of reporting, reducing the time and effort required to comply with requirements, and minimizing the risk of reporting errors. APIs provide automated reporting to regulators. In addition to automating data collection, APIs provide the foundation for machine-to-machine (M2M) reporting and machine learning.
Machine learning, artificial intelligence	Data mining algorithms are capable of organizing and analyzing large datasets, especially if the data are unstructured and of poor quality. Potentially, an artificial intelligence-enabled software could automatically adapt a financial institution to new changes in regulatory requirements.
Cloud technologies	Allow financial institutions to combine some of their compliance functions on one platform, which will allow them to be more efficient.

Source: Compiled by the author based on the monograph (Zhdanovich, 2021)

Regarding the issue of the impact of innovative technologies on the financial sector, we can identify two areas of innovation related to the transformation of regulatory practices: RegTech and SupTech.

Financial institutions consider RegTech as an opportunity to optimize the cost of compliance with regulatory requirements. In the ever-changing and reforming regulatory environment in the financial industry, there has been an increase in uncertainty of certain areas and risks, which has led to investments by financial institutions in technologies that can help improve regulatory compliance. Table 1 presents a number of innovative technologies used by financial institutions within RegTech to meet regulatory requirements and reduce the inherent risk of FinTech.

It is important to note that different countries take different approaches to licensing and regulating fintech companies that provide technology to other financial companies, including RegTech companies. European Banking Authority believes they are not a threat to consumer protection, market integrity, and financial stability, and therefore moves them outside the regulatory perimeter, while China requires them to register and subject them to regulatory oversight (FSI Insights, 2020). With

Table 2 Implementing innovative technology to improve the efficiency of financial regulation

Innovative technology	Ability to regulate using technology.
Cloud technologies	With cloud solutions as data exchange platforms, regulators can access company data, maintain their own reporting, and communicate in real time with multiple systems.
Machine learning, artificial intelligence	Regulatory data management is a key component of the regulatory life cycle. Financial oversight trends create not only a greater volume of data, but also a greater complexity of data and a higher level of scrutiny of regulated entities. AI and machine learning are becoming more visible as technologies that can be used to process and manage complex data.
Application Programming Interfaces (APIs)	Machine learning models can be integrated into a data collection platform to generate forecasts. Machine learning in regulatory reporting can enhance the regulatory lifecycle and solve certain data-related problems.
Blockchain and other distributed ledger technologies	A decentralized approach to exchanging and storing information. High potential in addressing issues such as financial inclusion, payment efficiency, and payment systems operational and cyber resilience.

Source: Compiled by the author based on articles and reports (REGNOLOGY, 2022) and (WORLD ECONOMIC FORUM, 2022)

the banking sector's embrace of digitalization, banking regulators must also adapt. The digital transformation offers regulators a number of opportunities to develop tools that will help them better understand the risks facing the financial sector (ECB, 2021).

Recent trends in financial regulation emphasize the revision of regulatory standards with greater local variation, the introduction of new methods of regulation and supervision, and the development of SupTech. In this context, the second direction of the transformation of regulatory practice following the development of digital technologies is the development of SupTech. Suptech is the short form of supervisory technology. The term "SupTech" refers to technology that supports supervisors. Bank for International Settlements (BIS) defines SupTech as "the use of innovative technology by supervisors to support supervision." (Table 2).

In addition, Table 3 also presents examples of countries and technologies used by regulators in the context of SupTech solutions, according to the report of the Central Bank of the Russian Federation. The most effective way for regulators and financial institutions to achieve their goals is to align their technologies and software. The interaction between SupTech and RegTech creates a seamless relationship between regulators and regulated, replacing slow, outdated, and expensive processes. The result is a smooth flow of data and a clear interpretation of rules. The quality of data is also improving. When processes are updated, RegTech and SupTech rules are automatically synchronized, so financial institutions always use the most recent versions of the rules.

Table 3 Examples of countries and technologies used by regulators as part of SupTech solutions

Innovative technology	Fraud detection system	AML/CFT	Risk assessment and management	Behavioral supervision	Admission procedures
Technologies for collecting, processing, and storing data	Australia USA Great Britain	Italy Mexico Brazil	Netherlands	Lithuania	
Machine learning, artificial intelligence	Australia USA Great Britain Singapore	Singapore Italy	Italy Netherlands EU	Spain Italy	EU
Natural language processing		Singapore Mexico	Italy USA EU	Spain Italy Australia	EU
Chatbots				Philippines	Philippines Australia

Source: Compiled by the author based on data provided in the article (REGNOLOGY, 2022)

In 2019, the Bank for International Settlements (BIS) established an Innovation Hub for central banks to increase international cooperation in the field of financial technologies. The BIS Innovation Hub has three main functions:

1. Identification, in a structured and systematic way, critical technology trends affecting central banking across regions and development of an in-depth understanding of these technologies that can be shared with the central banking community.
2. Development of public goods in the technology space to improve the functioning of the global financial system.
3. Support as the focal point for the central bank's network of innovation experts by holding regular events to exchange views and knowledge (BIS, 2021).

In January 2021, the BIS Innovation Center launched the BIS Innovation Network to support the Innovation Center's priorities, share information about technology projects, and discuss innovative solutions to problems relevant to central banks. The European Central Bank has also been actively involved in innovation. Due to the ever-increasing amount of data available, the European Banking Supervisory Authority embarked on a digital transformation process to implement its own supervisory technology solutions (SupTech) at the end of 2019 (ECB, 2022).

Asian countries provide another striking example. Regulators guide the development and implementation of technologies to maintain financial stability, including through the organization of cooperation with financial companies and external experts. Due to this, the Monetary Authority of Singapore (MAS) and the ASEAN Financial Innovation Network developed the API Exchange platform—APIX, which allows participants (financial and fintech companies) to integrate and test

their digital solutions via the cloud architecture (CBR, 2021a). APIX was launched by the Indian Prime Minister Narendra Modi and the Deputy Prime Minister of Singapore Tharman Shanmugaratnam at the Singapore FinTech Festival on November 14, 2018, to help market participants communicate, jointly develop experiments and implement new digital solutions (Monetary Authority of Singapore, 2022).

Another example is Australia. The Australian Prudential Regulatory Authority (APRA) is replacing its existing Direct to APRA (D2A) system with an innovative data collection platform called APRA Connect. The new system, which was launched in September 2021, allows regulation changes to be validated and applied instantly, and test submissions can be validated in accordance with APRA Connect's data validation rules in order to identify errors or warnings. The monitoring side is occupied by financial institutions that through the use of this software and common data rules, see that regulatory changes are reviewed and applied instantly. Financial institutions immediately align with current and future APRA Connect reporting standards (APRA Connect, 2022).

The UK has launched the Digital Regulatory Reporting project to streamline the reporting process for financial institutions. Digital Regulatory Reporting (DRR) is a joint initiative by the Bank of England and the UK Financial Conduct Authority. Two phases of this project have already been completed. Phase 1 discussed how to automate regulatory reporting by writing a regulation in machine-executable regulation (MER) format and developing the target operating model (TOM) options needed for digital regulatory reporting. A second phase focused on determining how domain-specific languages (DSLs) might be used to implement MER. As part of DRR Phase 3, the FCA is establishing the basic requirements for MRR and MER, as well as modifying the data we request and the way it will be used in new and existing regulatory areas (FCA, 2020).

The alignment of RegTech and SupTech in 2022 and beyond will result in significant cost savings and more efficient use of resources. Harmonizing the systems used by financial regulators and the institutions they oversee can eliminate duplication of effort, make it easier to implement new rules, and reduce the costs associated with late or inaccurate filings. An international experience study reveals that many financial market participants and regulators have started to implement innovative RegTech and SupTech technologies as part of their activities in order to optimize the interaction between regulators and financial market participants in order to simplify and optimize the implementation of regulatory requirements.

The study shows that the top areas of RegTech applications by financial institutions are personal identification, risk assessment and management, combating unfair practices, monitoring fraudulent activities, including fighting money laundering and countering the financing of terrorism. Among the uses of SupTech technologies, regulators use them to manage data, regulate reporting, monitor financial markets, enforce prudential regulation, and identify illegal practices. As a result of the rapid pace of digitalization, regulators often fail to take into account the conditions of the new reality and are behind the times. Therefore, an issue of transforming regulatory practices in the field of BFSI at a time of digitalization of economies and the search

for new effective mechanisms in the Russian Federation becomes relevant. Government agencies are challenged to develop or change rules at a pace never seen before due to the rapid emergence of new fintech services.

The Central Bank of the Russian Federation developed a report in 2021 on "Major directions for development of SupTech and RegTech technologies in the period 2021–2023." Within the framework of this document, the tasks involved in implementing both SupTech and RegTech solutions are described. Among the tasks involved in implementing SupTech solutions are:

- Increasing the effectiveness of data analytics by optimizing their collection, storage, and processing.
- Enhancing the level of efficiency and efficiency in identifying risks in the activities of financial organizations (including unfair practices in the financial market).
- Allowing employees to devote their time to solving complex (motivated) tasks (CBR, (2021b). Major directions for development of SupTech and RegTech technologies in the period 2021–2023. Retrieved from https://www.cbr.ru/Content/Document/File/120709/SupTech_RegTech_2021-2023.pdf (retrieved February 25, 2022) CBR, 2021a).

Among the tasks involved in implementing RegTech solutions are:

- Automation and standardization of business processes related to ensuring compliance with regulatory requirements.
- Reduce risks and costs, including those associated with compliance requirements, and make the process of meeting regulatory requirements more accurate.
- Enhance the level of efficiency in detecting and responding to fraudulent activity (CBR, (2021b). Major directions for development of SupTech and RegTech technologies in the period 2021–2023. Retrieved from https://www.cbr.ru/Content/Document/File/120709/SupTech_RegTech_2021-2023.pdf (retrieved February 25, 2022) CBR, 2021a).

The Bank of Russia is working toward the development of SupTech and RegTech, guided by the approaches laid out by the Basel Committee on Banking Supervision, including the principle that supervision should adapt to the level and trends of digitization of the activities of supervised organizations (Table 4).

Thus, digital innovations lead to economically significant changes in the production of financial services, which necessitates adapting regulatory and supervisory tools. Innovation in digital financial services can offer benefits ranging from improved customer experiences to easier access to financial services. However, regulators must balance these benefits against risks to consumer protection, market integrity (adequate competition), and systemic stability of economic systems.

Table 4 The Bank of Russia's initiatives in SupTech and RegTech

Direction name	RegTech/ SupTech	Technology consumer	Implementation results
Implementation of a system for monitoring and analyzing operational risks of banks	SupTech	Bank of Russia	1. The requirements for cross-checking financial statements of credit institutions with internal and external sources have been developed. 2. The requirements for comparing the operational risk of credit institutions with a typical operational risk profile have been developed.
Creation of a KYC platform	RegTech	1. Bank of Russia 2. Participants of the financial market	Plan prepared, business processes described.
Creation of a unified register of pledges	SupTech	1. Bank of Russia 2. Credit organizations	There has been created a register of collateral accepted by lending institutions as collateral (collateral register), containing information about the quantitative and qualitative characteristics of the pledged property, which will allow identifying its encumbrance.
Improving monitoring of customer transactions to identify unfair practices	SupTech / RegTech	1. Bank of Russia 2. Participants of the financial market	1. Determined the areas in which customer transactions can be better monitored to detect unfair practices, including criteria for market manipulation and abuses of insider trading, and control of concluded transactions in financial institutions. 2. Financial market participants have been provided with recommendations on RegTech solutions in the field of transaction monitoring.
Preparation of proposals for automated assessment and analysis of securities portfolios	SupTech	Bank of Russia	Several main directions were determined, business processes were developed to automate the assessment and analysis of a portfolio of securities, and an application was created
Information security external audit system	SupTech	1. Bank of Russia 2. Participants of the financial market	1. To verify that financial organizations are fulfilling the requirements of national information security standards, including the method of

(continued)

Table 4 (continued)

Direction name	RegTech/ SupTech	Technology consumer	Implementation results
			voluntary certification and the composition of subjects to be qualified, as well as the organizational structure of the system, a voluntary software certification system was developed. 2. A system for automating the analysis of software information security assessment results was developed and put into operation.
Stress testing (cyber exercises)	SupTech	1. Bank of Russia 2. Participants of the financial market	1. The concept of performing stress tests (cyber-tasks) in financial organizations, including the methodology and scenarios for conducting stress tests of financial organizations on issues related to information security, has been developed. 2. The ability to conduct a comprehensive assessment of the cyber resilience of the credit and financial sectors is provided.

Source: Data from the Bank of Russia (CBR, 2021a)

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AI, Blockchain, and IOT

Ankit Som and Parthajit Kayal

1 Introduction

Internet of Things (IoT) technology has progressively gained prominence in recent years, growing from mere terminology to groundbreaking corporate innovation. Due to the abundance of outgoing data from IoT systems, the Web has become an instantaneous pipeline of enormous volumes of information that organizations can examine to improve decision-making, upgrade performance, and increase revenue (Perera et al., 2014). Yet, there exist some hindrances to configuring and enhancing an effective big data analytics instrument that uses AI, such as a centralized ecosystem, cybersecurity, resource constraints, and unavailability of sufficient training data. Instead, a new domain, blockchain, provides a decentralized framework for the secure exchange of information and functions between the apices of an IoT ecosystem to eliminate centralized authority and solve data problems (Atlam et al., 2020). The tech industry as we know it is being revolutionized by blockchain and associated distributed ledger technologies. A new class of IoT applications will emerge because of the secure exchange of blockchain value between entities in a decentralized network. The combination of IoT, AI, and blockchain will enable maximum technological innovation (Reyna et al., 2018). Artificial intelligence (AI) is equipped to properly process data to extract useful insights, which in turn contribute to the Internet of Things. Blockchain, IoT, and AI are the main technologies driving the ensuing movement of digital transformation. In this chapter, we discuss how these technologies converge, enabling new autonomous business models and the innovative impacts of this triad on increasing the competitiveness of companies, for example, in marketing and sales, customer service, and growth hacking, among other areas (Salah et al., 2019).

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This chapter's structure follows a description of the IoT and its financial applications. The blockchain is then proposed as a solution to IoT's massive data security concerns. Then, we consider how artificial intelligence may be utilized to leverage enormous amounts of data created by IoT and secured by blockchain technology for real-world solutions and payment structures. Finally, we will look at how Fintech is merging these three technologies to bring answers to the financial industry's current problems.

2 Internet of Things

Internet of Things or IoT is popularly known as the technology of a rapidly expanding cluster of multiple interconnected physical and virtual appliances that communicate and convey data between devices via a wireless network without requiring human interaction. The phrase "Internet of Things" was conceived in 1998 by Kevin Ashton of the Massachusetts Institute of Technology (MIT) and defined as it "allows people and things to be connected Anytime, Anyplace, with Anything and Anyone, ideally using Any path/ network and Any service" (Sundmaeker et al., 2010). Cars, refrigerators, lights, thermostats, and various other devices embedded with sensors collect and share information in real time to ease lifestyle by creating innovative digitized services. IoT's success story is visible with the popularity of smart home devices like Amazon echo, wearables like Apple Watch and Fitbit, connected cars by AT&T, etc. (Atlam et al., 2018). The Internet of Things has advanced initially with the connection of two computers and progressed to a huge network of systems with the advent of the World Wide Web. Following that is mobile-Internet: the connection of mobile devices to the Internet, followed by people-Internet: the link backed by social media platforms. Ultimately, it advanced to the Internet of Things: the realm of associated items (Perera et al., 2015). The number of IoT objects outnumbered the global population back in 2008. According to a projection by Statista, the world is supposed to assimilate more than 75 billion IoT devices by 2025 as illustrated in Fig. 1.

The benefits of IoT go above and beyond Internet-enabled consumer devices. It can be used in the health sector to actively monitor patients within and outside the hospital setting and accordingly provide treatment by analyzing the collated data. Smart cities are coming up like Barcelona where traffic conditions are predicted and accordingly routes are managed, waste collection is optimized, etc. In the financial industry, IoT plays a crucial role, with the potential to alter the BFSI (Banking, Financial Services, and Insurance) sectors. As banks deal with a large amount of data collection and transfer, IoT assists banks and financial institutions in optimizing and streamlining their capabilities. Moreover, with the advent of digital payment systems that permit customers to perform a variety of transactions without having to contact a bank, and self-serviced customer service gateways, which allow troubleshooting by chatbots, IoT aids financial institutions in enhancing customer satisfaction, reducing risk, and enhancing the security of banking industry.

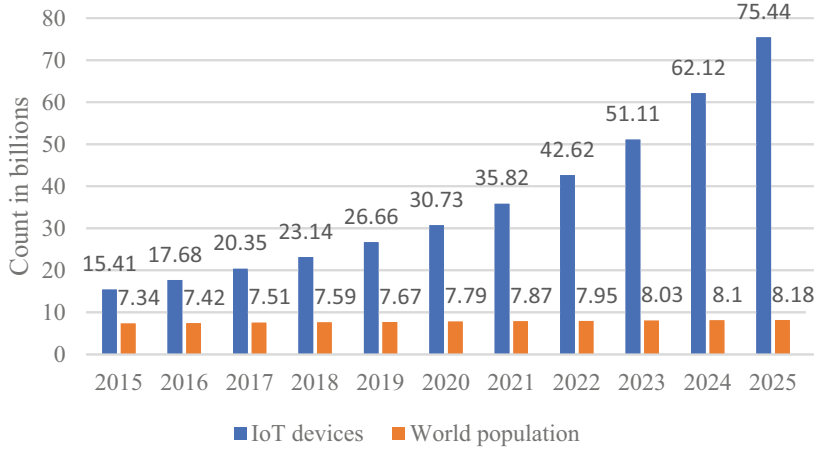

Fig. 1 According to data projections each person will be dependent on around 10 connected devices by 2025. Data Source: Statista

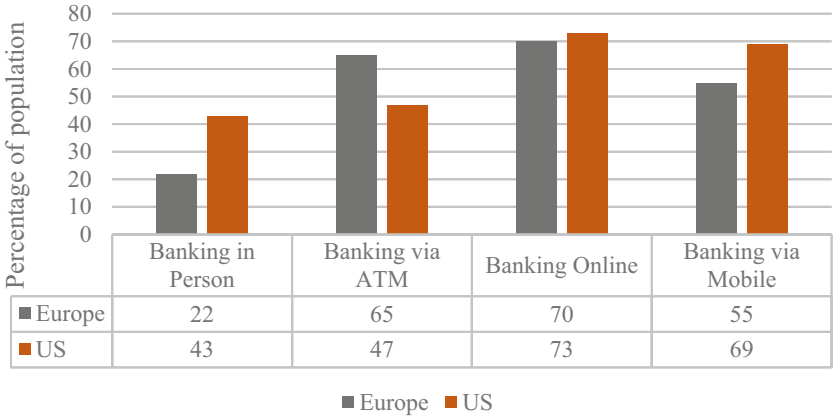

Fig. 2 Evolution of ATM users. Data Source: World Bank

3 IoT in Finance

The Internet of Things (IoT) is a component of intelligent infrastructure, and one such industry where IoT technology may provide substantial benefits is banking. The infrastructure's frontier currently includes ATMs (automated teller machines), point-of-sale consoles (POS), and e-wallets. Figure 2 depicts the evolution of ATM usage in major economies across the world. These digital banking systems allow consumers and their requirements to be discussed one-on-one, as well as the collecting, processing, analysis, and decision-making based on that data. Advanced smart banking systems are required to fulfil BFSI's expanding needs, and the IoT is

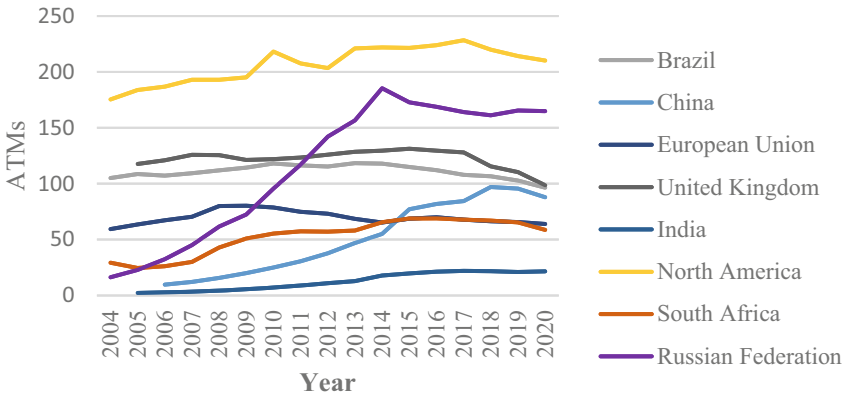

Fig. 3 Percentage of people using different means for banking transactions. Data Source: World Bank

one component of the digital banking infrastructure that matches these expectations. Figure 3 depicts the percentage of the population in Europe and the USA involved in banking transactions by various means as of 2020. It shows how an average individual depends on IoT for financial purposes.

Consumers may pay with publicly known smartwatches namely the Apple Watch, Samsung Gear, and FitPay. Recently, Barclays launched the bPay mobile contactless payment platform. Bluetooth beacons allow customers to personalize their experience (Internet of Things). Chase Bank is experimenting with a proactive service platform before consumers go to banks or ATMs. Barclays uses beacon technology to help travelers with disabilities navigate their stores. Enabling smart devices at home makes your home infrastructure smarter, closer to your customers, and able to manage a variety of services. Customers can access the new service through activated items running on Amazon Alexa or Google Home. US-based Capital One and UK Challenger Bank allow consumers to pay invoices using Amazon Alexa. IoT connections help individual customers digitize their businesses. This should result in the emergence of new technological industries. Self-aided ATMs, touch-enabled banking, and speech interfaces (Amazon Echo) all contribute to a better Consumer Banking journey (Drinkwater, 2017).

The Internet of Things (IoT) market in retail businesses is expected to grow by USD 44.80 billion from 2021 to 2026, according to Technavio (2022). However, the momentum might slacken to a CAGR of 16.48 percent due to data cybersecurity vulnerabilities (Technavio, 2022). One key reason fueling the Internet of Things (IoT) sector development in retail establishments is the growing cloud-based Radio Frequency Identification solutions.

Network services are without a doubt one of the chances that banks must seize in order to remain competitive. At present days, consumers demand much inventiveness from their institutions, particularly the new digital ones, which will provide them with solutions that are tailored to their modern connected lifestyle (Petracek,

2018). Clients are gradually anticipating simplicity, smooth, and rapid access to all financial services in response to the growing pattern of digitizing operations. Because of the IoT technology, one may manage his/her bank account out of any virtual environment. Furthermore, biometric information is unique, and distinctive to people (DNA, fingerprints, etc.) that are meant to accurately recognize an entity based on external, physiological, and perhaps even Behavioral features. Numerous financial offerings involve physical signings, which could be substituted by "Wet Ink" innovation, which is the duplication of documents of any touch-sensitive appliance's physical signature (Khanboubi et al., 2019). As a result, the client's actual attendance is therefore no longer mandatory. IoT technology enables financial institutions to identify and analyze the state of funded properties (cars, appliances, machines, etc.) real-time basis. Because of individuals' and assets' digital identities, the requests for finance and consignment of proprietorship may well be automated and fully online. As a result of the increasing popularity of the Internet of things, the scope and information rate will linger to increase. Corporations that effectively utilize this data are more will have more opportunities to develop effective algorithms that allow maximum benefits and targets via smart algorithm prototypes. Between concerns of increasing cybercrime, in order to ensure smooth financial operation, banks must provide innovative solutions based on biometric technologies that can recognize people based on biometric and technical features. There are actually two important steps on user travel that require different levels of security certification and verification. Apparently, Barclays has invented a vein fingerprint technology for transaction confirmation, payment or registration of offers. It is further feasible to examine the standard of collateral by inspecting the valuables and deciding to choose either to maintain the assets physically or not. For instance, whenever a bank sponsors an operation that does not get reimbursements, it might be shut down immediately. Everyone's attention nowadays is focused on a quick settlement. Policymakers are encouraging such that this innovation becomes vital. Presently, faith in wireless technologies is propelling the network adapters sector forward. Furthermore, the RFID system enables a reasonably secure degree of protection for progressively inventive linked products. As a result, the prospect should offer many such advancements that everything can become a source of the transaction. Wallets can hold funds without requiring a card or account and start purchases instantly at just about every point-of-sale terminal. Any item or piece of technology will have an associated, pre-funded wallet that would handle the expenditures instantaneously and quickly. Smart contracts enable financial institutions to offer products to customers in a computerized and expeditious manner. With smart contracts coming into the picture, payment terms will be able to automatically relate action to a condition, e.g., your apartment's landlord might tie your payment of rent on time to the availability of elevator services automatically. In the coming years, intelligent crowd-sourced funding is a system for gathering working capital—often modest amounts—from a multitude of investors via an online website in order to fund a venture. This can further enable examining the integrity of debtors and their creditworthiness by assessing and inspecting various IoT statistics. IoT combined with blockchain technology has the potential to change several areas of the

economy, beginning with financial services. It enables users to hold information in an unambiguous, safe, and decentralized manner. It appears to be a vast data repository that records all trades among its members from its inception. Blockchain could be integrated with IoT platforms to track analytics models that record data generated by IoT processes, enforce strong identity rules to keep them secure, and finally solve digital problems such as immediate payment calculations between network members and devices. More about blockchain technology in the following sections (McKinsey and Company, 2018). Personal financial management (PFM) services are a twenty-first-century innovation. During the 2000s, virtual PFM services were introduced in the USA. The guiding philosophy is straightforward: provide consumers with an objective understanding of their balances, earnings, and spending. This sort of assistance is offered in a variety of ways, but there are certain common characteristics and ideas. The range of PFM products offers the customer a view of every transaction that arrives and exits from their account. Leveraging statistics acquired from IoT, the next wave of PFM solutions shall assist bankers in providing increasingly personalized and customized solutions to their clientele. The only requirement is for an IoT to transmit indicators to measure the consumer's usage and enable/disable specified bank-managed items. KYC or Know Your Customer often applied in banking is a term to allude to identity and consumer information requirements. This should be mentioned that in the banking industry, KYC processes are primarily designed to meet statutory and supervisory criteria in order to avoid fraudulent transactions. The information gathered throughout those examinations can, of course, be used for commercial reasons. The usage of IoT with a distinctive and worldwide public key would describe a client's financial behavior to assist in giving relevant goods or services, such as a bank card featuring deals on businesses visited mostly by consumers.

4 Blockchain Technology

Despite the potential advantages presented by the IoT implemented in a variety of areas, the network infrastructure, in which all IoT objects are connected, handled, and controlled by a centralized server, faces a host of difficulties. These issues will stymie the development of IoT applications in the future. When the server breaks, this is a minor instance of failure whereby all IoT applications and services associated with it shall collapse, and thus affect the provision and quality of services offered by the IoT ecosystem (Atlam et al., 2020). Moreover, the centralized database which collects and stores all information generated by various IoT devices is a desirable target for any cybersecurity threats. Furthermore, the security of personal data appears to be in jeopardy, as all IoT data entails delicate safety structures. Upgrading the IoT to one of the distributed ledger systems may be the best solution, given the centrally managed IoT architecture's severe challenges. The most frequent and commonly used sort of such technology is blockchain. It is basically a decentralized, shareable, and incorruptible ledger that keeps track of all

transactions in a peer-to-peer (P2P) network. A catalogue of transactions gets consolidated and allotted to a block in the ledger. Thus, every block contains a log file with a date-time stamp and a hash function that is used to connect the prevailing block to the preceding block. As a consequence, a chain of blocks is formed, which is referred to as the blockchain. Sultan et al. (2018) precisely defined it as "a decentralized database containing sequential, cryptographically linked blocks of digitally signed asset transactions, governed by a consensus model." To record a transaction in the public ledger, the majority of network participants in the blockchain platform must agree. Distributed ledger technology encourages the exchange of information by ensuring that all contributing users/nodes in the blockchain get a mockup of the authentic ledger, allowing all users to be kept up to date on newly added exchanges or blocks.

Incorporating IoT and blockchain offers significant advantages. For instance, because there is no need for a database controller to regulate IoT devices and their communication services with one another, utilizing the shared system features of blockchains can resolve vulnerabilities and a point of failure attributed to a centralized IoT ecosystem. Besides that, blockchain provides improved privacy and security because it employs intricate cryptography algorithms, hash functions, and timestamps, all of which provide such a secure cloud infrastructure. Furthermore, blockchain technology offers a tamper-proof and incorruptible ledger to protect data from malicious threats, so that any records change can only be cached in the ledger if the large percentage of attributing users substantiate it (Karafiloski & Mishev, 2017). As a result, a reliable system is created in which the participating IoT applications seem to be the only entities that approve or disapprove a transaction based on their assent (Reyna et al., 2018). Figure 4 is an illustration of the advantages posed by integrating Blockchain with IoT.

Because IoT devices create huge volumes of data that are difficult to analyze using standard approaches, the big data analytics tool helps the blockchain to provide effective web data storage and processing. Furthermore, many transactions are processed in formalized ledgers, necessitating additional data analysis. Smart contracts are another essential element of distributed ledger technology that enables artificial intelligence technology based on predetermined conditions. A smart contract is traditionally a component of source code remote execution on blockchain to carry out a series of actions when certain terms are fulfilled or authenticated.

Blockchain was initially utilized for monetary operations and cryptocurrency, with all nodes in the blockchain platform executing and storing transaction records. Whereupon, because of the enormous perks, blockchain is now being embedded into a variety of disciplines. One such arena might be the Internet of Things (IoT). Incorporating blockchain and IoT can provide numerous advantages (Atlam & Wills, 2019). Meantime, blockchain technology is delegated and untraceable, making it ideal for IoT areas such as medicine, home automation, intelligent transportation, smart cities, and others. Consolidating blockchain in an IoT system is a challenging venture. Perhaps the most crucial stage is to ascertain the blockchain platform that would be used to integrate IoT and blockchain. The most widespread systems at present are Ethereum, IOTA, and Hyperledger, all of which are

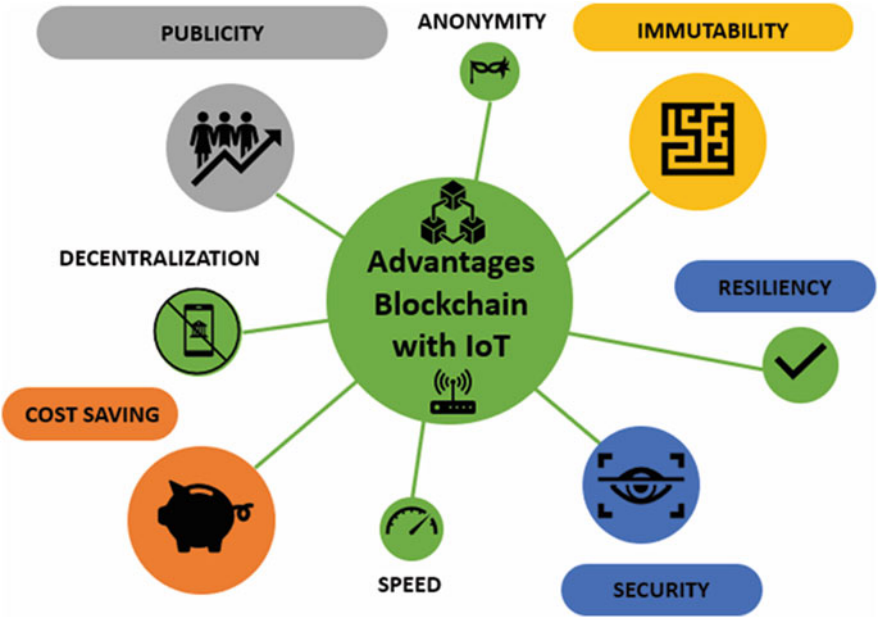

Fig. 4 Advantages of integrating Blockchain with IoT functionalities. Source: Compiled by authors

open-source platforms, which are free to use. They can also provide key capabilities such as linking blocks, cryptographically protected hashing of transaction records in an individual block, innovative traces, consensus, and smart contracts.

As often narrowly associated with only Bitcoin by the mass, Blockchain is so much more powerful than it is utilized to secure banking records as well as in creditworthiness, mortgage lending, mass transit, online broadcasting, healthcare, and other fields. Information access control, Fintech, Internet of Things (IoT), Cloud Services, Multimedia, Education, and Tourism are all examples of the present status of the blockchain (Maiti & Ghosh, 2021; Yeasmin & Baig, 2019).

Supply chain and logistics are critical examples of integrating IoT with Blockchain. A worldwide value channel with various parties renders end-to-end monitoring more difficult. When Blockchain and IoT are coupled, they can substantially enhance dependability and provenance (Liu et al., 2021). IoT may be deployed to capture mobility, climate, Geolocation, and other data, which will then be recorded on the distributed ledger. Information obtained can be developed to identify and highlight major issues. Integrating totally unmanned cars produced with the use of IoT automobiles to the decentralized ecosystem of blockchain allows crucial data to be communicated securely and rapidly. It moreover helps in a variety of fields, such as automatic gasoline purchase, self-driving automobiles, intelligent parking management, and so forth. Smart buildings are another IoT solution. A smart home system allows customers to operate their household wirelessly via various electrical

instruments such as a cellphone. The ledger technology utilized in home automation, on the other hand, is centralized, making it insecure. The sharing economy is a type of market structure in which resources are exchanged among individual entities over the web. Blockchain enables the transfer of wealth in a safe and decentralized fashion, eliminating the requirement for a middleman. Any object may be leased, purchased, or exchanged through a cloud-based marketplace of linked objects (Reyna et al., 2018).

5 Blockchain in Finance

The financial services sector is projected to be valued at USD $2.6 trillion by 2022. The international economy handles trillions of dollars per day providing for billions across the world and along with it, carries with it a slew of problems that they have been pondering for a long time. From the hefty cost of stakeholders involved to disruption, exorbitant documentation, and privacy violations; these obstacles seem to be the underlying cause of the industry's significant losses each year. Per a PWC report, 45 percent of financial mediators such as stock exchanges, money transfer services, and payment networks face financial misconduct every year. The global financial system's issues may be addressed via blockchain. Blockchain technology has the potential to provide a solution to the global financial system's problems. Blockchain in the financial sector has led to the implementation of decentralized finance or DeFi which is a type of finance operated by a blockchain process that combines smart contracts to reduce intermediaries. Research on the impact of blockchain shows that blockchain can minimize costs and transform finances in the long run (Nguyen, 2016).

Proper implementation of blockchain can save billions of dollars that banks will spend in a variety of situations, such as with KYC norms, banks keep their own customer databases and spend between US $ 60 million and the US $ 500 million. Each bank can access a distributed database via a blockchain that avoids database duplication (Nelito, 2018). The entire system is decentralized, and the repository is not controlled by a single institution, so there is no system failure. One can use smart contracts that eliminate the need for brokers. The microgrid is a good example of this. Microgrids with blockchain will change the ways to pay and use energy. Another use is in developing countries, which can be used to clean up the housing market and eliminate the so-called shadow economy (Harris, 2018).

As Blockchain technology becomes more prevalent, financial institutions aggressively research and deploy it to better the present centralized monetary industry. Banking institutions eliminate the intermediary by leveraging Cryptographic encryption, untraceability, and transparency (Underwood, 2016). Classical banks' marketing strategies and technological qualities have been altered by distributed ledger innovation. For starters, it lowers expenses and revenue exchanges. Because endpoint upkeep and acquisition expenses are exorbitant, corporate bankers frequently have to invest a significant amount in a centralized registry. However, many

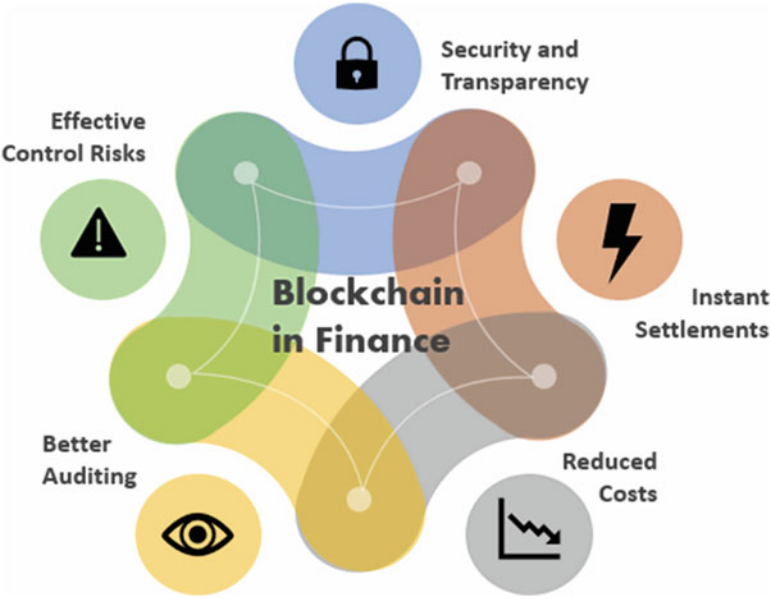

Fig. 5 Uses of Blockchain in the finance industry. Source: Compiled by authors

reconciliations and settlement tasks increase labor expenses and personal procedural risk. Blockchain's mechanization and adoption of distributed ledger can start the development with minimal prices and visibility, with minimal expenditure (Nguyen, 2016). Secondly, it could precisely manage vulnerabilities. The banking sector prioritizes loan surveillance; however, the real functioning is less dependable and successful. Furthermore, worldwide control of capital flows might create challenges. The Blockchain's multicentered characteristic sees every participant as a component in the Network, allowing effective peer-to-peer dealings among lenders and borrowers, removing the necessity of borrowing certificates by bankers as middlemen. The risk premium is significantly decreased as a result of knowledge asymmetries, and wealth administration capacity is increased. Ultimately, it looks for new methods to earn. Throughout the banking business, yet more corporate titans, particularly bankers' organizations, are engaging in or collaborating with Blockchain firms. Institutions must pursue creative business strategies in order to produce commercial offerings and expand opportunities in this intensely competitive climate (Chang et al., 2020). Figure 5 broadly highlights the major uses of Blockchain technology in finance domain.

As a result of the public autonomy, multicentered, and non-tamperable attributes, the centralized financial sector business plan has radically altered, optimizing the treasury back-office and infrastructural facilities, enhancing customer experience, as well as providing a transition possible for the financial institution from conventional payment business to online banking space. It is critical for achieving operational excellence in the lending business. Whenever a debt is involved, the global financial

sector appears untrustworthy and susceptible. Therefore, in sense, when a distributed system is utilized for lending activities, the client and the institution will be able to trace the entire process more easily since anyone can access data.

Blockchain technology has the potential to revolutionize trade finance. The industry currently relies on papers transmitted all across the globe for verification that requires a postmark for identification. However, no certification is required on the network. The surveillance of the documents will be made easier and more accessible by employing a computerized distribution network procedure. Cryptography is being used by FinTech businesses to increase compliance requirements. Because the blockchain is indelible, it eliminates the chance of mistakes and ensures the reliability of accounting and auditing. There would be little reason for authorities to intervene because the blockchain would record the participant's activities. A blockchain enables customers to control their unique identifying credentials and repute, share their details with someone without fear of compromising their security and authenticate any form of paperwork, such as statements and agreements. R3, a US financial technology firm, is creating Corda, a DLT framework, to support several expanses of commerce (Eyal, 2017).

6 Smart Contracts

A smart contract is an agreement between two or more entities that are electronically signed and configurable. A software agent, a virtual third party, can implement and impose (at least some) of the terms of such contractual provisions (Sotirios Stampernas, 2018). Smart Contracts are autonomous computational models (self-executing codes) that, once initiated, execute the underlying conditions automatically and in a mandatory manner, coordinating, confirming, or enforcing the mediation or contract results, executing a money transfer, and so forth. It is a "cryptoeconomically secured code execution" that runs on Blockchain (Wang et al., 2019a, b). Survey on blockchain for the Internet of Things. Computer Communications, 136, 10–29. When the defined condition is satisfied, the smart contract self-executes the corresponding contractual clause without the assistance of third parties. Furthermore, because all actions are documented and authenticated as transactions in a decentralized Blockchain ledger, it provides real-time auditing. These exchanges are traceable and distinctive, which improves hardware security. Smart contracts are said to have been invented in 1994 by an American cryptographer named Nick Szabo. He recurrently used the instance of a rental truck with a smart contract that gives back control to the vehicle owner when the tenant nullifies the instalments. Individual resources, such as IoT devices and digital assets, are transformed into virtual IDs on the blockchain, allowing them to interact with other resources. Smart contracts are a viable alternative to traditional contracts since they are dependable and effective. Smart contracts are implemented independently and autonomously by each node in the blockchain network. Many blockchain initiatives, such as Bitcoin and Ethereum, leverage smart contracts. Smart contracts have the

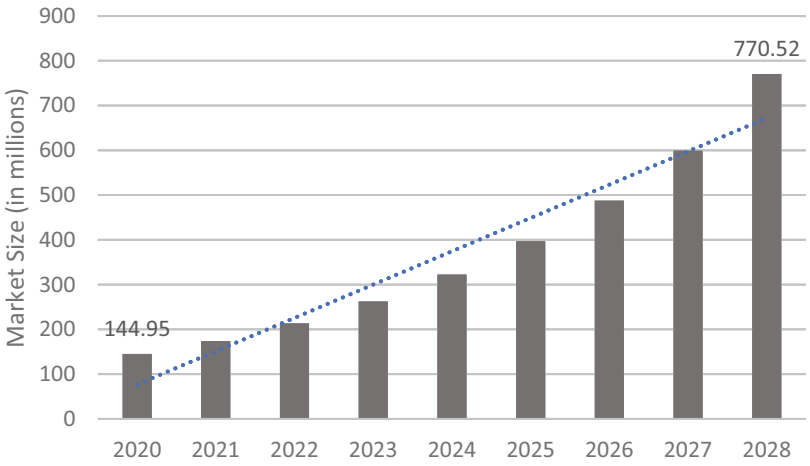

Fig. 6 Global smart contracts market size. Data Source: Verified Market Research, Graph compiled by authors

potential to boost IoT system performance and dependability. This is because the Internet of Things anticipates that detectors in unpiloted areas would operate in a dispersed fashion and respond quickly to particular requests. The key benefit of deploying smart contracts on public ledgers is that the contract's details cannot be changed by blockchain. Blockchain technology restricts the terms of the agreement from being tampered with or hacked. As a result, smart contracts deployed on a blockchain will reserve funds for confirmation, operation, adjudication, and fraud prevention. Besides, smart contracts can also help solve the moral hazard conundrum.

The Global Smart Contracts Market was worth $144.95 Million USD in 2020 and is anticipated to grow to $770.52 Million by 2028, rising at a CAGR of 24.55% from 2021 to 2028, according to "Verified Market Research" as depicted in Fig. 6.

The BFSI (Banking, Financial Services, and Insurance) industry has recognized the importance of blockchain technology in securing payment processing. Furthermore, the major revision from centralized network systems to distributed ecosystems is paving the room for future economic models in payment, online banking, and money transfer machinery.

7 Artificial Intelligence

Blockchain technology, even as remarkably potent, does have several shortcomings. While a few are technical in nature, others are deeply rooted in the established culture created by the financial services sector. However, AI could have a significant impact on all of them in one way or another. For artificial intelligence applications,

several elements of distributed ledger technology can be exciting. The decentralized and reliable nature of the blockchain, as well as the immutability and transparency provided by the origin of the cryptic trail, provide for the safe transfer of AI data, procedures, and models.

Artificial intelligence (AI) is the quest to replicate cognitive mechanisms or behaviors, usually performed by the human brain, but with the aid of computers or software. It is a system of realizing, reasoning, and rectification, or a set of instructions (algorithms) that allow computers to generate their own algorithms without explicit programming. AI is an interdisciplinary field that includes (and requires) research in a variety of disciplines including natural language processing, computer vision, the Internet of Things, and robotics. In this sense, it is a broad term that encompasses a wide range of concepts (e.g., statistics and machine learning). We can view AI as a fully functioning organism and make comparisons to determine the degree of relationship between AI and other (sub) fields. If artificial intelligence and the human body are similar, we must have a brain that does many tasks, such as language (NLP), perception (computer vision), and is in charge of a variety of functions. Machine learning can be thought of as specific movements, actions, or thoughts that we develop and personalize throughout the entire process. Human emotions and how we interpret our surroundings are at the heart of the Internet of Things (IoT). Finally, big data can be thought of as the food we eat, the air we breathe, the fuel that moves us, and anything else our senses pick up from the outer world. This is a rather crude comparison, but it shows how all the terms relate to each other.

Artificial intelligence (AI) and blockchain technology might help the finance sector become smarter and more efficient. Transparency and data aggregation are two benefits of blockchain. They also make sure that contract conditions are followed. Meanwhile, artificial intelligence (AI) can streamline and automate judgement calls and enhance organizational banking operations.

8 AI in Finance

Artificial intelligence (AI) is no longer a novelty, and it is fast evolving. Advances in technology improved consumer acceptability, and changes in regulatory frameworks will accentuate financial institutions' (FIs) decisions to embrace AI. With 24/7 access to accounts and financial advisory services, banks with AI can reduce hassle and dramatically improve the customer experience.

One of the most significant machine learning applications in the finance industry is credit scoring. Lending money is a business run by many financial institutions from large banks to small fintech companies. It is required to assess an individual's or a company's solvency in order to do so. Artificial intelligence allows for faster and more accurate assessments of potential borrowers through more complicated procedures than prior rating systems. To do this, advanced ranking algorithms use multiple explanatory variables (population statistics, income, thrift, credit score,

transaction frequency, etc.) to get the person's approval for the loan. Another benefit of AI-based scoring systems is the ability to make fair decisions. There is no human reasoning, such as the mood of a bank employee on a given day, or any other aspect that impacts decision-making.

The amalgamation of AI and blockchain is fruitful in this scenario. The lack of mobility in credit ratings is one of the flaws in today's credit management systems. The creditworthiness of a person cannot be transferred to another nation. As a result, a universal credit rating is necessary. The recent hacking incident involving credit reporting firm Equifax, which exposed the personal information of 143 million Americans, emphasizes the need to make the system more secure. Using blockchain to manage creditworthiness can improve the system's transparency. Lenders can use the blockchain to review an invariant record of financial transactions to evaluate a person's creditworthiness. Smart contracts guarantee that banks do not end up compromising applicants' personal data during the process of loan applications, simplify loan acceptance algorithms, and improve the flexibility of the loan approval process.

Another significant area where machine learning might help is fraud prevention. Payment card misuse and embezzlement are examples of scams. The prior has risen dramatically in recent years as e-commerce has grown in popularity, as has the number of e-payments and the integration of third-party suppliers. Anomaly detection is one of the specializations of machine learning techniques when it comes to identifying suspicious charges. These algorithms may search up hundreds of pieces of information about a transaction (past customer behavior, location, spending trends, and so on) and notify you if anything isn't quite right.

JPMorgan Chase is a consumer credit bank that extensively employs artificial intelligence. With retail banking accounting for more than half of Chase's net profits, they are using simple fraud detection tools for their consumers. For example, they've created a one-of-a-kind algorithm for detecting fraudulent schemes. When a credit card transaction is done, the information is transferred to Chase's data center mainframe to see if it is fraudulent.

Even though many fundamental machine learning techniques such as decision trees, random forests, and logistic regression trees may already yield acceptable results, the industry is always seeking methods to improve. More complicated algorithms adapted to massive data sets make this possible (both observations and potential characteristics).

Automated algorithmic trading incorporates the most recent cutting-edge advances in machine and deep learning with extensive knowledge in a variety of domains. While some of these systems' components seek to anticipate asset returns (to some extent), others may use a more conventional approach based on econometrics and modern portfolio theory.

Diverse sources of information have recently gotten a lot of press as a way to get a competitive advantage. Sophisticated object identification technology will aid in the analysis of satellite pictures, while advanced natural language processing (NLP) technology will allow for accurate emotion recognition from news features, Twitter, Facebook, and Reddit.

There exist asset management Robo-advisory services in which artificial intelligence (AI) generates portfolio sanctions grounded on an investor's individual (short- and long-term) goals, risk appetite, and expendable income. Investors simply need to deposit cash once a month and the rest is taken care of, including asset selection, purchase, and maybe rebalancing. All of this is done to guarantee that customers are on the quickest path to their objectives.

AI is being used in the banking sector to deliver a personalized banking experience for all consumers. Chatbots, for example, are becoming more difficult to identify from genuine consultants. You may comprehend your client's goals and try to steer them in the proper direction using modern NLP technologies. They can, for example, assist users with changing their passwords, checking the available balance, scheduling transactions, and so on.

Financial operations, on the other hand, are profoundly regulated, and financial organizations must thoroughly comprehend several algorithmic assumptions. As a result, an explicable model is critical for the financial industry. While it is appealing to use the most up-to-date neural network designs to obtain percentage points of accuracy, it is not always the ideal tool. Instead, a simpler machine learning model is picked for work such that Analysts are able to explain which factors impacted the result by employing such a model.

9 AI, Blockchain, and IoT

To this point, blockchain, the Internet of Things, and artificial intelligence have all been addressed separately. On the other hand, these achievements can and must be used together and will be combined in the future. IoT to collect and present data, blockchain to provide the infrastructure to define operational rules, and AI optimization processes and rules are all possible connections between these technologies (Salah et al., 2019). Artificial intelligence and blockchain (IoT) technologies are widely used in the Internet of Things. AI systems can interpret and store large volumes of data supplied by Sensor nodes. These three ideas can theoretically complement and combine to achieve their maximum potential (Zheng et al., 2020). For data management and business automation, the integration of these technologies has great potential. The use of smart contracts is a key aspect of the link between these three evolutions.

The Internet of Things (IoT), as previously discussed, is being industrialized in many practical applications, such as smart transportation and smart cities, to make human existence steadier. IoT provides solutions for efficient production in various fields. As IoT is industrialized, vast amounts of sensory data are generated by numerous sensory devices (Chung et al., 2017). As a result, big data analytics is becoming increasingly vital for IoT applications. To tackle these issues, several academics are proposing artificial intelligence (AI) technologies for the IoT. AI plays a key role in big data analytics as a powerful analytics tool that enables scalable and accurate data analysis in real time. The combination of AI and the Internet of

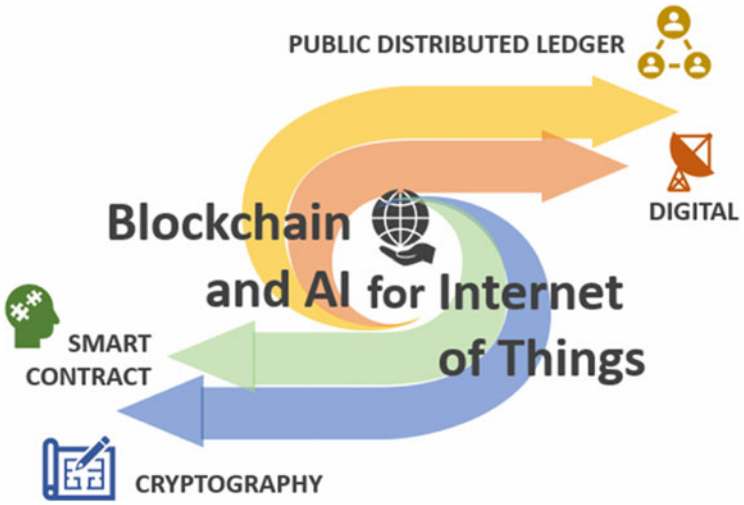

Fig. 7 Integration of blockchain and AI for IoT. Source: Compiled by authors

Things allows one to collect and analyze as much data as possible and discover the best ways to learn for a variety of applications including healthcare, smart homes, smart agriculture, smart cars, and more. According to a McKinsey (Tung, 2018) report, the valuation of artificial intelligence will grow to $13 trillion by 2030 per recent industry assessments. However, there are various barriers to using AI to build and develop successful big data analytics tools, such as centralized architectures, security and privacy protections, resource constraints, and insufficient data for training. In recent years, the combination of AI and blockchain has played an important role in solving these problems. AI and blockchain are coming together to explore massive amounts of data and solve database problems across enterprises. Artificial intelligence and blockchain are the most coveted technologies of the Fourth Industrial Revolution as artificial programs perform many error-prone tasks and eliminate the need for human labor previously required (Sandner et al., 2020). To eliminate centralized control and solve traditional AI challenges, blockchain provides a decentralized architecture that enables the secure flow of data and resources between multiple nodes in an IoT network. It is a distributed artificial intelligence system that blends AI with blockchain technologies. It is used to securely exchange encrypted signature information without the use of third parties (Team, 2018). In IoT applications, decisions can also be made so that machines can make autonomous decisions (Dinh & Thai, 2018). Figure 7 showcases the major breakthrough areas that the triad can together revolutionize in the recent future.

The merging of the Internet of Things, blockchain, and artificial intelligence will result in the development of new business models and digital transformation for all sectors. It has the potential to provide new revenue streams for IoT devices. As an example, consider a streetlight with a blockchain-based unique ID and blockchain-based currency. As a result, the lamppost is elevated to the level of a self-contained

entity capable of acting "on its own." A smart contract can be used by anyone to turn on the lights using micropayments. Someone pays for a lamppost, whether it is an individual, a corporation, or the government, and it turns on. In this case, one can use the Pay-per-use payment method. One may monetize the streetlight thanks to the inclusion of a digital wallet. To record information such as consumption, performance, and downtime, all streetlights may be connected to a blockchain. Artificial intelligence can utilize this information to optimize network upkeep. For instance, AI can forecast what is utilized the most and deploy a support staff as soon as a problem arises. Because AI can forecast the weather (solar energy), it can also forecast the additional electricity required to switch on the lamp. By more correctly anticipating the number of components required, AI might also assist streamline the parts ordering process and maintenance. This service cuts down on network downtime. It can be represented as an asset and sold to investors. Consequently, investors may be enticed to install and maintain streetlights in bulk in exchange for a share of the money generated by the streetlights. This has the potential to be a game changer. Because investors would be directly rewarded as part of their return on tokenized assets, tokenization of these assets might spark a new wave of investment. The benefits of tokenization may be extended to any IoT device and therefore a wide range of applications such as sensors, autos, automobiles, cameras, trucks, and dumpsters once these devices are connected to the Internet and blockchain networks.

10 Fintech

Financial technology, commonly known as FinTech, is the "wedding" of innovation and economics. Whenever technologies and money are combined, they produce a multiplier impact that is greater than their combination. According to Zetsche et al. (2017), today's FinTech is distinguished by a couple of major developments. The very first pattern is the increased variation brought forth by Big Data, deep learning, technological standardization, and Artificial Intelligence (AI). The second development is indeed the increase in the number of innovative nonfinancial corporations entering and investing in banking subsectors. FinTech may alternatively be divided into two components. The first component is about conventional financial enterprises undergoing a technological revolution. Conventional monetary institutions, for instance, Morgan Stanley, Industrial and Commercial Bank of China, and Goldman Sachs employ big datasets and perhaps other modern technology to enhance and alter existing services. The key element is that certain tech giants are attempting to use their capabilities to offer financial products. To illustrate, Meta, Apple, Google, Ant Financial (China), Apple, and Tencent (China) initially intended never to participate in monetary operations. However, in the end, they opted to construct their unique variants of the banking system to help the requirements of the clients and to generate new types of innovative economic panorama.

The conventional banking sector has been affected by FinTech. Following the 2008 Financial Meltdown, the scenery has transformed as a result of general

economic legislation and financial sector advancement (Anagnostopoulos, 2018; Brem et al., 2019). FinTech's key groundbreaking prospects are as follows. One of those is a mobile wallet, which includes services like WhatsApp payment, Alipay, and Apple Pay. Then we have a "smart contract," with participating companies such as "Ant Xiaodai," "Huabai" and "Jingdong Baitiao,". P2P financing is part of the smart contact subcategory. The final, which is particularly prominent and has already been covered, is known as the Blockchain. The primary tenets of these three key FinTech subjects are quick interaction, real-time information, creditworthiness, and notifications. The banking system is captivated by Blockchain technology because its qualities permit individuals to create confidence rapidly and have the ability to transform the institutional framework (Pilkington, 2016).

FinTech and IoT together have garnered widespread attention as examples of innovative technologies. FinTech is resulting in a slew of innovative goods and services, such as billing systems and others that aim to deliver convenient and efficient alternatives to conventional financial procedures. Furthermore, IoT has received much interest due to the sheer wide array of organizations and sectors that somehow this tech is tied to or has touched, and even those who aren't in the sector are keeping an eye on developments in this growing domain (Nakashima, 2018). In conclusion, the influence of blockchain technology on audit procedures is divided into two categories: The tamper-proof, decentralized database, chronological, and system characteristics of blockchain increase the trustworthiness and dependability of inspected company data while lowering the price of verifying reviewed organization information (Wang et al., 2019a, 2019b).

Advancements in technology such as Robotic process automation and Optical Character Recognition have considerably decreased the burden of monotonous operations performed by accountants. Such technologies can analyze and complete receipts electronically for real-time verification. The ledger of Bitcoin was the one to employ a decentralized accounting mechanism initially (Zhang et al., 2020). A miner is a device on the network. Those miners are interconnected via an Online peer-to-peer channel. Participants join this connection and make transactions algorithmically with several other members. Nevertheless, because the activity could be witnessed by everyone, it is untrustworthy. The answer, as per Eyal (2017), would be to utilize a minimal verification approach in which the operation is verified and updated sans revealing clarity. The advancement of such technologies is indeed driving a purposeful shift forward into Triple Entry Accounting (TEA) (Maiti et al., 2021a, b). The TEA is not really presently actively implemented in whatsoever substantial fashion, but there is a larger discussion over whether it is worthwhile to embrace such an innovative accounting technique. Transitioning to the TEA model is difficult, and for the time being, it is only an interesting theoretical endeavor. According to Tabrizi et al. (2019) and Verhoef et al. (2021), digitization is basically a profound metamorphosis of a financial strategy backed by such new technical equipment, instead of only technological transformation.

11 Conclusion

This chapter emphasizes the premise that the finance industry could be on the cusp of a new fiscal age, one that will be characterized by the implementation of new disruptive infrastructure based on Blockchain, IoT, and AI. Artificial intelligence and blockchain technologies are widely used in the Internet of Things. IoT to collect and present data, blockchain to provide the infrastructure to define operational rules, and AI optimization processes and rules are all possible connections between these technologies. These three ideas can theoretically complement and combine to achieve their maximum potential. For data management and business automation, the integration of these technologies has great potential. To eliminate centralized control and solve traditional AI challenges, blockchain provides a decentralized architecture that enables the secure flow of data and resources between multiple nodes in an IoT network. It is a distributed artificial intelligence system that blends AI with blockchain technologies. These technologies converge, enabling new autonomous business models and the innovative impacts of this triad on increasing the competitiveness of companies, for example, in marketing and sales, customer service and growth hacking, among other areas.

While emerging patterns indicate that international BFSIs seem to be on the path to digitization, there still is a long way to go. Information will continue to be the industry's lifeblood, and uniting economic materials for the successful incorporation of advanced techniques will help in the business administration process. The integration of IoT, Blockchain, and AI will be key in that process. It is clear that if international financial institutions play their cards well, they may make significant headway in revamping the present corporate structure, especially in the wake of the COVID-19 pandemic (Maiti et al., 2021a, b).

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Role of Digital Financial Inclusion in Promoting Economic Growth and Freedom

Malvika Saraf and Parthajit Kayal

1 Introduction

Digital and technological innovation is revolutionizing the financial services field. Financial technology (FinTech) innovative solutions such as digital money, peer-to-peer and crowd-funding online lending platforms, insurance technology, and cryptocurrencies have gained immense popularity across the globe (Maiti & Ghosh, 2021). In the past decade, FinTech has enabled retail market participants to seamlessly access financial services. Moreover, cutting-edge technological tools such as distributed ledger technology (DLT), artificial intelligence (AI), and cloud services are changing the operational management techniques in financial institutions and financial market trading. A significant number of new firms have prioritized the digital transformation strategy to achieve customer satisfaction (Feyen et al., 2021). In fact, leading banking and nonbank financial institutions are rapidly adopting digitalization in their internal operations and customer interaction procedures, to be at par with FinTech giants (Frost et al., 2019).

Focusing our attention on the highlight of our chapter, the ability to conduct financial activities independently and seamlessly without artificial barriers to market entry is referred to as financial freedom. Digital finance including the implementation and usage of financial technologies, online lending marketplaces, etc. is indispensable for attaining financial freedom. Digitalization positively affects the economy in many ways as well. It particularly leads to improvements in information processing, its dissemination and accessibility among the participants (Bilan et al., 2019). We can now receive actual and trustworthy information in real time via new intellectual capabilities and mitigate data processing time. The time taken to sort and integrate data is also reduced, which helps in making quicker decisions (Xu et al.,

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2018). However, there are certain challenges involved such as cybersecurity, risk management, hacking, and more. The continuous usage of digitalization in financial services helps in being compatible with used gadgets, and adapts easily to cyber-physical systems and data analytics platforms. All changes to the standards of financial services such as additions of as virtual reality, augmented reality, and human computers are made keeping in mind the primary requirements of end users. Customized services for consumers ensure smooth access of clients to the availability of banking, insurance, and investment services. All of these lead to the financial freedom of individuals and of countries eventually.

The COVID-19 pandemic is the recent obvious phenomenon that has significantly expedited the process of digital transformation. In particular, digitalization is the need of the hour to replace physical interactions between customers and providers, especially in banking transactions and financial services. It has remarkably increased financial freedom across the world during this pandemic phase via Internet banking, digital deposit and withdrawal, etc. The need for digital connectivity is extremely crucial for economies, businesses, financial services providers, and people as they navigate through the pandemic and the subsequent post-COVID-19 world. For example, the pandemic has compelled people to move toward making digital payments (Auer et al., 2020a). Since everyone had to be at home, online e-commerce platforms thrived, which greatly benefitted big technology firms and their financial activities (Alfonso et al., 2021). We also find that nations with strict COVID-19 policies and lower community mobility witnessed an impressive increase in financial application downloads during the pandemic (Didier et al., 2021). Finally, the pandemic has also accelerated the process of introducing central bank digital currencies (Auer et al., 2020b).

In this chapter, we first describe the motivation and cause for digital transformation in finance. The role of digital finance in financial inclusion and freedom is then explored. Subsequently, we analyze how digitalization impacts finance and its interaction between market participants in modern industrial times. Additionally, we focus on how digital finance leads to overall economic freedom, financial development, and growth of a country. Finally, how financial freedom is achieved in the BFSI sector is examined via banking performance and efficiency.

2 Financial Inclusion and Freedom

The G-20 and the World Bank have taken the first step toward helping reduce poverty levels in emerging and developing nations around the world by means of increased financial inclusion since 2010 (GPFI, 2010). In the light of today, digital finance, financial inclusion, and consequently financial freedom have become very crucial. They help in expediting economic growth and reducing poverty. If the number of issues relating to these is addressed appropriately, digital finance has the capability to work effectively for individuals, businesses, governments, and the overall economy.

Digital finance can be defined as "financial services delivered through mobile phones, the internet or cards" (Manyika et al., 2016). In other words, digital finance encloses a vast range of new financial products, a variety of customer interaction methods, and financial businesses—provided mostly by FinTech companies (Gomber et al., 2017). Implemented via digital channels, the provision of financial services aims to help mitigate poverty and introduce financial inclusion in developing countries, thereby leading to financial freedom.

Digital finance plays an integral role in the attainment of financial freedom. One, digital finance can lead to increased financial inclusion, provision of basic financial services to people, and expansion of financial services to nonfinancial sectors since more than half of the developing nations' population have a mobile phone now. Two, for the financial freedom of the poor in developing countries, digital finance is a means to efficiently allocate simple, affordable, convenient, and safe banking services. Three, digital finance transformation has the potential to have long-term positive effects on banking performance (Chortareas et al., 2013). Four, a full-fledged digital finance adoption and implementation can notably lower the circulation of fake currency, which benefits the financial monetary system, and regulators.

Digital financial inclusion is defined as "digital access to, and the use of, formal financial services by the excluded and underserved population" (CGAP, 2015). The procedure begins with the assumption that the underprivileged, excluded, and/or underserved population in developing nations has legitimate bank accounts. Then we discuss whether they require digital access to carry out basic financial transactions without physical contact, seeking their financial freedom.

Digital financial inclusion undoubtedly provides the needy with financial freedom to some extent. Banks can lower their costs by minimizing queues, reducing manual documentation, and keeping fewer bank branches (Manyika et al., 2016). Moreover, with digital financial inclusion, many depositors can effortlessly switch banks within a matter of minutes, compelling banks to offer best-in-the-business services or risk losing their customers to rival banks. The welfare of people and businesses with a reliable digital channel can also be improved to access funds and conduct daily transactions (CGAP, 2015).

Financial inclusion is the ability to access essential financial services by households and firms for the enhancement of poor family units, resulting in financial movement (Durai & Stella, 2019). It can also be defined as the utilization of formal financial services by the poor. With financial inclusion, financially excluded individuals in the past will now be able to secure education, save, invest, and also develop businesses, which lead to poverty alleviation, financial freedom, and overall economic growth (Beck et al., 2007a, 2007b; Bruhn & Love, 2014).

Financial inclusion is a quintessential step toward providing financial freedom to the poor. It gives the low-income category people a chance to save for the future fostering growth and stability in personal finance, and incessant use of bank deposits creating a stable deposit base for banks to dig into during unavoidable distressed times (Han & Melecky, 2013). Additionally, poor households get the golden opportunity to accumulate savings, make investments and effortlessly access credit via greater financial inclusion. Financial inclusion also empowers such households to

deal with income shocks in case of unavoidable circumstances such as illness or job loss. One of the many positive impacts of financial inclusion is the attainment of financial freedom for individuals and the financial stability of the system. This is achieved by reducing procyclicality risk, increasing the volume, and stability of the deposit base of banks to weaken their dependence on volatile noncore financing, thus ameliorating overall banking system stability (Khan, 2011).

The influence of digital finance on financial inclusion is now more conspicuous than ever. When digital finance pertains to the lives of low-income and poor individuals it enhances their access to basic services, thereby leading to augmented financial inclusion in rural areas (Ozili, 2018). Digital financial services show a considerable scope for expanding the allocation of financial services to a sizeable section of the society, including the poor via transformational technologies such as internet banking, mobile banking, e-wallet systems, and digital payment infrastructure at affordable rates through appropriate modes and secure environment (Siddik et al., 2020).

There exists a two-way causality between digital finance and financial inclusion. On one hand, digital finance expedites financial inclusion. People in high, middle and low-income categories should convince their friends, family, and acquaintances belonging to the poor segment of society to open bank accounts. This will help them get access to digital technologies for a wider range of financial services and a seamless transactional experience. Such a kind of persuasion can enable them to take advantage of digital financial services since they are more likely to believe known people using digital platforms than banking professionals who visit their homes with various schemes. When poor people finally open a bank account, they can save and borrow from the financial system, as well as invest and earn returns (Haider, 2018). Digital finance provides a stronghold over customers' personal finance, instant financial decision-making, and the capacity to make and receive payments. Financial inclusion and financial freedom are win-win situations that are attainable through digital finance (Durai & Stella, 2019). On the other hand, financial inclusion can boost the usage of digital finance by increasing a bank account holder's knowledge about various digital finance channels. The influence of digital finance on financial stability and financial freedom positively affects banking performance. It helps banks in lending, broadening the reach of financing as well as helping people shift from traditional cash to digital payment methods (Chortareas et al., 2013; Risman et al., 2021).

Overall, this topic sheds light on the impactful interrelationship between digital finance, financial inclusion, stability, and freedom. This can be well illustrated with a flow chart in Fig. 1. Digital finance has an affirmative impact on financial inclusion in advanced economies through financial technology providers, mobile network providers (Durai & Stella, 2019; Haider, 2018), etc. The seamlessness with which digital finance serves individuals with low income and from vulnerable communities is far more valuable to them than the inflated cost they end up paying to procure such services from conventional regulated banks. Only when the poor segment of our society is successfully able to use and take advantage of digital financial services for

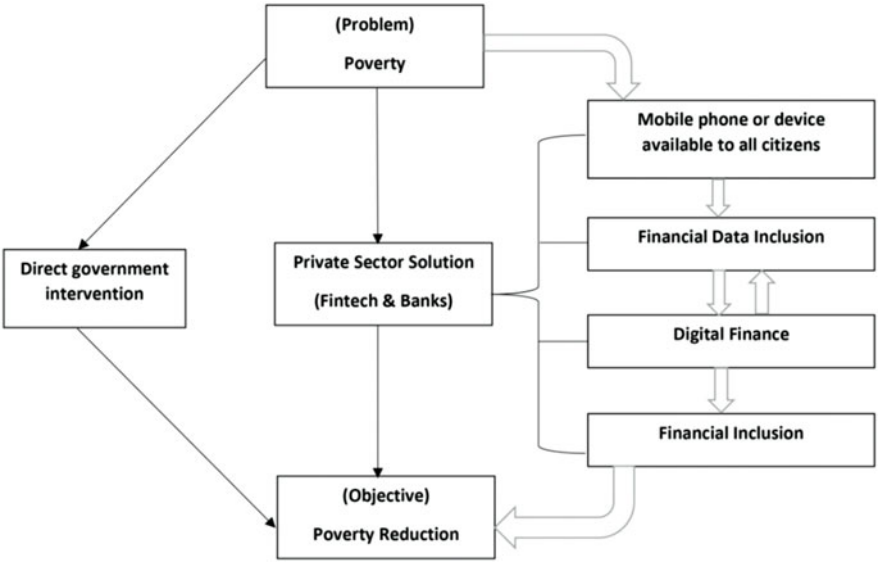

Fig. 1 Framework showing the contribution of banks, governments, and FinTech companies to digital finance and financial inclusion. Source: Authors

their day-to-day transactions, it is possible to accomplish that digitalization helps in achieving financial stability and freedom on an individual level.

3 Digital Finance in the Modern Industrial Era

In the era of the modern industrial revolution or as we call it Industry 4.0, digitalization and virtualization have modified the nature of the financial association between participants in the market. A significant number of business operations and services are dynamically shifting to the virtual environment (Bilan et al., 2019). The preference of consumers is toward mobile or Internet banking, virtual operations, and online consultations with their accounts. There are online peer-to-peer platforms that facilitate loans straightaway from the creditor to the borrower. There are crowd-funding platforms as well where, on a charitable basis with cash or kind payment, people can raise money for medical emergencies, investments, or other needs under special conditions. Peer-to-peer loans have greater availability and price advantage as compared to borrowing from banks since transaction costs are very low without the interest margin of the bank. It is a superior form of lending and borrowing when compared with the traditional banking business (Lenz, 2016). However, there are many factors determining the cost of loans and the selection criteria of borrowers by creditors on the peer-to-peer funding platform (Gavurova et al., 2018).

We discuss the constituents of online funding services as an alternative to conventional banks and financial intermediaries. With digitalization, Industry 4.0 has positive impacts on the overall economy. It particularly leads to improvements in information processing, its dissemination and accessibility among the participants (Bilan et al., 2019). We can now receive actual and trustworthy information in real time via new intellectual capabilities and mitigate data processing time. The time taken to sort and integrate data is also reduced, which increases the quality and helps in making quicker decisions (Xu et al., 2018). The progression of technology and digitalization of financial services are directly connected to the growth of FinTech start-ups and the usage of innovative financing techniques. These methods ensure the delivery of online funding services to the main market players.

Online platforms such as peer-to-peer and crowd-funding platforms are especially helpful for those categories of borrowers, for whom bank credit products are either unavailable or too expensive (Bilan et al., 2019). This is usually faced by small- and medium-sized businesses which undergo various hurdles while receiving bank loans due to high interest, the need for collateral, the scarcity of available loans, etc. (Rahman et al., 2016). Yet another reason to go with crowd-funding platforms instead of bank lending is the need to finance unprecedented projects that come with high risk. Either very limited banks fund such projects, or they are reluctant altogether (Cichy & Gradoń, 2016). Thus, to finance green projects crowd-funding platforms can be regarded as a second reliable source of additional financial amenities (Pimonenko et al., 2017). We are aware that the cost of borrowing can be significantly reduced via alternative online financing channels, as compared to banks. At the same time, high inflation, decreased household savings, hostile investment climate, and business conditions have a similar negative impact on the growth structure of financial markets, comprising the banking sector and alternative financing market.

While investigating the condition of the economy, one should pay particular attention to the business environment and the availability of funding sources for small- and medium-sized businesses (Civelek et al., 2016). It is clearly observed that SMEs are the key users of crowd-funding and peer-to-peer business lending. Additionally, the factors determining the condition of the financial system have a direct effect on the evolution of alternative financing. The services of banks are physically accessible to a major part of the population via branch networks. Moreover, various savings schemes offered by banks are considered less risky. Thus, during periods of distress, bank liabilities tend to be less volatile than the ones of nonbank financial institutions (Leonov et al., 2012).

The extent of financial inclusion in the country is a dilemma modern society faces. We know that financial inclusion is the ability to procure requisite financial services for all groups of people regardless of age, income level, credit records, residential place, etc. (Durai & Stella, 2019). Borrowers with a high credit risk such as people with low income, no employment, or credit background are often denied loans due to the high probability of default. In rural and remote areas, people have limited access to bank loan resources (Beck et al., 2007a, b; Bruhn & Love, 2014). In such situations, people will surely look for other means of funding and use online

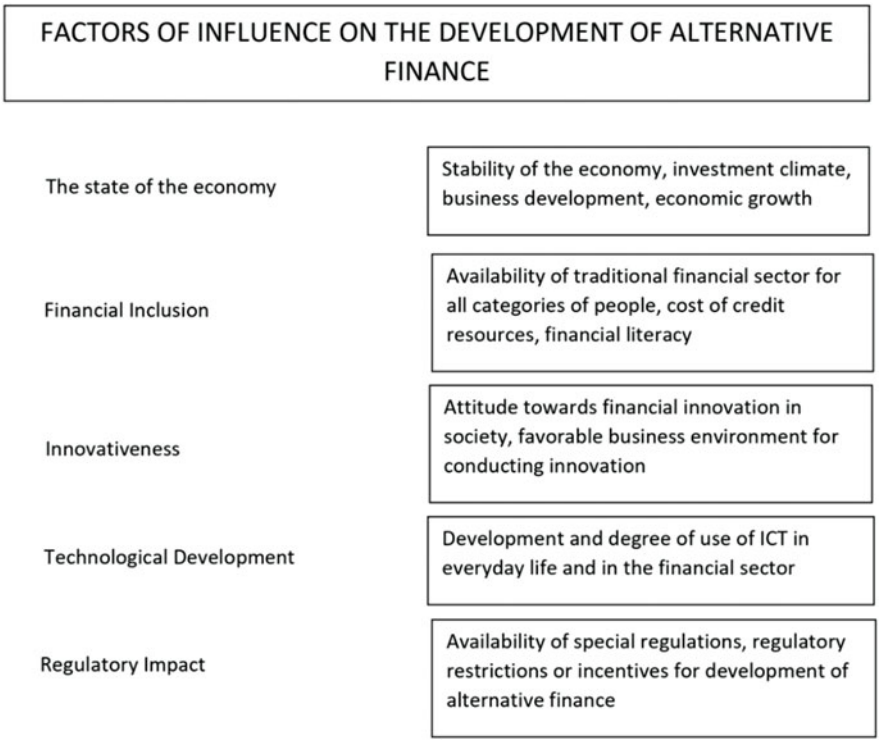

Fig. 2 The factors impacting the development of alternative finance. Source: Authors

financing platforms. Digitalization is drastically changing modern society and every sphere of human activity. It is extensively used in the financial sector and alternative financing is an appropriate exemplar. Online funding platforms are inventions for the market as a whole. They can be considered one of the most successful financial technology startups.

Alternative finance refers to not only financial but also technical innovation. Its emergence would not have been possible without the evolution of information and communication technologies (ICTs) (Mushtaq & Bruneau, 2019, Rekha et al., 2021). The factors impacting the development of alternative finance are described in Fig. 2. Alternative financing channels facilitate developing direct contact between creditors and borrowers, bypassing conventional banking and other nonbank financial systems. Using these platforms demands an Internet connection and basic computer knowledge. Therefore, the number of Internet users and potential entrants in the alternative financing world depends on the degree of technological advancement in the country (Bilan et al., 2019).

Alternative funding sources have their set of drawbacks as well. These online platforms suffer from inefficient risk management. Metrics like the cost of a loan and risk tier are difficult to estimate based on easy questions or data retrieved from social

media networks. On the brighter side, banks have a dominant risk management system that cannot be compared to Internet companies. Hence, the convergence of these two kinds of financing will mitigate their weaknesses and provide added benefits to all financial market participants (Bilan et al., 2019). Analogously, banks have a strong regulatory framework that ensures safety and stability in the financial system. But, the regulation of alternative funding channels is disintegrated in many nations which could cause macroeconomic threats to financial stability.

Digitization and virtualization clearly lead to colossal changes in the financial services market. Along with getting rid of the drawbacks of traditional financial institutions, direct links between the creditor and borrower of financial resources can be established (Bilan et al., 2019). Alternative means of funding are often regarded as a sole proxy for bank lending. This mechanism is clearly a threat to traditional banks and nonbank financial intermediaries such as credit unions and pawnshops. However, there is a possibility for both methods to coexist and grow in parallel. Conventional financial institutions should take advantage of digitalization, implement big data solutions, operations automation, and more, to be at par with online funding techniques and strengthen their competitive positions (Temelkov, 2018). In this respect, banks should try to apply convenience, flexibility, and low-cost technology in their operations. They should also create a partnership with participants in the Fintech segment (Nakaso, 2016).

4 Economic Freedom, Financial Development, and Growth

According to research, financial inclusion (FI) is regarded as a significant impetus for economic development (Claessens, 2006). FI is nothing but universal access to formal financial services, including underprivileged families as well as micro and small enterprises (Asian Development Bank, 2012). Although a well-segmented inclusive financial system has its benefits, more than 50% of the global adult population is unable to access formal financial services (according to the World Bank, 2017). Despite the fact that achieving FI is a global socioeconomic task at hand, it is more impactful in less developed nations than the developed ones since it is integral for mitigating poverty and attaining growth (Kim, 2016).

As per studies, two kinds of factors that drive FI across countries are structural factors and policy-related factors (Rekha et al., 2021). Fundamentally, structural factors arbitrate the cost of providing these financial services to people, while policy-related factors are necessary to establish a facilitating environment for the same. Information and communication technology (ICT) infrastructure is one of the preliminary structural factors. The dissemination of ICT has rigorously transformed the world by reducing poverty and inequality, accelerating overall growth, and stimulating financial inclusion by facilitating greater access to finance (Mushtaq & Bruneau, 2019).

Innovation in technology can be regarded as the backbone of economic growth. In the attempt to formalize the financial system, it is contended that FI is one of the

many ways in which ICT reduces income disparities and expedites economic growth (Andrianaivo & Kpodar, 2011; Tchamyou et al., 2019). Moreover, an improved blend of ICT and the financial sector will most likely give rise to enhanced digital financial inclusion to close the gap in financial infrastructure (Mushtaq & Bruneau, 2019). Digital financial inclusion is an evolving phenomenon that leverages ICT to boost financial inclusion purposefully. Furthermore, increased ICT penetration promotes economic and financial freedom by fostering FI which in turn uplifts financial sector development. Since economic freedom is one of the crucial determinants impacting financial development and growth, we have a strong rationale for investigating its aftermath on financial inclusion (Rekha et al., 2021).

Both hypothetical and empirical literature have found that economies having a greater depth of financial inclusion are directly linked with higher rates of GDP growth as well as lower-income inequalities (King & Levine, 1993; Beck et al., 2007a, b; Demirgüç-Kunt & Levine, 2009; Demirgüç-Kunt & Singer, 2017). We are aware that financial inclusion is usually measured by the number of accounts owned by individuals, while the financial development of a nation is generally measured by macroeconomic signals such as gross domestic product (GDP). Several factors directly determine both financial inclusion and the financial development of an economy. These factors are information availability and accessibility, per capita income, stable governance, quality of institutions, and the regulatory environment (Allen et al., 2016; Rojas-Suarez, 2010; Karlan et al., 2014). There is adequate empirical evidence on the FI–economic development nexus. In developed nations, FI fundamentally emphasizes creating awareness of unbiased and affordable financial services, while in developing ones the focus is on the accessibility of both financial services and financial literacy (Rekha et al., 2021). Further, while evaluating the relationship between financial inclusion and financial stability, we clearly notice that FI helps mitigate income disparities and hence leads to financial stability (Neaime & Gaysset, 2018). The number of savings account holders, loan takers, bank branches; ATMs, etc. directly impacts the economic and financial growth of a nation (Sharma, 2016).

A lot of academic groundwork has backed the interrelationship between financial development and economic growth, highlighting that enhanced service availability by acclaimed financial intermediaries and markets, leads to economic development and vice versa (King & Levine, 1993; Neusser & Kugler, 1998; Beck et al., 1999). In this case, the real economy grows with increased demand for financial services which boosts financial sector development. Thus, the need for financial services significantly adds to the development of the financial sector when the overall economy prospers (Jung, 1986). One has the freedom to work, produce, consume, and invest in any possible way in an economically free society.

Past research has recognized a substantial association between economic and financial development and economic freedom (Hafer, 2013). It is further observed that rapid economic growth is inevitable in countries that enjoy greater economic freedom and exhibit high-level development in financial intermediaries. High levels of financial development are directly linked to future capital accumulation and efficiency improvements with which nations employ capital (King & Levine,

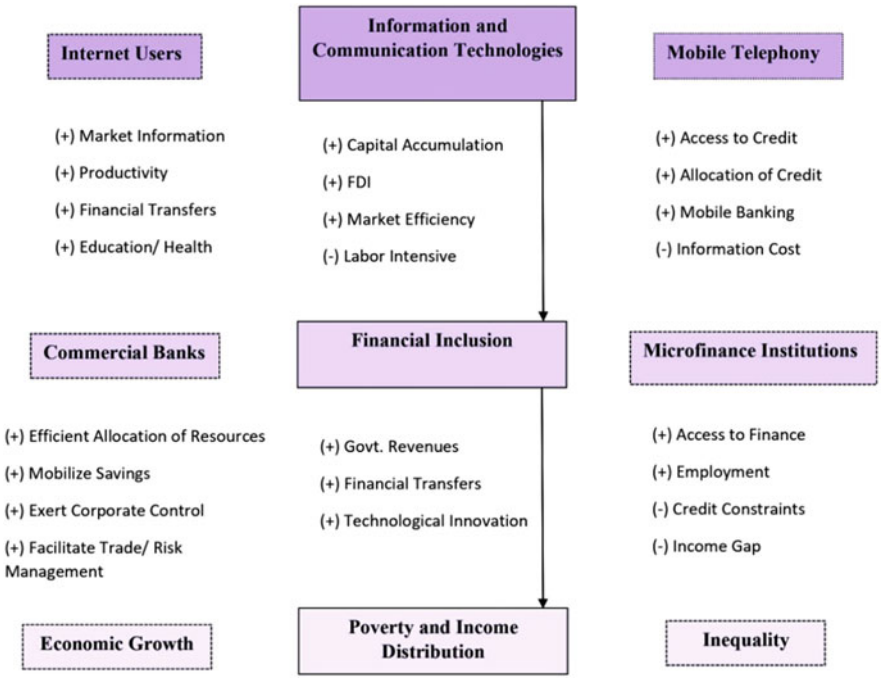

Fig. 3 This figure shows how technological innovations like ICTs lead to financial inclusion and as a result economic growth, inequality, and poverty reduction. Source: Authors

1993). Research also rightly justifies the connection between economic freedom and development (Carlsson & Lundström, 2002). Financial freedom, which is one of the components of economic freedom, has a substantial long-term association with financial inclusion (Rekha et al., 2020).

Talking about the technological aspect of FI, there is a solid relationship between ICT diffusion and FI. It focuses on the need to strengthen the ICT infrastructure, e-commerce services, and digital banking rollout (Rekha et al., 2021). We can see the entire process from ICT diffusion to financial inclusion to economic growth in Fig. 3. ICT policy measures, as well as the progress of e-commerce and e-governance, must be thoroughly evaluated by policymakers. Investment in the ICT sector is integral for the advancement of emerging nations with weak economic conditions (Demirgüç-Kunt & Singer, 2017). ICT penetration through mobile telephony rollout has substantial advantages such as improved access and connectivity, which enhances financial depth. It can be shown that ICT diffusion plays a vital role in the advancement of communities through multiple channels. Its contribution to the education sector is impressive. Virtual education is the need of the hour, which is facilitated through increased Internet access, and electronic, and print media. By aiding the distribution of crucial and rapid medical information and allowing online operation facilities in rural areas, ICT plays its part in uplifting the health sector (Mushtaq & Bruneau, 2019). An increase in the number of financial intermediaries,

such as banking institutions and capital markets, expedites the overall economic growth based on ICT. The role of the government is substantial in designing new policies and development strategies to promote ICT infrastructure which stimulates financial development, financial inclusion as well as economic freedom by fostering digital finance. This will enable citizens to benefit from low-cost, high-speed Internet services. Further, it will make e-finance easily accessible and available for businesses and other industries (Rekha et al., 2021). The dissemination of technology is identified as the key channel through which productivity growth can be successfully achieved (Comin & Hobijn, 2009).

With regard to economic and financial freedom, policies are made to foster financial accessibility by refining the availability of credit information, creating competitiveness, and eradicating entry barriers. Apart from strategies aimed at expanding banking penetration, the focus should lie on enhancing the quality of financial institutions and their service delivery. It is also quintessential to mitigate income disparities, upgrade literacy levels, and improve the communication infrastructure to build financially inclusive communities.

In summary, this part of the chapter analyzes the interconnectedness of ICT diffusion, economic freedom, financial development, and economic growth with financial inclusion. It is imperative to note that financial sector development considerably impacts financial markets and inclusive growth to achieve long-run sustainable development (Rekha et al., 2021). At a broader level, careful alignment between the ICT policy and growth policy is critical for addressing financial development, which reflects favorably on financial inclusion. Our discussion has significant policy implications and stresses the importance of creating an economic environment that is conducive to sustained economic growth.

5 Financial Freedom in BFSI Via Bank Efficiency

The indexes of "economic freedom" are being increasingly used in recent research work on banking (Demirguc-Kunt et al., 2004) and more importantly bank efficiency (Chortareas et al., 2011a, b). The evolution of quantitative indexes of economic freedom in the past two decades has facilitated us to analyze the effects of liberal economic institutions on various facets of economic performance (Chortareas et al., 2013). An interesting question arises here as to how economic and financial freedom impacts the functioning of financial institutions. The definition of financial freedom indexes used here is similar to the concept of deregulation, i.e., the removal of artificial barriers that prevent entry and/or competition between products, markets, and institutions. Thus, it is not unusual to assume that the financial freedom counterparts of the economic freedom indexes are inversely correlated with the degree of regulatory tightness in banking (Barth et al., 2008). In this part of the chapter, we attempt to explain the effects of financial freedom indexes on bank efficiency. We strive to show that banks that operate under a high degree of financial freedom and fail to display, ceteris paribus, higher levels of productive efficiency

would contradict the basic traits of economic and financial theory (Sufian & Habibullah, 2014; Lin et al., 2016).

The reasoning behind the relationship between financial freedom and bank efficiency is plain sailing. The fewer restrictions financial institutions need to encounter on how to conduct their business, the more proficient they will be in administering their costs. This will result in the optimal allocation of resources (Chortareas et al., 2013). Our discussion is confined to the context of a particular bank performance measure—productive and cost efficiency in commercial banking.

Many studies highlight diverse factors that impact the effective functioning of banks within a country, such as Hong Kong (Lim & Randhawa, 2005), Korea (Park & Weber, 2006), Taiwan (Kao & Liu, 2009), Thailand (Chansarn, 2008), Malaysia (Sufian, 2009), and Indonesia (Margono et al., 2010). Most of these studies point toward the fact that there is a strong association between financial freedom and banking proficiency. Analogously, documented literature indicates that a certain amount of non-restriction facilitates overall productivity in the banking markets as well as decreases their borrowing cost (Claessens & Laeven, 2004; Roychoudhury & Lawson, 2010; Goddard et al., 2011). Additionally, bank inefficiencies can create serious consequences for social welfare in the form of deadweight social costs since inefficacious banks could charge above marginal social costs for their output, achieving excessive profits. Moreover, post the global financial crisis, attaining high levels of cost-effectiveness for banks has become a crucial determinant for their survival (Goddard et al., 2001).

In the evaluation of banking efficiency, some contributions emphasize the ramifications of the institutional environment within which banks operate (Demirguc-Kunt et al., 2004; Barth et al., 2008). It has been confirmed via studies that regulatory, economic, and institutional dissimilarities play a pivotal role in illustrating the discrepancies in the smooth functioning of banking institutions across the globe. Into this bargain, multiple studies have started incorporating relevant signals that investigate the extent of financial liberalization. Concrete evidence has designated that an increase in market power causes greater cost efficiency in banks. Some pointers reveal that for banks that enjoy high market power, financial freedom has a negative impact on their efficiency. Some levels of market power may be obligatory to guarantee the productivity of the banking system, but higher financial freedom may be detrimental to cost-effectiveness.

There are several reasons that lead us to believe that economic and financial freedom tends to have a positive effect on banks' efficiency. For instance, when new companies start out, banks help them with capital, proving the competence of banks in supplying funds to a wide range of companies (Shakhashiro et al., 2022). Moreover, higher economic freedom permits banks to issue more loans and funding to international companies as well as ensure a fair risk-return trade-off for the banking sector. Analogously, an enhanced environment for business, prominent economic growth, and thus banks' efficiency can be achieved via complementary economic and financial freedom. In other words, increased profitability of banks (Holmes et al., 2008), greater demand for their products and services, lesser inflation,

and a more sustainable macroeconomic framework can be established with a fair degree of economic and financial freedom (Shakhashiro et al., 2022).

We also find enough evidence showcasing the fact that banks' productivity scores are significantly mitigated when they operate under restrictions and controls in the economy (Porta et al., 1998; Fries & Taci, 2005). Indeed, banks and financial intermediaries are more likely to engage in competitive activities when they function in a lesser restricted ambience. In this context, it is evident that increased regulations and controls hinder the working efficiency of banks. This leads us to believe that policies and regulations that focus on constraining banks' financial freedom give rise to ineffectual resource allocation (Chortareas et al., 2013).

Shedding light on the recent COVID-19 pandemic, institutions in the BFSI sector globally were compelled to adopt digital technologies in their day-to-day functions due to a huge rise in transaction volumes. The pandemic has pushed banks to embrace holistic technological innovation strategies and rethink the allocation procedure of their services, products, concepts, and ideas. Thus, the BFSI sector including banks and other financial intermediaries cannot sustain itself without implementing advanced data integration and innovative system software for efficient operations management. The pandemic has undoubtedly taught the banking sector how to be prepared for and handle unexpected circumstances (Maiti et al., 2021).

Our arguments significantly contribute to the existing literature by emphasizing the relationship between the efficient functioning of banks and the various elements of the economic freedom indexes. Our priority is on the financial freedom index that measures the degree of efficacy of an economy's banking system as well as liberty from government intercession in the financial sector. We have already observed that imprudent impinging by the government adversely impacts the operations and day-to-day activities of banks (Chortareas et al., 2013). In countries where a high level of economic and financial freedom and good governance is predominant, banks tend to showcase relatively higher levels of cost-effectiveness. This implicitly shows more effective management in controlling costs, maximizing revenue streams, improving banks' financial freedom, and efficiently allocating resources. Therefore, financial and economic freedom should be the foundation key to an environment that facilitates an appropriate cycle of entrepreneurship, innovation, and stabilizing economic growth and prosperity (Shakhashiro et al., 2022).

6 Conclusion

Overall, we have observed how digitalization helps to achieve financial freedom, financial development, and economic growth in a country. The critical aspects to look back upon are to appropriately allocate basic financial services to society, including the poor via digital technologies, make borrowing convenient and seamless with alternative financing methods as well as expand the reach of digital financial services via the dissemination of ICTs. A final point to take note of is the

manner in which banks accomplish financial freedom through their performance and efficiency.

We have seen that technological and digital developments have the potential to make financial markets more effective, diverse, competitive, and inclusive, but could also increase concentration. Competition is introduced by innovation, especially in emerging and developing countries (Pazarbasioglu et al., 2020; Frost et al., 2021). Economies with less developed financial markets are the ones where FinTech has significantly thrived (Didier et al., 2021). Keeping in mind all its advantages, there are multiple concerns around the adoption of digitalization as well. Regulators and consumers both have questions about data security, financial stability, financial integrity, fair competition, and consumer protection. The wide use of digital technologies has increased the probability and scale of cyberattacks, which are a serious threat to the security and privacy of customers' data on digital platforms. Regulators' awareness of cyber risks could force them to rethink the trade-off between efficiency and security in financial services (Caruana, 2016). Similarly, customers' awareness that their data is prone to cyberattacks can discourage them from using digital channels or performing essential financial transactions until strong customer protection frameworks are introduced. Lastly, there are issues currently around sustainable energy and digital payments that remain challenges for IoT in Fintech. As we progress to the future, the growth of a new technology named "neurotech" will have the potential to act as an enhancement catalyst in the Fintech industry. Neurotech-enabled IoT (NIoT) will amplify the 3Ms (Man, Machine, and Memory) relationship for seamless business operations (Maiti & Ghosh, 2021).

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Nexus of Digitalization, Social, and Governance Factors

Charumathi Balakrishnan and Habeebu Rahman

1 Business in the Era of Digitalization

Corporate reports containing financial and nonfinancial information are vital for companies to have an adequate flow of communication with their stakeholders. In addition to cost estimations and taxes, financial accounting information can assess economic performance and help make strategic decisions for companies. Accounting has become increasingly multifaceted in recent years. The field of accounting has evolved significantly with the advent of digital technology. As a result of rapid technological changes, accounting information must shift from the past to the future as innovative management approaches are emerging due to the impact of digital technology on all aspects of the business.

After three industrial revolutions, we are going through the fourth industrial revolution, also known as Industry 4.0. After the first industrial revolution (from the mid-eighteenth century), it took 150 years to establish the electricity and manufacturing industry. The mechanization gained public acceptance 250 years after the first industrial revolution. The third industrial revolution began with electronics and automation. The fourth industrial revolution is the convergence of the virtual and physical worlds. These three revolutions combined had a far greater impact on the global community. Due to these seismic changes, people have become more aware of producing, consuming, and moving around their surroundings. The widespread use of smart and digital technologies has expanded modern civilization's possibilities (Nambisan et al., 2017).

The current technological revolution affects nearly every aspect of our lives. The digital transformation of society is required for it to evolve and adapt to the process.

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The majority of global economic output will be digital and digital innovations will be critical in achieving the Sustainable Development Goals (SDGs). Organizations must invest more and more in digital technology because their working environments are changing. The use of financial data has always been required for executives to make effective decisions. Finance professionals can better understand their clients' business environments and prospects with deeper insights based on external signals. Their current situation requires constant access to historical financial data. Traditional accounting tasks can now be automated. Solving problems and making decisions digitally requires fundamental shifts in our thinking. Small and gradual changes should be made, and their implications should be studied. It is a radical and disruptive new path in the digital world. Short-term activities that inspire future actions are more likely to be required now than in the past. No industry leader can afford to be complacent in the face of evolving threats, data sets, digitization, and regulatory obligations. Digital technology affects accounting and finance, and the availability of information and accounting practices are becoming more standardized and automated.

Misunderstanding the capabilities of new technologies is one of the most significant impediments to business growth. The emergence of advanced technologies has impacted the financial industry in the past few years. These include Advanced Analytics (AA), Machine Learning (ML), Optical Character Recognition (OCR), Artificial Intelligence (AI), Robotic Process Automation (RPA), Distributed Ledger Technology (DLT), and the Internet of Things (IoT) and its subset Industrial Internet of Things (IIoT) (Goswami et al., 2022; Manman et al., 2021). Due to these innovations, the finance function becomes less transactional and more value driven.

Robotic process automation increases productivity, reduces costs, and ensures verification of financial transactions. As a result, machines replace workers. Cloud-based platforms and software as a service can keep the existing financial management operations up-to-date and cost-effective. Analytics is reshaping the financial services industry. It takes a lot of data to generate new ideas. Patterns and trends in large data sets can monitor market developments, threats, client preferences, and other factors using machine learning tools. Maiti et al. (2021a, b) noticed that today's accounting practices heavily rely on technology to perform various accounting tasks and it is critical to recognize the recurring pattern that emerges with each new technology and how it may be applied to real-world business and the creation of new opportunities in the field of accounting. To provide insight into the evolution of accounting technology over years, Maiti et al. (2021a, b) developed a hype cycle for accounting technology with five stages: the Technology Trigger, the Peak of Inflated Expectations, the Trough of Disillusionment, the Slope of Enlightenment, and the Plateau of Productivity.

A considerable number of studies have already highlighted the importance of Environmental, Social, and Governance (ESG) investments (Maiti, 2021). Organizations are giving more importance to their business model's ESG aspects than productivity. The COVID-19 pandemic has already highlighted the importance of social and governance factors in any organization (Maiti et al., 2021a; Maiti et al., 2021b). The rapid digitalization triggered by COVID-19 offers the chance to rethink

making choices and how we deploy technology in new and relevant ways to go forward. Significant opportunities exist for businesses that can recognize and harness the potential of data to provide more sustainable solutions. For example, as part of the effort to track greenhouse gas (GHG) emissions, satellite imagery and other forms of remote sensing are being used in conjunction with artificial intelligence and data science expertise to track entity-wise GHG emissions as they occur, as is the case with Climate TRACE. These contribute to the accounting of GHG emissions, which is based mainly on direct, independent observation of the environment.

Businesses have relied on their ability to stand out from competitors since the dawn of time to succeed. In a digital world, this will become increasingly important. Understanding digitally enables organizations to understand the business models and gather information about a company's external environment, including competitors, suppliers, customers, and structural market changes. The ability to extract information from data sources and using them will be critical for accountants to thrive in the new digital economy. Not using digital methods reduce the value of accounting over time.

"Digitization" of accounting enables a shift from analogue accounting to digital accounting. As a result, firms can analyze, transmit, or utilize the data extracted from the so-called "physical carriers of information" digitally. Additionally, digitization is a term that refers to the automation of existing manual and paper-based procedures. "Digitalization" uses digital technologies and digital data, modifying how stakeholders and companies engage and interact. In contrast to digitization, digitalization embraces the potential of digital technology to acquire and analyze data to make better business decisions and create new business models rather than mere digitizing the existing data and processes. More than simply integrating new technology into a current business model, digital transformation entails a company's ability to respond quickly to changing conditions by leveraging the power of information and communication technologies. To take full advantage of the opportunities brought about by digital technologies and their impact on society at large, businesses must undergo a digital transformation that is both fundamental and rapid.

The application of XBRL is considered one of the significant steps toward digitalization of accounting and reporting, which could pave ways to embrace digital transformation. The XBRL reporting standard is more vital than ever. It is an Extensible Markup Language (XML) based language and open global framework for tagging data—it has been characterized as a "dictionary of tags"—and, while it has been around since 1998, it has only just begun to gain popularity, with increased demand for its usage in both financial and ESG/sustainability reports.

2 Digitalization in Corporate Sustainability Reporting

Corporate reports containing financial and nonfinancial information are vital for companies to have an adequate flow of communication with their stakeholders. In addition to cost estimations and taxes, financial accounting information can assess

economic performance and help making strategic decisions for companies. Accounting has become increasingly multifaceted in recent years. The field of accounting has evolved significantly with the advent of digital technology. As a result of rapid technological changes, accounting information must shift from the past to the future as innovative management approaches are emerging due to the impact of digital technology on all aspects of the business.

To ensure fair disclosure, transparency, accountability and stakeholder engagement, financial and nonfinancial information management has evolved to comply with international regulations (Bebbington & Thy, 1999; Larrinaga et al., 2002; Stubbs et al., 2012; Stubbs & Higgins, 2015; La Torre et al., 2018). To provide open and responsible information to all stakeholders, corporations, nonprofits, and SMEs have tried social and environmental sustainability reporting (Massa et al., 2015). Corporate reporting strategies and processes must be digitized in many ways (Cockcroft & Russell, 2018, Gepp et al., 2018, Marrone & Hazelton, 2019, Perdana et al. 2014).

One of the most important research topics is the distinction between financial and nonfinancial information (Bagnoli & Watts, 2007, Frost, 2007, Zhang 2011, Stubbs & Higgins, 2015). Corporate reporting methods and models must be examined to achieve corporate social responsibility, transparency, accountability, and stakeholder engagement (Bebbington & Thy, 1999; Stubbs et al., 2012; Stubbs & Higgins, 2015; La Torre et al., 2018).

The annual financial reports are meant to push corporations to be more transparent and responsible. The European Union (EU) Directive 2014/95 on nonfinancial disclosure mandates integrated financial reporting with nonfinancial information such as environment, health, safety, and corruption. Sustainability reporting is based on various international standards and best practices, including nonfinancial data. It includes the Global Reporting Initiative (GRI) and the United Nations (UN) Global Compact (Farneti & Siboni, 2011; Martin-Sardesai & Guthrie, 2019). Significant firms use nonfinancial information reporting such as sustainability reporting or social and environmental reporting (Massa et al., 2015).

Financial, manufacturing, intellectual, human, social, and relationship capitals are expected to be tapped into by the integrated approach (De Villiers et al., 2014; De Villiers et al., 2017; Rinaldi et al., 2018; Stubbs & Higgins, 2015). Recent research works in the area of corporate reporting have focused on integrated reporting (Flower, 2015) with a well-posed financial and nonfinancial decision-making process that involves the development of numerous procedures and operations that benefit from developing an integrated report.

Stubbs and Higgins (2015) state that the sustainability report should emphasize environmental and social aspects while considering stakeholder demands. This discipline includes social and environmental accounting in addition to financial accounting. Sustainable accounting and reporting are becoming more common (Lodhia & Sharma, 2019). Recent research has examined the possibilities of big data, social media, and XBRL to enhance business communication. Incorporating digital and intelligent technology into corporate reporting benefits all parties

involved by streamlining financial and nonfinancial reporting (Cockcroft & Russell, 2018, Gepp et al., 2018, Marrone & Hazelton, 2019, Perdana et al. 2014).

Marrone and Hazelton (2019) examined the impact of new technology on the accounting profession and its techniques. Real-time reporting has become more critical for public disclosure (Gepp et al., 2018). New big data technologies will allow managers to compare financial and nonfinancial performance measures (Cockcroft & Russell, 2018). Ad hoc reports based on big data may help organizations assess their performance. It also allows firms to share data and information across computer systems (Perdana et al., 2014; Baldwin & Trinkle, 2011; Doolin & Troshani, 2004; Valentinetti & Rea, 2013).

3 Application of Extensible Business Reporting Language (XBRL)

New communication avenues for organizations and consumers have opened up due to advances in information technology. Accounting data is atomized and arranged to facilitate automated reporting, known as digitizing financial data. Digitization improves accessibility, openness, quality, and comparability of information. They may also boost corporate accountability. Federal and state regulators have invested much in promoting digital corporate reporting.

The United States (US) Federal Reserve Board and the Bank of Japan have built legislation and infrastructure to enable public companies to submit digital reports. All EU-listed companies started submitting corporate notices in digital format to the European Commission-designed European Single Electronic Format. The Australian government decided on adopting digital business reporting.

The digitization of corporate reporting will need significant modifications to the corporate information architecture. Collecting and analyzing data and providing information have always been a difficulty. In addition to high implementation costs and change aversion, vital stakeholders such as financial report preparers, data consumers, regulators, and standard setters have many duties (Guilloux et al., 2013; Locke et al., 2018). A system's effectiveness will be judged in part by how quickly digital corporate reporting is implemented.

How does corporate use XBRL-based digital reporting for decision-making? Information in XBRL format reacts differently from information in Portable Document Format (PDF). Trial participants using XBRL-based hyperlinked financial statements outperformed those using paper-based financial statements (Hodge et al., 2004). An experimenter's capacity to find information in a business report was examined by Ghani et al. (2011). Arnold et al. (2012) evaluated the user experience of an XBRL-tagged and hyperlinked Management Discussion and Analysis (MD&A) to a PDF-formatted version. Employing XBRL-based formats saved investors' time and helps them to make better judgments, but the presentation was more challenging to interpret for investors unfamiliar with XBRL. They studied how

experimental participants used financial statements in PDF and XBRL-tagged hyperlinked spreadsheet formats. Participants could absorb and integrate footnotes in financial statements to make better judgments regardless of the presented data. A comparison of automated and manual ratio computation in XBRL and PDF financial statements shows that the latter is simpler to use (Locke et al., 2013). An Excel report with hyperlinked line items and remarks was preferred over a shortened PDF report. XBRL-based statements help users access information more quickly. However, evaluating an XBRL-based report is complex. Given the limits of early study design and the level of technology, researchers examined the effectiveness of hyperlinked vs non-hyperlinked views (Hodge et al., 2004). Users may manage calculations and navigate spreadsheets using XBRL-based statements (e.g., Locke et al., 2013; Birt et al., 2017).

Regulators collect a substantial amount of data from firms in order to fulfil their regulatory responsibilities. Regulators all across the world are implementing the XBRL standard to improve reporting. There is a substantial quantity of specialized XBRL software available to assist regulators with the simplification of their reporting implementation. Support for businesses required to comply with XBRL reporting requirements is extremely prevalent across commercial accounting, enterprise resource planning, and regulatory reporting systems, easing the process of enabling the necessary reporting environment. Regulators and government agencies seeking to modernize their reporting frameworks must: (a) Be clear about the project's objectives and scope; (b) Determine how the resulting data will be used; (c) Establish the critical nature of data comparability early on; (d) Determine the extent to which existing data definitions (XBRL taxonomies such as IFRS) can be reused; and (e) Determine their policies and procedures regarding respondent burden. To enable digital corporate reporting and for computers to "read" accounting data, standard-setters must create a taxonomy for assigning contextual "metadata" that codifies disclosures originating from accounting concepts, standards, and practices.

The financial markets' reaction to digital corporate reporting has been studied extensively. Research by Hao et al. (2014) found that XBRL filings had a substantial impact on share price after accounting for business size and risk. Efendi et al. (2014) found that share price variation rose when companies filed XBRL digital corporate reports on a different date than they submitted HTML-based corporate reports. This new "mode" of accounting information is seen as more significant by capital market users because of the shift in relative abnormal returns.

Studies on early adoption revealed that XBRL-based digital reporting would save capital expenditures, enhances analyst forecast accuracy, and boosts analyst following (Liu et al., 2013). Unusual transaction volume may be reduced using digital corporate reporting (Blankespoor et al., 2012). Before the requirement, the mandate benefitted big, sophisticated capital market players that could incorporate corporate XBRL-based digital data into proprietary databases, construct prediction models, and undertake large-scale trend research. Market liquidity decreased, resulting in unfavorable selection and information asymmetry. The early adoption of XBRL-based digital reports often cite implementation challenges as poor digital accounting

data quality and user ignorance (Debreceny et al., 2010). Digital corporate financial reporting has several obstacles to solve. An absence of complete corporate information infrastructure is one of the obstacles (Perdana et al. 2014).

According to available literature, XBRL-based digital corporate reporting decreases capital market players' information processing costs while enhancing efficiency. Studies show that using XBRL for digital reporting increases investors' fundamental analysis and market efficiency. There is evidence that benefits to stock markets are not distributed fairly. Digital reporting benefits institutional investors of all sizes and complexity since they may leverage XBRL's analytic capabilities early in the standard's implementation (Blankespoor et al., 2012). As corporate information bases grow, smaller institutional investors will likely have a competitive edge over prominent institutional investors (Bhattacharya et al., 2018). Those who like to invest locally vs investors who prefer to invest overseas may benefit from digital reporting by more sophisticated or less established listed firms (Kim et al., 2019; Li et al., 2020). It seems that the usage of digital reporting information, rather than its easy availability, may impact capital market indices. Investors might create their private databases and complex data process algorithms to take advantage of electronic reporting data.

Indicators of the capital market may improve or worsen due to more tailored digital reporting, including more data and reducing unfairness. Inline-XBRL (iXBRL) is becoming increasingly crucial for mandatory sustainability reporting. In the light of increased environmental, social, and governance matters, companies must now disclose ESG data more than ever. To offer precise and consistent structured data, inline-XBRL syntax is required. Integrating digital and transparent reporting is simple with inline XBRL.

ESG reporting must be required, and ESG disclosure should be more open. For long-term sustainability and ethical impact evaluation, consider (a) the environmental category comprising all environmental issues, whereas (b) the social category including workplace relations, human rights, cultural diversity, and product responsibility. These criteria and resolutions are vital to most investors who wish to keep investing in companies that follow them. ESG issues are critical for a company's long-term strategy and shareholders' value creation. Understanding how ESG fits into a company's long-term strategy may help CFOs and other business leaders. In addition to fast data processing and digestion, investors need credible, and comparable data.

The data from www.xbrl.org shows that there has been an increasing trend in the adoption of XBRL since its introduction. The year 2016 witnessed the maximum number of adoptions, the majority of which are the financial regulators. Table 1 shows the year-wise XBRL adoption classified by countries. The Netherlands has seen the implementation of XBRL in 14 different filings, followed by the United Kingdom (9), Spain (8), China and Germany (7 each), and France (6). Countries such as Australia, Denmark, Finland, India, Japan, and the United States have five filings in XBRL.

Figure 1 shows the year-wise XBRL adoption classified by required agencies such as business registrars, capital market, financial regulators, government, tax

Table 1 XBRL adoption across nations

	2001	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Netherlands						1		1		2		1	3	1	4			1	14
United Kingdom								3			1		2			1	2		9
Spain		2		3	1					1								1	8
China					2		1		1		1		2						7
Germany				1				1			1	1	1		1		1		7
France											1		2	1				1	6
Australia	1						2			2									5
Denmark								1			1	1	1					1	5
Finland											1		1			2		1	5
India						1		1	1			1			1				5
Japan			2		2								1						5
United States		1				3									1				5
Belgium				1							1		1					1	4
Estonia							1				1		2						4
Indonesia											1	1	2						4
Ireland									1		1		1					1	4
Italy					1					1				1	1				4
Sweden												1	1		1			1	4
Colombia												2					1		3
EU											1		1				1		3
Greece																		1	3
Liechtenstein											1		1					1	3
Luxembourg											1			1				1	3
Malta													1					1	3
Norway												1			1		1		3

Poland													2				1		3
Portugal											1		1					1	3
Croatia																		1	2
Hungary																		1	2
Israel					1									1					2
Malaysia												1			1				2
Mauritius													2						2
Qatar											1						1		2
Saudi Arabia										1		1							2
Turkey												1	1						2
Austria																	1		1
Brazil											1								1
Bulgaria																			1
Chile						1													1
Cyprus																			1
Georgia																	1		1
Kuwait													1						1
Latvia																		1	1
Lithuania																		1	1
Peru								1											1
Romania																		1	1
Russia															1				1
Singapore				1															1
Slovak Republic																		1	1
Slovakia																			1
Slovenia																	1		1
South Africa															1				1

(continued)

Table 1 (continued)

	2001	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
South Korea				1															1
Taiwan							1												1
Ukraine																		1	1
United Arab Emirates											1								1
Uruguay											1								1
Grand Total	1	3	2	7	7	6	5	8	3	7	18	12	30	5	13	3	11	20	170

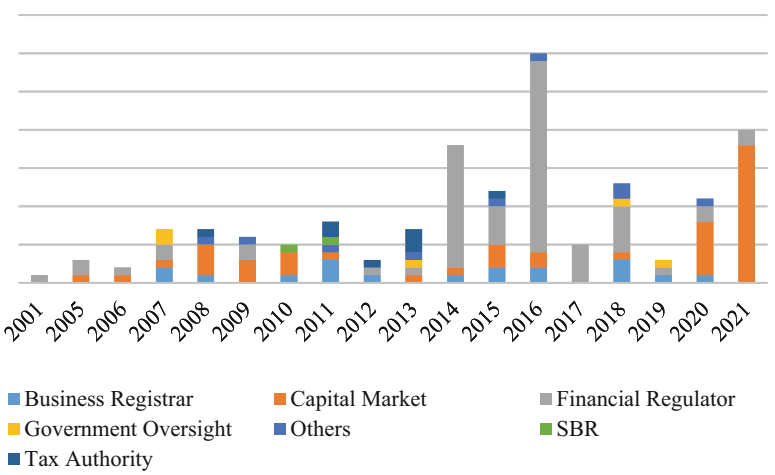

Fig. 1 Year-wise XBRL adoption classified by required agencies; Data Source: www.xbrl.org

Table 2 XBRL requirements by regulators

Business Registrar	18
Capital Market	47
Financial Regulator	81
Government Oversight	5
Others	9
SBR	2
Tax Authority	8

authorities, Standard Business Reporting (SBR), and others. It demonstrates a year-over-year increase in XBRL use and the increased participation of regulators in promoting adoption over time.

Tables 2 and 3 show the total XBRL requirements throughout the period. Financial Regulator is the group that implemented a maximum number of XBRL requirements, which is 81, followed by Capital Market (47) and Business Registrar (18). It is clear from the figure that financial regulators and capital market segments adopted XBRL in large numbers compared to the others.

Table 3 shows the XBRL requirements by regulators across years.

Figure 2 shows the XBRL adoption categorized by regulators such as business registrars, capital market, financial regulators, government oversight, Tax Authorities, Standard Business Reporting, and others.

Figure 3 shows the XBRL adoption categorized by countries. The Netherlands (14) is the country with the highest number of XBRL requirements, followed by the United Kingdom (9), Spain (8), Germany (7), China (7), and France (6).

Table 3 XBRL requirements by regulators across years

	2001	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Business Registrar				2	1		1	3	1		1	2	2		3	1	1	
Capital Market		1	1	1	4	3	3	1		1	1	3	2		1		7	18
Financial Regulator	1	2	1	2		2			1	1	16	5	25	5	6	1	2	2
Government Oversight				2						1					1	1		
Others					1	1		1		1		1	1		2		1	
SBR							1	1										
Tax Authority					1			2	1	3		1						
Total	1	3	2	7	7	6	5	8	3	7	18	12	30	5	13	3	11	20

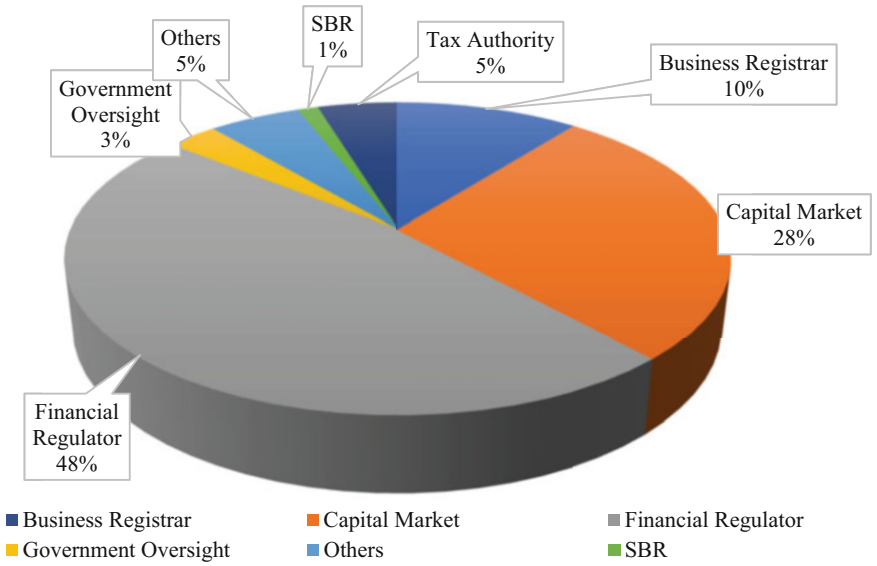

Fig. 2 XBRL adoption categorized by regulators. Data source: www.xbrl.org

4 Applying XBRL for ESG Reporting

There are numerous ESG frameworks and scoring options available for companies. Diverse scoring methods and data interpretations are used in ESG frameworks to address various issues. Determining which reporting standards to apply becomes more difficult due to the lack of agreement between ESG frameworks. As evidence emerges that sustainable company practices are connected to profitability, investors and acquirers are increasingly interested in ESG rankings. In recent years, the term "social responsibility" (formerly known as "corporate social responsibility") has come to mean more than just "giving back to the community."

An amendment to the International Financial Reporting Standards Foundation's Constitution allows creating an International Sustainability Standards Board (ISSB) to formulate IFRS sustainability standards. A solid foundation for sustainability standards was laid by the ISSB. The ISSB was announced during the UN Climate Change Conference (COP26) in Glasgow, UK, in 2021, creating the IFRS Sustainability Disclosure Standards, a comprehensive global platform for sustainability reporting. All indications point to standards based on digital data and analysis. The ISSB comprises the Value Reporting Foundation (VRF), which houses the Sustainability Accounting Standards Board (SASB), the Integrated Reporting framework, the Climate Disclosure Standards Board (CDSB), and the Global Reporting Initiative (GRI) (IFRS Foundation, 2021).

The demand for sustainability information has increased in recent years as investors recognize the importance of ESG factors in evaluating a company. Investors require the data to assess how companies manage these issues and how they

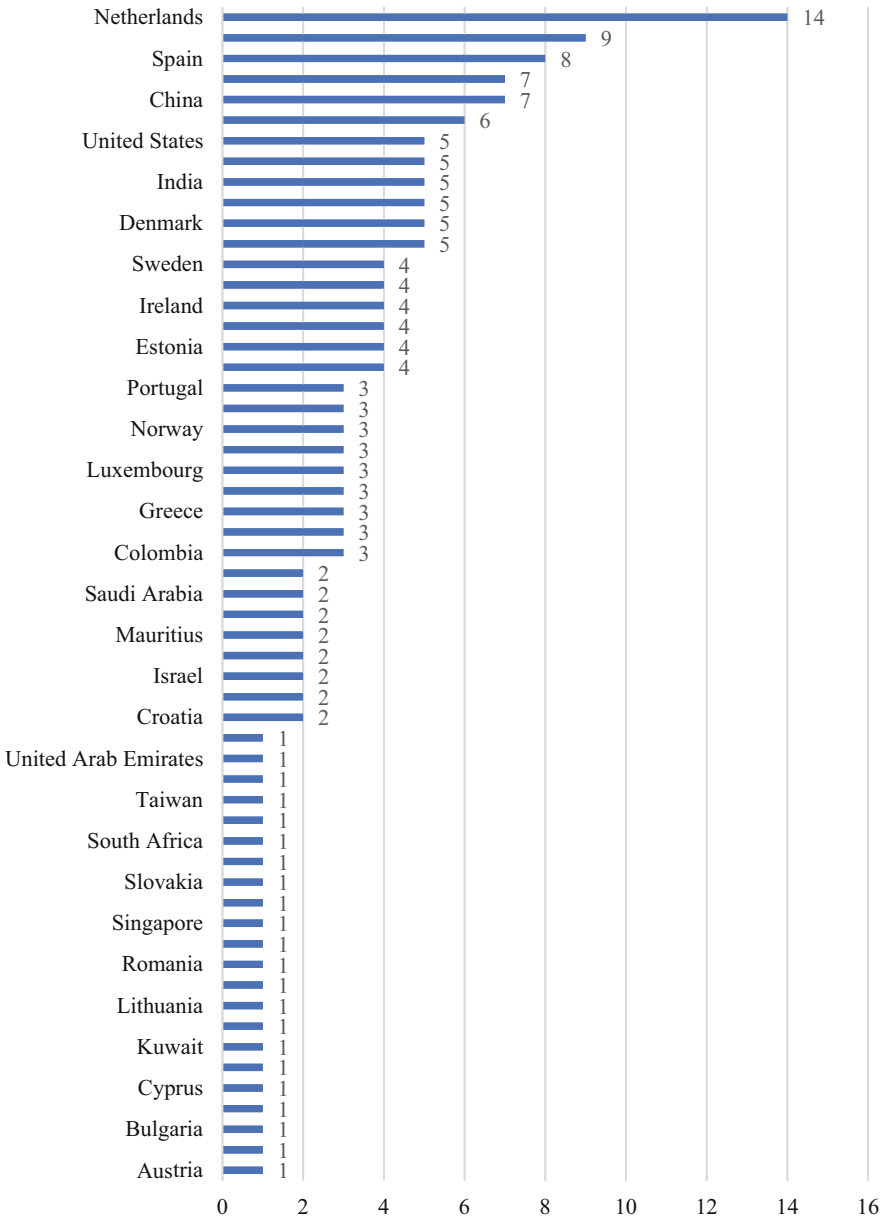

Fig. 3 XBRL regulations/requirements categorized by countries. Data Source: www.xbrl.org

impact long-term performance. As a result of increased investor demand and challenges such as climate change, regulators are increasingly focusing on material ESG data. A significant challenge is that, while various sustainability frameworks and

standards are currently in place, they have led to a patchwork of reporting obligations that must be brought into greater harmony. There are several sustainability reporting criteria, each with a distinct emphasis. Some are concerned with nonfinancial norm-setting, while others are concerned with framework for non-financial information, and yet others are concerned with framework for climate-related disclosures.

As ESG issues have gained prominence in the investment and business world, many companies and investors have expressed an interest in expanding their use of sustainability measures. These efforts, however, may be hampered if reliable data are not available. The absence of consistent and universal standards for evaluating businesses' ESG performance is frequently identified as the most significant barrier to investors incorporating ESG considerations into their investment process and companies' capacity to compare their performance to their peers. Investors are becoming more interested in acquiring consistent and comparable ESG data from companies worldwide.

It is necessary to standardize measures and disclosures on the effects of sustainability concerns on a company's current and future outcomes to ensure consistency and comparability in sustainable reporting. Global regulators are paying close attention, as evidenced by the formation of the ISSB by the IFRS Foundation, which is tasked with developing a set of high-quality, globally comparable, digitized sustainability standards.

ISSB is expected to rapidly progress toward digital-focused standards that could support sustainability reporting in the years ahead. The XBRL taxonomy for the criteria will be developed, making digital ESG disclosure reporting easier for issuers and data aggregation and analytics easier for investors. This will improve the usability and comparability of ESG reports as the taxonomy is implemented in XBRL. There is a significant lack of ESG measurements that can be compared across businesses and countries. Like IFRS and Generally Accepted Accounting Principles (GAAP), the new XBRL taxonomy seeks to improve the quality and comparability of sustainability reports by improving the machine readability of financial reports. That has become more important as more companies use sustainability standards and the integrated framework to report sustainability information.

Data analytics and technology are critical in collecting, analyzing, and interpreting data and the production and disclosure of financial and nonfinancial reporting. Innovative technology and data analytics can improve corporate reporting to shareholders and stakeholders while increasing accountability and transparency (Bebbington & Thy, 1999, La Torre et al., 2018, Stubbs et al. 2013; Stubbs & Higgins, 2015). There are strategic impacts of innovative and digital technologies on corporate reporting and other areas of business (Gray et al., 1996; Gray, 2006; Jensen & Berg, 2011; Higgins et al., 2014; De Villiers et al., 2017; Guthrie et al., 2017; Rinaldi et al., 2018).

Corporate reporting infrastructure must be changed to support XBRL-based digital corporate reporting, especially the ESG aspects. These updates will improve information accessibility, transparency, accuracy, and comparability. To reduce regulatory compliance costs while improving regulatory surveillance and

monitoring, regulators around the world were initially urged to develop and implement digital corporate reporting initiatives. As a result of these initiatives, financial reporting firms must submit statutory corporate reports in digital formats (in XBRL or iXBRL). Changing laws and accounting standards are critical to digital corporate reporting. Developing reporting taxonomies as part of the digital corporate reporting infrastructure is essential. Research on stakeholder dialogues and institutional factors like taxonomies and corporate reporting requirements is needed. Academics may research current regulatory and policy developments when developing new taxonomies and accounting standards. The regulatory regimes and taxonomy development methodologies influence how far firms adopt new reporting practices.

Apart from making data collection more accessible, digital reporting allows examining data to see if preparers follow accounting standards and policy decisions. In this stage of reporting, digital reporting data are emphasized even more. Potential applications of digital reporting and Internet communication technologies are highlighted in some studies (Perdana et al., 2014; Cockcroft & Russell, 2018; Gepp et al., 2018; Marrone & Hazelton, 2019). We cannot ignore the role of digital technologies in supporting stakeholders' engagement and shareholders' needs for transparent and fair information when it comes to the corporate reporting process and accounting. There is a link between firm-specific reporting and capital market indicators. Measures including Information Efficiency, Value Relevance, and Bid-Ask Spread are positively linked with reporting customization (Cormier et al., 2018). A company's financial statements are more likely to be followed by analysts if they use XBRL. Less XBRL usage meant higher loan processing costs (using loan spreads) (Chen et al., 2017). Prediction errors and dispersion are higher for firms that use proprietary footnote extensions, but thorough footnote labelling reduces prediction errors and dispersion.

A broad range of capital market indicators, including information efficiency and effectiveness are improved by XBRL-based digital reporting. Capital market participants can access more information with digital reporting while paying less for it. Fundamental analysis enhances market efficiency. The impact of digital reporting on capital market indicators is regulated by how it is used rather than its availability. The shift to digital reporting is linked to changes in stock market indicators. Instead of improving capital market indicators, more customized digital reports increase information processing costs and reduce comparability.

Ongoing changes in audit and assurance processes can be tracked using XBRL-based reporting. Due to advances in analytics and big data, it is now possible to audit the entire transactions rather than just a small subset of transactions. To explain the effectiveness of their compliance monitoring and risk assessment activities, authorities have determined that digital reporting can be reused across large datasets. Streamlining the reporting process reduces the administrative burden placed on reporters when they switch to a new digital reporting system. Rules significantly influence infrastructure development and adoption for those who create or consume digital corporate reports. The XBRL technology is a perfect example of this.

Governments will require corporate to file digital reporting on sustainable aspects of businesses and the digital corporate sustainability reporting has a broader

implication for the reporting organizations, regulators, and users of information. It is known that the impact of corporate reporting goes beyond technological aspects and into other domains. Based on the evidence currently available, it can be concluded that XBRL will be able to unify accounting languages as well as financial and nonfinancial sustainability standards in order to reflect the true picture of a company's performance in an integrated manner in the coming years. Standard-setters, regulators, reporting organizations, information users, investors, and auditors will all have a more significant role in the growth of digital reporting than ever before.

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Risk of Digitalization and Financial Freedom

Guirinskiy Andrey

1 Introduction

Scientific progress now is going more and more rapidly, and it involves new and modern forms of information technologies, and this all is named as digitalization of society. Economic systems of many countries are looking for more effective ways for using the results of digitalization of their society, in order to enhance the economic level. Regarding the Russian Federation, it implies international cooperation and the development of digital technologies, and it is the priority and a strategical goal. Due to the state policy, Russia has achieved a sensible progress in building a digital society and digital government that brings a real contribution to digital freedom. There is a state Russian program "Information society" and its purpose is to achieve some social effects due to informational and technological development and the goal of another program, being the "Digital economy of Russia"—is the growth of economy.

The baseline of any digital economy development is constructing process which is running during many years along. Moreover, up to now we can see that the information and technological paradigm of the new type of society has been formed. It was a consolidation of informational resources and technologies in one volume where many IT firms became common features for individuals. For example, the digital platform in education is connecting thousands of distributors of online subjects and millions online students all over the world. We are witnessing the radical shift in business relationships into digital ones, which are fulfilling in an electronic environment due to the constant analyses of digital data in a real-time mode. More

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and more often the process of searching and choice of relevant proposals is being made on a digital platform, which displaces the electronic mail from business communications and also Internet shops and telephony. The passenger transportation market is the most popular example of this trend, but in many other types of economic activity (banks and education institutions) we can observe some changes and it is an impulse for further digital freedom and innovation.

There are some sensible results of digitalization being as follows: the active using the IT by citizens in business and personal communications, that permits to collect data (digital footprints) about their activity: connections with mobile applications, web services, including place and time of allocations; the growth of popularity of mew channel of communication for business partners with other clients and customers through messengers. Recently, it was not fully available in business activity. As a result of high speed in information flows, it is necessary to underline the growing volume of scientific, technological, and social information resources and that is the real value for digital freedom and innovational activity. Intensive development of IT infrastructure is ruling to the available computing power facilities growth, and they can be used in processing and transmission of growing volume of information. In addition, the very important thing in building the digital freedom environment is the relevant legislation for IT and information using.

The above-mentioned results in digitalization have to be a new source of innovational development of companies all over the world because of the fact that they resulting digital transformation of base models and processes (Swan, 2015). It is important that it is a replacing process in channels of cooperation with partners into the digital one and we see new resources of digital freedom and activity. So, I suppose that the results of digitalization can be used in all sectors of the economy. It is necessary to realize the foreign and domestic results of research. Due to digitalization process, we can diagnose the process of consequent liquidation of boarders.

2 Innovation as a Factor of Digitalization and Financial and Digital Freedom

In the modern world economy, we are witnessing the changes in the main tendencies of informational and technological development of business partners including branches and regions. The common informatization is consequently transforming into digitalization and it results in the new digital economy in turn. The digital economy, being a new event, is attracting more and more attention from the part of politics and economists. A lot of governments in many countries are choosing the digital way of development. The real efforts from the governments of South Korea, the USA, Great Britain, Singapore, China, and other countries are done with developed or developing economies for the above matter. (Swan, 2015).

The requirement for the new sources of innovation and digital freedom, which are guaranteeing the stable economic growth is the main impulse to the national

initiatives for many countries for transmission to the digital way of living. Innovational activity, being the sensible feature of digital freedom, is constantly changing under digital progress. The digitalization of the society and freedom in all digital aspects is focusing on the consolidation of IT, made by any country into IT infrastructure, which is available for use in the business activity of firms and people. There is constructed a new platform for innovation within organization (Swan, 2015). The result of digitalization is also connected with the big technical progress for many territories with telecommunication facilities, internet network, and also with relevant legislation base mantainance for active digital economy development. Thousands of developers in mobile applications have a possibility to propose their own software for smartphone owners through mobile devices being with the hand of device owner. And we can see a difference between informatization and digitalization concluding with the difference of volumes in using IT technologies. Digitalization is a wide unit including people, organizations, and a lot of devices switched on Internet.

New possibilities in digital freedom and innovation are also opening through the IT culture which is prescribed by using many different types of devices, i.e., smartphones, tablet computers, and personal computers and it can be enclosed with high skill of people in computers including software and hardware. The World Bank has an analysis of readiness for digitalization among 180 countries all over the world (Digital Banking Maturity, 2020). The results of international research show us that digitalization is forming possibilities for transmission into digital economy and it means that it is possible to increase the efficiency of business due to IT technologies and big data overviewing (Digital Banking Maturity, 2020). But the full effect depends on the level of digital freedom realized in innovation capability and activity. A comparison of the first 40 countries from the analytical list of World Bank in terms of readiness for digital economy activity shows that more than 80% they are common regarding the level of digital freedom and innovation. In some countries the innovation potential is not used in full scale, and among these countries we can see such states like Poland, Chilly, Russia (Digital Banking Maturity, 2020). The low level of digital freedom and innovation activity is preventing the development of digital economy due to the fact that just existing of the internet and its using cannot result in the high level of efficiency. It is necessary that IT technologies became a source of innovation and world researchers are confirming that IT realization does not automatically lead to changes in business processes, products, services, and ways of its distribution. But innovations are according to many efforts together with IT for countries prosperity.

Changes in informational and technical paradigms are creating possibilities for completing the list of individuals and companies of innovation activities. The modern approach to digital freedom and innovation not completely observes new positions for development using digitalization. Many experts are focusing their attention on financial, regional, and other aspects of innovation. The research in digital freedom and innovation have a big significance in the context of digital economy development, taking into consideration the fact that the real effect on economy depends on innovation.

Scholars in a world economy science about digitalization started from the beginning of the XX century. In the first research, the digital economy was defined as the use of information technologies in different fields of activity (Tapscott & Williams, 2012). In that period of time, the categories of science were on the level of initial forming. Many definitions were very close by meaning and used equally in many cases and approaches despite of the academic or business environment. Such equal definitions were formed as "digital technologies" "electronic technologies" information technologies and other derived concepts as "digital economy," "electronical business," "informational society" (Tapscott & Williams, 2012). A little bit later some definitions and conclusions were altered. One of the first researchers in this field was Professor Don Tapscott from Toronto University who suggested such a definition as "vikinomika" (Tapscott & Williams, 2012). First research devoted to the problems of digitalization were done by professor at Open University in Catalonia M. Castels, by professor at University of London (Castells, 2001) F. Webster (Webster, 2005) and many other experts and scientists. Also, problems of innovation and digitalization were reflected in books of American professor Reich (2010) and Harvard University professor P. Drucker (2002).

Open discussions in academic society are continuing today regarding the definition of digital economy and digital freedom. In Russia, a document named a Strategy of informational society development for the period up to 2030 was issued. In this document, we can see the definition which seems relevant enough. The digital economy is defined here as business activity where the key factor of production is the data in digital format, the analysis of big data and the use of the results thereof which permit to increase in the efficiency of different types of technologies, production, equipment, safekeeping, purchases, and delivering goods in regarding of traditional forms of business activity. Scholars are confirming the fact of transmission to the next coming phase of social and economic development from postindustrial (informational) to post informational (smart and digital). The remarkable feature of the digital economy is the possibility for business companies to do innovational activity together with using the complex IT and information resources, including all infrastructural elements. The high level of results is fulfilling for the account of synergetic effect of accumulated resources in the economy working with it. For the goals of creation, the new economic benefits, the digital economy attracts all IT infrastructure, including calculating facilities of each business company, other organizations. Changes in technologies and ways of economic modes of development are conducting to the replacement of economic paradigm. In such a paradigm, the interaction between figures is more important than the list of figures in action. It is worth paying attention that under the pressure of digitalization the replacement of capital generation and its reproduction is taking place.

Taking into consideration the definition of digital economy, the main resource of increasing the effect of different fields of economic activity is definitely data digitalization. This is in practice the whole modern volume of information. In very rare cases the information submitted is in non-digital form. The key of transmitting to the stage with digital features is the automatic verification and analysis of data of all types. The work with information resources is aiming at permitting business

individuals to receive new economic effects in production, marketing of goods and services, and contact with clients and customers, i.e., to achieve new effectiveness due to accumulation of IT and information in society.

It is accepted that the accumulation of IT, including corporative and individual computer devices of different types, the stability of connections and interactions with different services result in the accumulation of data unavailable up to now. But each person or device is leaving a digital trace or traces very long and detailed through multiple intermediary Internet services and Internet gates. This trace is being saved in the centers of data verification. Automatic mode of data verification with the use of forecast analysis, computer tutorials, and artificial intelligence technologies is capable to complete the new level of decision-making process. For example, it may be realized in customer service and in the construction of social safety and comfort. In a more common approach, the activity with informational resources is connected with analytics. Methods of information analytics applied for digital data are permitting to accumulate new knowledge coming to innovation. Beginning from the intensive development of IT and digitalization we can formulate three periods in practical use in everyday economy. They are as follows: automatization, informatization, and digitalization. While the IT technologies were developed, the automatization process of separate functions and operations from the very beginning and then whole economic systems was raised. The developing process in IT is going synchronously with the theory of economic management as a cybernetic system and management. It can be done with many complicated elements and connections within the frame of this system. We can consider the cybernetic system of economy as a complicated system of management having particular purposes and with capability of adaptation, self-organization, i.e., it is able to replace the structure while developing. The cybernetic method is searching for the informational aspect of a matter as an organized system, owned by a structured, stable body, and supported by informational managing processes.

To measure and to control changes in some separate elements is possible only with electronic calculating systems, its use permits to make an automatization of routine operations, made with prescribed algorithm. Due to automatization the speed of data analysis, the accuracy significantly increases, and also decreases the level of the mistake regarding the same process done by man. The dispersion of cybernetic method regarding the economic process's results information of IT requirements and the demand for IT is growing. At the same time, we can diagnose intense forming and development of IT industry and IT market. IT market is comprising the development and production of computer and telecommunication equipment and also the elaboration of soft for different spheres and computing devices.

Due to the development and distribution of IT the postindustrial economy was born, where concurrent adventures were based on intangible assets and quality of data verification. With the development of postindustrial economy, the increasing demand for IT technologies is becoming a part of national economic systems.

The tendency of the international market of computer and technical equipment is witnessing high levels of development which are well over volumes of other types of the market during the period of postindustrial economic phase. Technologies became

more and more complicated and productive due to their development. Gordon Moor made a conclusion about microchips with twice the capacity of transistors on one crystal every 1.5 years (Moor, 1965).

At the same time IT became more available for use in different fields of industry due to decreasing in its cost. As the process of IT penetration in economy grows the significance of information quality for business companies and regions and also demand for more complicated informational decisions is also growing. The analysis of computer technologies volume used in the world economy shows that since the 1980s there was a serious growth of IT use in communications and expert systems, based on information processing (Tapscott & Williams, 2012). The growth in IT expert system uses and Internet distribution is witnessing a transition into IT informatization period. For that period, we have a typical future, being the decreasing of IT-specific weight in statistical analysis. This process is due to the absence of radical changes in methods of data collection and its volume increasing. Processes of data collection remained very expensive and labor-intensive until the 2000s. Besides the work of data specialists elaborating methods of collection, storage, clearing, verification, and data processing big volume of interweavers, computer operators, and stuff for data verification in paper and subsequent digitalization were necessary.

During the period of informatization, the object of IT influence became bigger up to the business process and company as a whole. For the informatization development, there was a markable volume of companies that used automated management systems. The main purpose of company automatization may be characterized as the quality of decision-making process with the information facilities assistance, mantling different data structures, subjects, frequency, and intensity of information flows. Distribution of information in the society resulted in the fact that firstly baseness and secondly personal communications were transmitted in a telecommunications network and beginning from the 1990s on the Internet as it was. It is necessary to stress that in the 2000s, the telecommunications market multiplied and exceeded the growth of computer technologies (Dneprovskaya, 2018).

During the period of informatization, many sociologies and economists began to talk about informational and net economy, where people, production activity, technologies connected with telecommunication lines were organized in a new business environment—electronic business. Manuel Castells said that the world enmeshed by communications became smaller than it is. It was mentioned that the feedback between economic systems and other business units in one country and in all other countries is decreasing to the volume of one click of a computer mouse or reply of an automatic informational system due to data alteration. The influence of IT on social and economic relationships is very big and such definition as IT revolution appeared. Some experts define the IT revolution since the moment when the first computer was made, or first telecommunication net was created or since the moment of radio electronic industry started. But revolutionary effects of IT use which changed sensible part of people's activities were taken place in the middle of the 1990s.

Intensive development and IT use, the informatization procedure almost in all branches of economic activity begins when we see a productive enough and cost

available personal computer together with the net being the global one. A new quality in personal computers user's interaction in online mode was realized.

The history of personal computer technologies shows us that the first computer was invented and produced by Xerox company in 1975 and then Apple submitted their own invention in 1978 and after that, we saw IBM variant in 1981. But a sensible period of time those technologies were not so popular among small-sized and medium-sized business. Firstly, IT of those days were very expensive. Secondly, it was absolutely necessary to have computer competencies in order to feel itself comfortable and it was defined as computer literacy. Some inventions helped users to feel free and comfortable and a user-friendly interface, HTML language, web design soft and other facilities were developed. For working in the middle of Internet environment it is not necessary to have some very special competencies and knowledge. It is quite enough to follow references to the relevant programs and data, and you can achieve the proper goal. This is also the development of digital freedom with the easiest way through the computer line. Manuel Castells (Castellls 2001) considers that the principal difference of informational and technical revolution comparing to its historical predecessors is that than previous technological results remained on limited territories, but new IT is powering the new space in an immediate mode.

Due to the processes began in the 1990s in many factories, especially including small- and medium-sized companies, we could observe personal computers and they were connected by the Internet. And above process brought the real effect, being as follows: (a) the access to the Internet, IT, and other information resources had been enlarged; (b) information volume had increased though the cost of its distribution and multiplication had decreased; and (c) the information process had covered almost all types of economic activity. The business environment is becoming almost totally electronic. There is a definition the "electronic business" and it means that all communications are transmitted on electronic net. And together with the above, we can define such special categories as "electronic commerce," "electronic education," "electronic government," and so on. It is also a real development of digital freedom forms. In that case, electronic business and separate web instruments are no longer considered as innovations (Dneprovskaya, 2018). In fact, electronic communication services became the standard in information types of economic activity. In this group, we can observe financial, educational, and other relevant services. IT is distributed all over the world and penetrated social and economic relations, having the features of high-priority technologies. Due to this matter an intellectual asset, consumer attractiveness of the product and service was created.

Developed countries are given the initiative to the development of a global informational society for overcoming the digital disproportion. It is possible to characterize the digital disproportion as big differences between separate regions and countries regarding the terms and conditions in access to IT and digital resources. The digital disproportion has a danger which is connected with the fact that successful development of the country and business units within that is only possible when they are included in computer and technological global system. Even the only participance in this system requires expenses from the part of business units for acquiring soft and hardware and payment for use of telecommunication line

services. At a national level, we see the necessity of sensibly high expenses and efforts in forming the modern IT structure. Beginning from the 1990s and till the 2000s, the economy of developed countries demonstrated the attractive speed of economic growth but beginning from the middle of 2000s this growth became less markable. High rates of economic growth were supported by automatization from the very beginning and then by informatization. But in 2000s, the potential of economic growth with automatization factor was almost exhausted. The reason for this comprises several factors. Firstly, even technologies as they were after their wide distribution, stopped as the source of concurrence adventures but transferred into usual technologies for a work in modern global information and technical system.

The second factor is caused by the fact that subsequent improvement of IT and the replacement of old technologies with new ones is not showing the same effect in labor productivity compared to those items of the very beginning of the 1990s. For example, with the realization of a new text editor the speed of document making is sensibly multiplied, but this feature is not changing so rapidly when new versions of a product are issued. The same analogy is in web services of electronic mail taking into consideration the fact that it was a sensible effect only from the very beginning. For many years, this type of service was a popular instrument of common work but now we are unable to consider this as the source of innovation and additional sensible breakthrough in digital and financial freedom. The subsequent growth in labor productivity and economic growth may be guaranteed by the way of digitalization and transition of business models and external and internal interactions between business units and participants. This also confirms the fact that financial freedom became more markable throughout digitalization. Now in the informatization stage, communications transformed from discreet to continuous, but at the same time they are more intensive. Informatization is coming to end after its deposit to financial freedom and it is transferring to the new stage named digitalization. On the board of informational and technical paradigms, we can see new definitions for strengthening the financial freedom and inventing new digital facilities in order to help to achieve it.

3 Bank Sector as a Factor of Financial Freedom in Digitalization Process

Banks are the institutions that are constructing the boards of financial freedom in the relevant sector of the economy. Banks are implementing more and more often digital technologies for the innovational products and services make it available to the customer. Such technologies comprise artificial computer education, deep analyzes of the data, the blockchain register, cloud storage, and verification, interfaces of different types of programming, etc. The new technologies are building new possibilities and options but at the same time, this freedom contains some new risks and

dangers. We can see in Basel Committee report the recommendations for banks which are working hard on digital platforms and using innovations very actively have to guarantee effective measures of hedging with the risk which may be occurred. At The same time, banks are trying to eliminate the sources of risk appearance. The character and volumes of risks which are having a place in banking sector in their traditional activity are changing seriously when digital technologies are developing.

Experts point out that the realization of new digital technologies is influencing more concretely the category of nonfinancial risks, in other words they are that of cyber safety, compliance risks, fraud risks, and also risks connected with money laundering and terrorism hidden financing. This is the other side of financial freedom and digitalization. International experts are researching this matter as a fin-tech problem. The serious research issued in 2018 (Stulz, 2019) and devoted to the analyses of fin-tech and its influence on banks activity, and the problem of bank risks transformation was done by Basel Committee yet in 2010. The key risks connected with digital technology development are strategical risk, operational risk, cyber risk, and compliance risk. The above-mentioned group of risks can be referred to banks of any type, but not only they are potentially relevant for other groups of financial institutions. There was another serious research being the global review of banks risk management and it was prepared by an auditor and consulting company Ernst and Yang together with the Institute of international finance. Due to analysis of this document, there are the main items in my opinion. Banks are supporting the changing picture of risks in the field of cyber safety and the growing concurrence from fin-tech companies as one of the main sources of danger. Despite deep implementation of digital technologies which are expanding the financial freedom banks have the real perspective to enlarge the digitalization, especially in the field of back-office activity. Also, the perspective way of digitalization of banks' activity is the way of elaborating and implementing the quantity valuation models not only in the field of financial risks but also not directly in financial fields as well. I mean some specific types of risks being reputational, strategical cyber risks and some others. The key direction of improvement in the field of banks risk management which can preserve the financial freedom in banks' operations is a strong hedge from cyber risks. Banks are making many efforts in order to have a decision-making process over changing opinions about operational stability and its components. In accordance with the expert's information in 2016, there were more than 4 thousand vulnerabilities in the informational systems of banks, and they result in malfunctions in systems of personal data storage. When financial freedom is expanding it will be followed by newly borne risks.

First of all, it is necessary to say about strategical risk. The development of fin-tech companies and their entrance to the financial market in many Western countries changed the valid present legislation in accordance with that matter. Special regulation regimes increased the volume of profit losses for some banks in regions. Existing financial institutions may lose the sensible part of their sector of the market, in case when the participants of it will be able to use new technologies in the most effective and cost-effective mode. Also, new participants may submit

analogical services but cheaper and they will fit more accurately to the needs of the customers. In modern terms and conditions, the decreasing profit process due to the absence of flexibility in the interaction with the customers may weaken the capability of banks to hold the cycles of business activity.

In the next item, it is necessary to analyze the operational risk. The big volume of digital technologies is leading to the increasing of the interaction between participants of the market using the same platforms and it may result in the situation when the failure in IT functioning may be transformed into systematic crises, especially where concentrated services of one or several dominated players. In addition to the above the volume of banking sector participants is increasing the complexity of the system and favorize the appearing officers who had limited skill in and knowledge in risk management. The European Council (Diamond, 2017) upon system risks is stressing that the old banks' IT systems are very hard to be modernized to new conditions of exploitation. Besides this, we can observe that many banks are using a sensible part of outsourcing staff using cloud services or throughout other partner relationships and agreements with technological companies. This situation is worsening risk management and decreasing the transparency of operations. The big outsourcing practice may lead to increasing in risk volumes, connected with the data preservice and safe storage, confidentiality, money laundering, and criminality in cyberspace. Those risks have even more serious character if the stuff not completely fulfill the level of efficiency in meeting the accepted legal standards and control facilities in preventing risks. In fact, outsourcing exploitation may increase risks connected with nonformal obligations of the bank in supporting its customers. The situation may be in such a manner when it will be forced to support the provider having the financial problems because in another case they may be out of service on the part of provider. The services of that provider can be critically important.

The next item is connected with growing problems with compliance requirements in money laundering prevention standards. Digitalization together with financial freedom growth is making problems also in that way of financial activity. New parameters of vulnerability may be developed due to new technologies and financial products elaboration and implementation. The growing volume of digital technologies is leading to the growing volume of fin-tech companies. The digitalisation of financial cash flows in many countries may simplify and cheapen cross boarder transactions as it was with Ripple Company in the USA, and on the other hand the transaction monitoring must be more effective. New participants in financial sector are able to change sensibly the bank system and they may violate the conditions of banking sector regulations and meet less strong items of present valid legislation. So, if measures adopted will be not proportional to the risks in money laundering preservation it may result in some distortion in the concurrence situation.

Besides this, if banks are cooperating with fin-tech companies and making transactions on behalf of customers they will be forced to include these operations in the scope of money laundering regulation and control. This situation is different from that which is existing in nowdays practice. Now a customer makes operations with a bank card or account, and it is the bank that is responsible for proper identification of

the customer and letting them make operations of suspicious character. The result may be a much higher level of automatization among banks and fin-tech companies but less of transparency in the process of operations fulfillments and who is responsible for meeting requirements of present valid legislation. So, the outsourcing of fin-tech companies multiplies risk of money laundering for banks because they have a much higher responsibility for their actions.

The next item to be analyzed in this context is the problem of compliance risk. This risk is including risks of not fulfilling the local legislation regarding the preservation of personal data. The risk of nonfulfillment of requirements upon personal data storage may be extremely multiplied, when banks are cooperating with a big volume of outsourcing companies and each of these companies trying to have access to the personal data of customers for their own purposes. The subsequent item is connected with risks of outsourcing companies as they are. Banks are using this facility in a constant mode, and they have a purpose to meet the support of their own product based on digital technologies. As per auditing and consulting company, Deloitte, the main drivers of outsourcing in a bank sector we can consider decreasing expenses and exploitation flexibility and reinforcement of safety and operational stability. At the same time in accordance with items of Basel Commute upon banks control it was permitted to pass some functional obligations to outsourcing companies but that risks are in any case submitted to the responsibility of banks as a head organization. Key items of risk management which have to find a balance between financial freedom, digitalization, and legislation compliance are reflected in relevant documents devoted to basic principles of bank control, principles of operational risk management, and also outsourcing in financial services. Some of the mentioned principles relate to corporate management and it is relevant not only for valid banks but for new participants in financial market. In bank service operation we see several partners (for example, several banks or fin-tech companies) it is possible to observe the ambiguity in the process of obligations distribution upon legislation compliance and it potentially increases the variability of operational incidents. The key problem of financial organizations is the problem of operation control and risk management which are taking place outside banks, so saying in outsourcing companies. Outsourcing risk will be more identifiable if in some part of service done by outsourcing company there will be the biggest companies and the reason of risk concentration will be growing.

The further issue of our analysis is the cyber risk. The growth of this type of risk was defined not only by banks but also by controlling boards as one of the most dangerous in the process of digital technology use. This conclusion was also made by Basel Committee (The G20 Seoul summit leaders' declaration, 2010) in one of their last researches and it was stressed that new technologies and business models are increasing in sensible volume the exposure to cyberattacks on the part of the banks if systems of management are archaic and not completed with last updates. In addition to this, the big depending on new technologies, increasing the connections between organizations and sectors of economy not covered by equal banking legal requirements may transfer the bank system in a vulnerable position regarding cyber danger and personal data may be under attack. As per Ernst and Yang (Ernst and

Yang 2019) researches, the other problems connected with cyberattacks are that against systematically significant financial institutions or against even hole branch of industry as telecommunication, for example. Taking into consideration, the fact about the guarantee of personal data safety it is not surprising that banks are concerned with the problem of customers' data loss. At The same time banks are concerned about integrity of data in more than 50% financial institutions are considering these risks as extremely dangerous in subsequent 5 years.

This item is about the risk of liquidity. The use of new technologies and modern mobile devices is permitting customers to transfer from one bank account to another immediately. At the same time, the mobile device owner is able to invest immediately from the account in bonds and acquire shares from investment funds in order to receive a much higher level of profitability. Access to the wide list of investment instruments, on the one hand, is increasing the loyalty of customers but on the other hand, increases the volatility of funds applied to deposit accounts with the bank. All above-mentioned items may lead to turbulence in the liquidity level of the bank as a credit institution.

This item relates to risks of Cloud technology use. The use of cloud technology providers for the storage of confidential banking data relates to several potentional vulnerabilities. These vulnerabilities may cause the loss of important data, integrity, and availability in any period. The application of this type of technology is raising many questions and concerns on the part of regulators boards in many countries. As per experts, banks are mostly concerned with reputation losses as opposed to regulators. At the same time, state boards are concerned with the geographical placement of servers with information and data stored. It is important that in the process of digitalization as a reply of competition, banks are timely concerned with the supporting their ancient technological systems and also hold work over elimination of shortfalls in the persons identification system as a baseline invention on the coming stage of progress. Today, banks are giving much effort to the base elements of future wide digital system of bank services. That means that banks are focusing on financial operations and risks enclosed. This tendency is one of reinforcement of financial freedom on the one hand and on the other hand it is a progress with the subsequent digitalization. To minimize several financial risks some financial institutions, expand the volume of the staff working in the field of risk management. The other coming stage of financial freedom and digitalization will relate to technical adaptation on the part of the customers, being the advanced users of modern bank products. This process is strictly connected with transferring all banking products to the online mode and sensible update the cyber risk hedging procedures. In the final stage of digitalization and modernization being a strategic positioning, banks are modernizing their offices and implementing high standards of cyber safety. The bank regulation procedure now is applying, for example, the SupTech technologies Among the adventures of this system are such facilities as real-time access, advanced methods of data extracting, automatic forming of statistic data, collecting procedures from nonstructural data, and many others. These systems favorites both to financial freedom and to digitalization.

4 Cryptocurrencies and Digital Technologies as a Factor of Financial Freedom and Digitalization

The definition of the digital economy was suggested in the middle of the 1990s when American professor Negroponte formulated the conception of digital economy (Negroponte, 1995). In the modern aspect, the digital economy is the system of economic social and cultural relations raised on the base of information technology use. In Russian legislation, there is the definition of digital economy as the economic activity including the key factors of production. These key factors of production are the verification of data in digital forms and due to this it is possible to make the production process more effective. More effective processes may take place also in purchasing goods and other operations connected with proper economic activity. This definition underlines the most important elements of economic analysis which also includes the recording procedure for big data, etc. Some objects of economy are yet connecting with each other on digital platform and others are going to be included in this process. The very interesting approach to define the digital economy as the economy existing in the environment of a hybrid world and this hybrid world is the world where we may observe the real and virtual space. Some processes, in this case, may be done in virtual world and after that can be implemented in the real one. If the digital structure and instruments are available, we may observe the full cooperation in the hybrid world for all participants of the economy. We can consider the digital economy as a supplement to the real one and this can be a stimulus to the real processes. At the same time, the level of digital economy is closely connected with the level of digital economy. But, in any case, we can see a priority of real economy as the baseline of any production process in real time. Informatization is strictly connected with Internet development and other similar instruments of communication. Processes of informatization are very important for all sectors of economy including production, healthcare, education, financial sector, and many others. But the analog economy is the priority in any way and without this, we are unable to use the achievements of digital economy. But the digital economy is the way to the competition stimulation and online access is very important for this procedure. This availability can be extended to the physical persons, to the juridical persons, and to the state boards.

The digital economy is in the center of attention for every international organization and consulting company. In 2016 World Bank has published the report devoted to the international development and it was named as Digital dividends. (World Bank, 2016) this report contains the analytical material about poverty problem in different countries and social problems. In this report, it was stressed that we have now the informational and communicational revolution in human history. More than 40% of people have Internet access all over the world. And even the poorest part of people has access to the internet and this access is more available than access to the toilet and other everyday needs.

As per World bank the effect of digital technologies is the effect of result from its use favorizing to the economic growth and the population employment and the

availability of services on the state level. There is a tendency to decrease the cost of any services when digital technologies are implemented. This process is valid for social and economic transactions, for citizens, and state sector. The speed of transactions is multiplied sensibly despite the fact that it relates to penalties of payments, for flats and other payments. Many interactions have more effect because of the fact that the services proposed became cheaper and faster in more comfortable format. At the same time, Internet technologies are helping to avoid the informational asymmetry between the seller and the buyer, and it results in the transparency of transaction. Digital technologies are free form boards and favorize to integration of the community, information nets are making the connection between people easy, and it makes the global society filling. The above-mentioned report stressed that for 10 years passed the quantity of internet users multiplied by more than 3 times. But at the same time, a lot of people have no possibility to have access to the Internet and it is a result of inequality by gender, geographical, and property principle.

It was said above about the positive effects of digital technologies, but it is necessary to say about risks connected with digital technologies and cryptocurrencies. The World Bank report also pays attention to that problem. The first serious risk is the risk of inequality in the labor markets due to the extreme speed of digitalization. The subsequent risk relates to monopolization due to the absence of competition between digital platforms and not properly effective regulations in this field. The third risk relates to reinforcement control over citizens on the part of the state. In the opinion of The World Bank experts, it is necessary to decrease the risks cited above. The process of decreasing will run with analog facilities being rules of conducting business, classes for citizens to learn new technologies in the order they can apply them in the new reality. When a citizen becomes more qualified in new technologies, they can be attracted to the procedure of governing using new professional possibilities. Thus, we can identify the key elements of policy in economy. The first is the modernization of present valid legislation and it helps the competition. The second one is development of the education system and professional skills forming relevant competences. The third one is the state system modernization in the field of extending services helping to make the governing procedure better.

The financial sector is the baseline of any economic system fulfilling the money turnover between the participants of financial and economic relations. Financial institutes are the mediators in deposit operations and operations for money raising. Banks, for example, are accumulating funds from one person and reroute them to other financial sectors or instruments. The modern stage of financial sector is the stage of new technologies implementation. New information technologies are permitting to govern the cash flow with new progressive methods without intermediary's help and protection. This is a fin-tech conception and it can be divided into three categories. The First category is the company that is servicing existing financial institutions. In this case, each bank has a subsidiary. The Second type of companies include the companies which are constructing new technological ways of development for the wide circle of consumers. And the last item is the fin-tech company doing fin-tech and other relevant businesses. In this category, we may include the consulting companies doing their business for private customers.

Financial technologies are running fast and fin-tech accords a real sensible influence on the banking sector. Banks are providing many types of services as an alternative to traditional bank services. This is favorizing of the digital freedom. But for the modern period, we can see some type of limit in effectivity in financial market. The witness of this process is the decreasing competition between banks, and mostly this process was taken place due to high barriers to bank change. The problem is that despite new technologies and innovations the essence of services remained unchanged. There are some companies covering the market failures and at the same time proposing the most comfortable financial services. The bank account is now the base service of any credit institution, but some companies offer additional services. In many countries, the companies realize some services like Pay-Me, TiPay, and many others and these services are services of mobile acquiring. This service is permitting to avoid the use of terminals for bank plastic cards. All these facilities allow small and medium-sized companies to be in a strong position in competition with big corporations. In reinforcement of digital freedom we can pay attention to the new investment technologies implemented by the financial sector of economy. As a part of digital freedom, three are nonbanks organizations and organizations of microfinance procedures using p2p technologies. The next way of reinforcement of digital freedom is the way of online credit operations and based on mobile devices. The subsequent item relates to scoring procedure. The scoring procedure is aiming at doing the valuation of risk. So, the most convenient investment procedures I can name online payments, mobile wallets, and soft permitting to govern by own accounts being different types like financial and analytical. Special services for small businesses like remote accounting and purchasing management are also available. The main trend of financial and cryptocurrency development is the availability of digital instruments for customers. The cellular operator has now become an element of the new payment system, and this is also a feature of digital freedom. The mobile device is also the station for managing financial cash flows. The absence of intermediaries in financial operations results in decreasing the transaction cost and reinforcing the speed of transaction from the one hand. But on the other hand, the question about reliability of the partner became more and more relevant. This problem is quite familiar for the Internet shops and distributors and for Internet banks and participants of p2p credit operations. In that case, it is necessary to stress that internet technologies must have the way of regulation of reliability among the participants of one or another operation.

The main tendencies of the banking sector relate to the liquidation of branches and offices and the realization of remote identification concept and decentralization instead of real offices. Another trend for the banks is the trend of bank assets consolidation, i.e., the quantity of banks is decreasing, and the process of assets multiplication is running. There is the circle of financial projects around banks and banks became an IT company in order to be built in ecosystem an to occupy the place in line for creating services for customers. And that is why blockchain technology is developing so actively because it permits to support technically the modern tendencies exciting in financial market. It is worth thinking that blockchain technology has appeared as an answer for globalization and super centralization of financial system.

For the modern financial market, the net effect is very common, which means that when one more user is added it is favorized for all others. Blockchain technology permits to set decentralized control in the net and it confirms the net effect. The blockchain predecessors were electronic money and they were evaluated seriously over the past 25 years. They were officially confirmed in 1994 when banking system of the European community published the results of the electronic money phenomena, and it was recommended for banks to reinforce control through bank routing information in order to save the system of noncash payment. It means that such control must be fulfilled by the centralized board of central banks in European countries (European Central Bank 1998).

There is not only one standard and confirmed definition of electronic money containing exclusively the economic and juridical sense. In Russian present valid legislation, there is the definition about money funds which is delivered from one person to another one and they account for that information and the volume of money received without a bank account. The owner of money can give transaction instructions in electronic forms. Some exceptions relate to funds received by professional participants of bonds market, clearing companies, and private pension funds. Now, it is necessary to underline some main features of electronic money funds. Firstly, electronic money transfer is the transfer without a bank account opened. Secondly, there is a difference from the usual transfer without a bank account, and the electronic transfer permits the situation when money is received but payment instruction follows later. Thirdly, in some cases the transit status of money may take place in transactions with private pension funds and other agents, it is précised that it is not the case with electronic money. Fourthly, the instructions may be delivered only by electronic way of communication. The electronic facility of payment is the instrument, which is within the frame of noncash payment rules, but all procedures are fulfilled with the use of telecommunications. So, it is significant that electronic payments are bank cards being credit and debit. Also, we can add to this information systems and electronic wallets because all the access is possible in electronic mode. But in practice, the category electronic money is applied to a very wide list of payment instruments based on innovational platforms. The electronic money is also the storage system of traditional currencies and also private currencies, and the turnover may be held upon rules adopted by the state and also by rules adopted by private payment systems.

Electronic money often differs from fiat national currencies and there is a classification upon the level of that. The third generation systems are WebMoney and PayPal and for the fourth generation, it is necessary to classify Facebook Messenger, Transferwise, Dwolla, Revolut, and Simple Bank. The main feature of 4G services is the new level of safety proposed to the customer and the flexibility. The customer is not saving his/her money directly with service but only with reference to the account. The reference is in activation upon request of the customer. Financial instruments of 4G are bank services, they have an orientation to the needs of the customer and IT companies are providers in fact. Such activity of IT companies is not connected with the relevant license for bank operations. The dependence on infrastructure is the weak feature of the system. But despite this, there is a big demand for these services, due to the minimum bureaucracy and simplicity in use.

An example of good combination of all services and the best quality of its fulfillment is Facebook Messenger, permitting to fulfill micropayments within the frame of social net. Financial systems of the fourth generation are still centralized and well-known Western company is responsible for storage and safety of data, like Google, for example. Blockchain technologies and other similar facilities are composing the next level of financial instruments and it is a 5G. This level has its own special features like absolute cross-border character, cross platforming, a simple way of use, and very fast speed in operations fulfillment. It is also necessary to stress that the value is also under control of the user and any operation without user's activity is impossible. Other features relate to the lowest or null charges, the highest level of safety due to cryptography, decentralization, and full transparency of money turnover between accounts. Swan (2015) considers the blockchain as a fifth revolutionary paradigm of calculations. The changing of paradigm relates to technology development. In the first stage, mainframes were invented and produced and the second stage was devoted to the personal computers. Then the Internet was implemented, and mobile devices and social nets were becoming the fourth paradigm and blockchain became a new step in the current 10 years.

The key feature of blockchain is the distribution and it means that there is not only one common place with all data in storage. The register is taking place with all participants of the system and is automatically upgraded when any changes were done. Each user has access to all transactions fulfilled beginning from 2009. Users are collective notaries confirming the validity of information every second. Blockchain is a distributed database system and contains information about all transactions done by system users. The information is stored like a chain of blocks and in every block put a fixed volume of transactions. For the presentation of a new technology example they have chosen a bitcoin and today this type of currency is a very well-known form of blockchain appliance. In this bitcoin example, the transaction is made between the electronic wallet of customers. Participants of the system receive charges for their contribution to the bitcoin environment. The participant who chained blocks with transactions receives that charge and it is a stimulus for supporting the system in a proper mode. And the very important attribute of the system is the irreversible character of transactions. It means that as soon as the block is formed any alterations and changes are impossible. The main purpose of the blockchain use is the constructing an opened system free from external invasion. The system works upon rules once elaborated which are unchangeable for everyone. The internal architecture is guaranteed that all rules are going to be fulfilled for every file of information in distributed register. In this case, the problem of reliability is not existing between participants forever. It is necessary to know, what is the contribution of blockchain technology to the financial sector development and to digital freedom. It is important to stress several spheres where blockchain use is urgent.

Firstly, the blockchain is very fruitful in the fields where the distributed register and decentralized system for data storage is required. The blockchain technology seriously simplifies the work with assets. The blockchain may be compared with the big electronic table for registration of all lists of assets for making operations with them in a global mode without restrictions upon forms of assets, type of participants,

and the geographical place. The blockchain may be the instrument for registration, accounting, and exchange of any financial, tangible, or intangible assets. As soon as all participants use the common complete of data, the blockchain allows to decrease the risk of bugs, discrepancies, and delays, connected with coordination. Secondly, services of blockchain may sensibly decrease the significance of intermediaries, fulfilling the functions of storage and information safekeeping more effectively. The transparency between customers may change the practice of business making, minimizing the transaction cost. Banks, stocks, and other financial institutions have an aspiration to learn the technology and adopt their activity for new requirements. Many banks are constructing blockchain laboratories for testing and verifying new technologies making their own instruments based on progressive technology. Thirdly, the technology of blockchain is considered as a new channel for investments and this also favorizes for digital freedom. The crowdfunding based on blockchain technology permits small-sized firms to attract funds for future developments. This situation creates a paradoxical situation when the idea has a cost bigger than funds for its realization. Both the transparency and the other features make this way very popular among startups and existing business. The blockchain is very useful for IT technologies because IT is traditionally supporting and automatized business. Blockchain technology is opening a new era in digital freedom because of the possibilities analyzed above. The blockchain technologies are taking place not only in financial sector but in other sectors of economy and social life. In Holberton School in California the blockchain technology in verifying student assessment sheets and other educational documents was realized. This process has begun in 2017 (The Holberton School 2017). In health care also, we can find the use of blockchain technology using it in document turnover. But for the modern period the sensible risk regarding cryptocurrencies may be observed in a financial aspect. In FATF reports and in International Monetary Fund papers attention was paid to the risks of money laundering in cryptocurrency use. Positive aspects making digital freedom and resulted from several features of cryptocurrencies being as follows: the availability due to the open code and it means that it can be bought by any person; anonym character of transactions and it means that there is now information about the owner; decentralized character of turnover and it means that there is not any central financial organization being in charge about that matter; the inflation defense; the transparency of the operations; minimal commission for any transaction. But risks are also available, and they are also together with positive factors. Negative aspects are every day a high level of volatility and very sensitive to many factors; relatively low speed of transactions; legislation is not properly adjusted; low level of information defense because in case when you lost a password there is impossible to renew access to the wallet and all funds will be irrevocably lost; the consequent decreasing the profitability in mining crypto, and it means that more transactions more expenses. It is important to underline that in such situation's cryptocurrency is unable to fulfill all main functions of money, especially as the facility of exchange, the treasury instrument, etc. The limitation done by the computer program does not allow to use the crypto as a universal facility of change. The sensible level of volatility in exchange procedure against fiat money makes that process ineffective.

The same factor does not allow to use crypto as a calculation unit and it is impossible to use crypto in investment projects. But today the development of digital freedom gives us a hope for future stable crypto. The attractive factor of crypto is explained as the type of private money. The great scientist and researcher Friedrich fon Hayek analyzed this phenomenon in his book (Hayek, 1976). Scholars proposed an absolutely new approach to freedom through the denationalization of money. An effective monetary policy can be based on competitive behavior of currencies. Those currencies have their turnover in parallel mode and the currency can be considered as a usual consumer good and this good must be fulfilled on a market base. Only competition may filter bad currencies and bring them away from the market and save the best ones. So, only the best currencies filtered by the market and tested for long period of time can fulfill the role of money and be able to make all functions belong. The first attention must be paid to the capability to save the money cost, i.e., to have a stable rate with predictable fluctuations in a real and convenient corridor. The scientist said that when private money is in turnover it will not be influenced by nonmarket factors, including some resolutions of state boards. Hayek raised questions and problems very actual for digitalization and freedom problems right now. He offered to avoid the negative influence of the state through the mechanism of private money.

5 Conclusion

Digitalization is one of the most important features of the modern period and this category is in all aspects of life in any city or country. Freedom has a tendency to be much stronger and more multifunctional. Globalization and modernization freedom provide a new potential for growth. I can underline several main aspects of digitalization of our life, and they are innovation, banking sector, new technologies, and cryptocurrency as the highest level of digital freedom in twenty-first century. The prosperity of the world is strictly depends on what the civilization planning to fulfill and how it can be realized. According to the analyses given, it is necessary to stress that any progress is unable without freedom and digitalization. So, digitalization and freedom are both sides of one medal. It is very important to have a synergy in developing digitalization and freedom and the coming progress must include the digitalization and freedom in the first range.

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