

MONITORING OF DIGITAL TRANSFORMATION RISKS AS A KEY POLICY TO PREVENT FUTURE FINANCIAL CRISES

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Abstract

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The digital transformation of finance has been significantly facilitated by the COVID-19 pandemic, and it has become the dominant trend and the driving force of development in the upcoming years. The digital transformation brings not only benefits to financial markets, people, companies, and institutions, but it also results in dramatic changes of the underlying risks. The nature, mechanisms, and scale of financial crises are bound to change substantially. The paper develops a new, forward-looking approach to financial crises research. We build further upon the multidisciplinary research agenda on digital transformation by Verhoef et al. (2021). Achieving a bright digital future requires knowing and managing the adverse effects of digitalisation (Clim, 2019; Dickson, 2019; Gimpel & Schmied, 2019). Our literature search has not found any studies on digital transformation risks as a key policy to prevent future financial crises. The purpose of this paper is to examine the existing system of risks monitoring, to analyse changes in risks due to the digital transformation in finance, and to provide policymakers with insights regarding the related evolution of risks. This paper is a policy analysis type of research containing a systematic overview of risk assessment reports at the global and the EU levels.

Keywords: Financial Crisis, Digital Transformation, Risks of Financial Systems, Risks Monitoring

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1. INTRODUCTION

Risks of financial systems are a matter of key importance for policy-makers. Consideration of risks is the primary element for financial crises

understanding and ensuring financial stability. One possible approach to the research of financial crises consists of a retrospective analysis of historical data. For example, such an approach allows studying the impact of different types of past financial crises

(currency, banking, and debt) on the income of the poor during the crisis time (Nikoloski, 2011; Rewilak, 2017).

Meanwhile, as of now the financial system, and more generally the whole society, passes a unique point of its spiral development. The vector of evolution is defined by the trend of the digital transformation in all areas of human activities. The digital transformation has been significantly facilitated by the COVID-19 pandemic, and it is going to become the dominant trend and the driving force of development in the upcoming years.

The importance of digital transformation can be illustrated by Europe's example. The digital decade was announced in Europe in March 2021 (European Commission, 2021). The policy program sets a vision, targets, and avenues along four dimensions, which cover nearly every aspect of society: 1) digitally skilled population and highly skilled digital professionals; 2) secure and substantial digital infrastructures; 3) digital transformation of businesses; and 4) digitisation of public sectors.

This tremendous digital transformation will have risk implications and limit the applicability of historical experience due to fundamental changes in functionality of the financial system, as well as due to the transformation of the existing and the appearance of new risks. The nature, mechanisms, and scale of financial crises are bound to change substantially.

Under these circumstances, the importance of forward-looking studies of risks associated with the financial systems increases considerably. Such studies that would focus on the new characteristics of risks launched by the ongoing digital transformation would naturally supplement the historical (i.e., backwards-looking) approach to research.

This paper is a policy analysis type of research. The purpose of this paper is to examine the existing monitoring of risks associated with the financial system, to analyse changes in risks due to the digital transformation in finance, to provide insights regarding the related evolution of risks, which could be used by policy-makers for monitoring of risk and other purposes, including tracking the impact of macroeconomic shocks and designing policies that protect the more vulnerable groups in times of financial crises. Our findings show that the monitoring system established by the policy-makers remains to be mainly focused on monitoring the financial system risks from the perspective of the traditional risks paradigm (credit, market, operational, etc.). Risks associated with the digital transformation of the industry are still monitored in a fragmental way. Recommendations on new indicators, changes in the risk monitoring system, and other policy implications are provided in a risk-by-risk breakdown. The paper's contribution is a systematic overview of risk assessment reports at the global and the EU levels. Furthermore, we emphasize that in the digital space, all geographical locations are equally distant. National and regional regulatory regimes might not be able to properly address risks of the digital finance. Thus, to ensure proper digital transformation risks monitoring and prevention of future financial crises, global cooperation between regulatory authorities shall be

improved by using common methodologies, consistent risk indicators, and unified databases.

The remainder of the paper is structured as follows. Section 2 highlights the literature review, whereas. Section 3 addresses various aspects of the research design, including data, and research methods. Section 4 presents a critical review of the existing risk monitoring system developed by policy-makers from the perspective of to what extent it incorporates monitoring of risks related to the digital transformation. The assessment is performed at two levels: global worldwide and European level of risk monitoring. Section 5 provides discussion and policy implications of the research, whereas Section 6 underlines the main conclusions of the study.

2. LITERATURE REVIEW

Numerous academic works study the safety and soundness of the global financial system as well as issues related to systemic risk reduction and relevant policy measures and regulatory reforms. A structured comprehensive overview of post-crisis regulatory research publications can be found, for example, in Meier, Rodriguez Gonzalez, and Kunze (2021).

The empirical studies on financial crisis and poverty can be classified as the past event study literature. For example, by using data on 187 banking crises in 126 countries over the period 1970–2009, Van Dijk (2013) examined the impact of a crisis on the economy and the financial sector as well as on health, education, poverty, and gender issues.

Another example of such empirical study is Nikoloski (2011), which estimated the aggregate impact of financial crises on poverty by employing a comprehensive panel dataset on 90 low and middle-income countries for almost 300 banking, currency, and debt crises identified in the past. A similar approach can be found in Rewilak (2017), who empirically investigated the impact of financial crises on the income of the poor by using annual data for 61 countries from 1973 to 2011.

Chen and Yeh (2021) complement the event study literature by investigating the impact of the recent COVID-19 shock on stock market performance by providing insights into both the pandemic impacts and the policy effects of monetary authority on industrial portfolio performance. Meanwhile, all publications related to the event study literature define the study object in the past.

Digital transformation is an ongoing innovative process with implications for all areas of human activity. Digital transformation and resultant business model innovation have fundamentally altered consumers' expectations and behaviours, putting immense pressure on traditional firms, and disrupting numerous markets. These wide changes increased the importance of transdisciplinary studies with respect to digital transformation. A multidisciplinary research agenda on digital transformation (including the following research topics: phases of digital transformation, digital resources, organization structure, digital growth strategies, metrics, and goals) is proposed by Verhoef et al. (2021).

Galaz et al. (2021) bring together previously disconnected research fields (i.e., studies of the wider social and economic implications of artificial intelligence (AI), research on systemic risk, and the sustainability sciences) to help guide future research, and inform current policy debates about the governance of AI. We conclude by posing broadly formulated research questions as a way to lay the foundation for transdisciplinary work across these diverse and until now poorly connected strands of research.

In contrast to the event study literature, in many cases the literature on digital transformation is forward-looking. Using as a starting point the importance of advanced technology products in the global production and trade, a big layer of the research literature devoted to the digital transformation is primarily focused on the advantages of the new innovative technologies and leave the associated risk beyond the scope of the studies. Wysokińska (2021) shows that leading technologies can allow Sustainable Development Goals (SDGs) to be achieved faster and more effectively. For these purposes, it is necessary to eliminate the persistent, significant income differences between developing and highly developed countries and disparities in access to the use of innovative solutions (including social innovation). These studies are very important but shall be complemented by digital risk-oriented studies as well.

Digital transformation is expected to bring greater tangible and intangible value, but changes do come with certain costs and risks, sometimes unforeseen. Achieving a bright digital future requires knowing and managing the adverse effects of digitalisation (Reddy & Reinartz, 2017; Ciurak, 2018; Clim, 2019; Dickson, 2019; Gimpel & Schmied, 2019). Meanwhile, our literature search has not found any studies on digital transformation risks as a key policy to prevent future financial crises, as well as an overview of risk monitoring system established by policy-makers from digital risks monitoring perspective.

3. RESEARCH METHODOLOGY

The choice of the research method is determined by the type of the research question. The conventional quantitative empirical methods are not applicable due to the forward-looking focus of the research question. The econometric modelling methods are concentrated on past crises and past experience. They do find causalities and provide explanations to the performance of the dependent variables, but for the past performance, i.e., in situations, which already took place.

Under the circumstances of the innovative digital transformation of finance, the common assumption — the past performance may serve as an indication of the performance in the future, which constitutes the core basis for the applicability of the empirical methods, is not suitable anymore. It is because of the radical changes in underlying risks, which are introduced by the digital transformation. The nature of risks facing the financial system depends on the functionality of the financial system, i.e., technologies applied by the incumbent financial institutions, organization of business processes, characteristics of products

and services provided to customers, channels of financial products and services delivery, etc. The comprehensive historical multi-country datasets, which form the basis for retrospective empirical studies, are not relevant to the research question of the current study. Various reports (regular and ad-hoc) published by policy-makers were used as inputs for the research.

The paper develops a new approach to financial crises research and contributes to the retrospective research methods of financial crises. It shifts the research considerations to the future as opposed to the analysis of historical phenomena.

In connection with this, a qualitative three-stage research method was chosen. The first stage includes a critical review and assessment of the existing risk monitoring system developed by policy-makers. The risk monitoring system is examined from the perspective of to what extent it incorporates monitoring of risks related to the digital transformation. Digital transformation is an ongoing process, which develops over time and, in particular, results in the appearance of new characteristics of risks. Risks associated with digital transformation are becoming progressively pronounced. Timely recognition of these new risks and inclusion of them into the monitoring system is of great importance for ensuring financial stability and financial crisis prevention. Our literature search has not found any such concise overview that has already been done.

The second stage of the research incorporates analyses of ongoing trends introduced by the digital transformation in the financial system, as well as the extrapolation of these trends to the future. One of the key questions addressed at this stage is: *What is the current profile of the risks undertaken by the financial intermediaries for income generation purposes and how is this profile going to change due to the digital transformation of finance?*

At the third stage, risk implications of the digital transformation in finance were derived and structured taking into account the fundamental changes to be introduced in the functionality of the financial system by the digital transformation. The study spreads to the financial system clients and provides considerations of the advances in the corporate governance principles in the digital age, potential changes in the companies' business models due to digital transformation, and reassesses basic principles of doing business with respect to the data-driven economy.

4. RESULTS: MONITORING OF DIGITAL TRANSFORMATION RISKS

4.1. Global risk reports

The World Economic Forum engages the foremost political, business, cultural, and other leaders of society to shape global, regional, and industry agendas. Since 2006, on an annual basis, the World Economic Forum publishes a report on major global risks, which require societal cohesion and global cooperation to resolve them. In its first report of 2006, the Global Risks Report sounded the alarm on pandemics and other health-related risks. That year, the report warned that the lethal flu, which spread would be facilitated by global travel patterns and

uncontained by insufficient warning mechanisms, would present an acute threat. The 16th edition of the World Economic Forum's Global Risks Report of 2021 focuses on the risks and consequences of widening inequalities and societal fragmentation. As emphasized in the preface of the Report, disparities in health outcomes, technology, or workforce opportunities are partially the direct result of the dynamics the pandemic created, and partially of the already-present societal divisions that have widened, straining weak safety nets and economic structures beyond capacity. Whether the gaps can be narrowed will depend on the actions taken in the wake of COVID-19 to rebuild with a view towards an inclusive and accessible future. The gap between the "haves" and "have-nots" will widen further if technology access and ability remain disparate (World Economic Forum, 2021).

The 2021 Global Risks Report presents the aggregated results of a comprehensive survey, in which respondents were asked to assess the likelihood and the impact of individual risks. The risks are assessed against five dimensions: economic, environmental, geopolitical, societal, and

technological. The top risks identified in the Global Risks Report 2021 are presented in Table 1 below.

The definitions of the top technological risks, which have been defined in the World Economic Forum Report, are the following:

- *Digital power concentration* — concentration of critical digital assets, capabilities, and/or knowledge by a reduced number of individuals, businesses, or states, resulting in discretionary pricing mechanisms, lack of impartial oversight, unequal private and/or public access, etc.

- *Digital inequality* — fractured and/or unequal access to critical digital networks and technology, between and within countries, as a result of unequal investment capabilities, lack of necessary skills in the workforce, insufficient purchase power, government restrictions and/or cultural differences.

- *Information technologies (IT) infrastructure breakdown* — deterioration, saturation, or shutdown of critical physical and digital infrastructure or services as a result of a systemic dependency on cyber networks and/or technology: AI-intensive systems, the Internet, hand-held devices, public utilities, satellites, etc.

Table 1. Top global risks identified by the World Economic Forum in 2021

<i>Top risks (and their risk dimensions) by likelihood</i>	<i>Top risks (and their risk dimensions) by impact</i>
1. Extreme weather (<i>environmental</i>)	1. Infectious diseases (<i>societal</i>)
2. Climate action failure (<i>environmental</i>)	2. Climate action failure (<i>environmental</i>)
3. Human environmental damage (<i>environmental</i>)	3. Weapons of mass destruction (<i>geopolitical</i>)
4. Infectious diseases (<i>societal</i>)	4. Biodiversity loss (<i>environmental</i>)
5. Biodiversity loss (<i>environmental</i>)	5. Natural resource crises (<i>environmental</i>)
6. Digital power concentration (<i>technological</i>)	6. Human environmental damage (<i>environmental</i>)
7. Digital inequality (<i>technological</i>)	7. Livelihood crises (<i>societal</i>)
8. Interstate relations fracture (<i>geopolitical</i>)	8. Extreme weather (<i>environmental</i>)
9. Cybersecurity failure (<i>technological</i>)	9. Debt crises (<i>economic</i>)
10. Livelihood crises (<i>societal</i>)	10. IT infrastructure breakdown (<i>technological</i>)

Source: World Economic Forum (2021).

As the 2021 Report stresses, "a widening digital gap can worsen societal fractures and undermine prospects for an inclusive recovery. Progress towards digital inclusivity is threatened by growing digital dependency, rapidly accelerating automation, information suppression and manipulation, gaps in technology regulation and gaps in technology skills and capabilities" (World Economic Forum, 2021, p. 8).

The risks imposed by the digital transformation had been highlighted by the World Economic Forum in the previous years as well: those included data fraud or theft, cyberattacks, and IT infrastructure breakdown. Digital power concentration and digital inequality are the new risks added in 2021. We may conclude that a growing number of technological risks is observed.

The Financial Stability Board (FSB) performs the regular monitoring of global trends, risks, and innovations of non-bank financial intermediation. The monitoring report, which is a key part of FSB's efforts to enhance financial system resilience, analyses the following financial stability risk metrics (Financial Stability Board, 2020):

- credit intermediation;
- maturity transformation;
- liquidity transformation;
- leverage.

The aspects of digitalisation and new risks due to reliance on new digital processes are discussed among the innovative trends in the non-bank financial intermediation:

- crypto-asset-based lending was reported in nine jurisdictions;

- digital-only non-banking financial companies are becoming involved in credit intermediation;

- consumer credit provided by FinTech companies, which credit granting process is supported by machine learning, allowing near-instant credit risk assessment and personalised offerings.

In the FSB working agenda there are topics relating to the financial stability, regulatory and supervisory implications of FinTech, the use of artificial intelligence and machine learning, RegTech, SupTech, and BigTech, as well as the reporting of cyber incidents for regulatory purposes (Financial Stability Board, 2021).

The International Monetary Fund (IMF) provides periodic assessments of global prospects in its regular reports, in order to maintain stability and prevent crises in the international monetary system. The IMF Global Financial Stability Report assesses global capital markets and financial imbalances and vulnerabilities that pose potential risks to financial stability. In the report, the financial vulnerabilities of the global financial system are elevated across the following dimensions: leverage, liquidity, maturity, and currency mismatches (International Monetary Fund, 2021). Concerning the digital transformation, it was noted that:

- The pandemic will likely induce structural changes and digital transformation in many economies.

- Fiscal policies should enable a green, digital, and inclusive transformation of the economy.

The World Bank actively helps countries share and apply innovative knowledge and solutions to the challenges they face. There are many reports on digital technology published by the World Bank (for example, World Bank, 2016, 2018). In 2016 the World Bank introduced the Digital Adoption Index (DAI), which is a worldwide index that measures countries' digital adoption across three dimensions of the economy:

- people (expanding opportunities and improving welfare for people);
- government (the increasing efficiency and accountability of service delivery for the government);
- business (increasing productivity and accelerating broad-based growth for business).

World Development Report 2021: Data for Better Lives differs by focusing on how the data, rather than the adoption of digital technology, can improve the lives of poor people (World Bank, 2021). The report addresses the tension between the tremendous potential of using data employing digital innovative technologies to improve the lives of poor people and the downsides of this opportunity, which can harm individuals, businesses, and societies¹.

4.2. European and industry level risk reports

The European Commission (EC) monitors Europe's overall digital performance and tracks the progress of EU countries in digital competitiveness by the Digital Economy and Society Index (DESI), which is published on an annual basis.

The DESI is composed of five principal dimensions, each divided into a set of sub-dimensions, which are in turn composed of individual indicators (European Commission, 2020a). The DESI dimensions are:

- connectivity (types of broadband connection);
- human capital (basic and advanced skills);
- use of the Internet (content, communication, transactions);
- integration of digital technology (business digitisation, e-commerce);
- digital public services (eGovernment, eHealth).

The digital transformation in finance is monitored by the e-Banking indicator, which captures the propensity of Internet users to perform online banking transactions (% individuals who used the Internet in the last three months).

The European Systemic Risk Board (ESRB) publishes reports on potential systemic risks arising in the financial sector on a regular and ad-hoc basis. In the latest available regular ESRB Risk Dashboard (European Systemic Risk Board, 2021a), which is prepared in cooperation with European Central Bank, systemic risks are analysed against the following dimensions:

- interlinkages and composite measures of systemic risk;
- macro risk;
- credit risk;
- funding and liquidity;

- market risk;
- profitability and solvency;
- structural risk;
- risk related to central counterparties.

Risks related to digital transformation are not presented among a set of quantitative and qualitative indicators of systemic risk in the EU financial system.

The ESRB also publishes regular reports on potential EU non-bank financial intermediation risks. Reports aim to consider a range of systemic risks and vulnerabilities related to non-bank financial intermediation, including those related to interconnectedness, liquidity, and leverage. The monitoring is performed in several breakdowns: developments of main aggregated indicators; entity-based monitoring (investment fund sector and other financial institutions); activity-based monitoring (derivatives, securities financing transactions, securitisation).

EU non-bank financial intermediation risks are combined by the ESRB as follows (European Systemic Risk Board, 2020a):

- risk-taking, liquidity risk, and risks associated with leverage;
- interconnectedness and the risk of contagion;
- activity-related risks in derivatives and securities financing transactions;
- remaining gaps in data and risk metrics.

The risks associated with the digital transformation are considered in the report in the context of:

- So-called "global stablecoins", which are the second generation of crypto-assets, are focused on addressing the high volatility common to many crypto-assets. They are global in nature, create promising opportunities and as a result can leverage a large customer base, actively involved in the cross-border transaction. But, by doing this, stablecoins also create new risks for customers and the financial system as a whole. Risk mitigating mechanisms should be implemented in all components of the ecosystem of stablecoin arrangements (issuing stablecoins, managing the underlying assets, the transfer infrastructure, etc.).

- Faced with the rapid and global digitalisation and technological advances, policymakers and regulators will have to continue to monitor and coordinate closely.

- The continued transition towards automated, digital operations, algorithmic trading, the automation of transactions tailored to customer preferences supports the strong growth of the European Exchange-traded fund (ETF) market and involvement of that a growing number of institutions, which are willing to trade, as well as related risks.

In ad-hoc ESRB reports risks related to the digital transformation are considered from both perspectives:

- as a source of new risk, in particular, cyber risk (European Systemic Risk Board, 2020b);
- as a mitigation tool for existing systemic risks. In particular, risks related to the profitability and resilience of banks due to the prolonged environment of low (and even negative) interest rates can be addressed by banks' digital transformation and improving cost efficiency (European Systemic Risk Board, 2021b).

¹ See also an earlier research on this from Thales Group which concluded: "Organisations keen to gain a competitive edge through digital transformation are putting their data — and potentially their customers — at risk" (Dickson, 2019, p. 3).

The European Central Bank (ECB) monitors financial stability in line with its mission’s objective to keep prices stable in the euro area. The Financial Stability Review is published by the ECB on a semiannual basis and analyses potential risks to financial stability. In the latest available Financial Stability Review (European Central Bank, 2021) the main highlighted trends are related to increasing concentration of risk in more vulnerable sectors and countries; increasing signs of asset quality deterioration; corporate zombification as post-pandemic risks in the euro area; vulnerabilities to sharp increases in interest rates; climate-related risks to financial stability, etc.

The digital-related risks are considered in the following context:

- Given the low interest rate environment and profitability challenges may limit the required digital transformation.
- Crypto-assets are still not used widely for payments in the EU, so financial stability risks appear limited at present.
- Cyber incidents reported to the ECB increased mainly driven by incidents with malicious intent.

The European Banking Authority (EBA) is an independent EU Authority with its overall objectives to maintain financial stability in the EU and to safeguard the integrity, efficiency, and orderly functioning of the banking sector. The EBA publishes the Risk Dashboard report, which summarises the main risks and vulnerabilities in the banking sector in the EU by looking at the evolution of risk indicators among a sample of banks across the EU. The Risk Dashboard is prepared quarterly and includes indicators set up in

four “classical” risk assessment dimensions: solvency, credit risk, and asset quality, market risk, profitability, as well as liquidity, and funding.

In the latest available Risk Dashboard (European Banking Authority, 2020) the risks of digitalisation in the EU banking industry are discussed in the context of operational resilience:

- Phishing attempts and other types of cyberattacks are becoming more common.
- Due to the increasing share of digital-savvy clients and remote working banking staff, technology-related disruptions might have a significant impact.
- The increase in remote customer onboarding may expose banks to additional money-laundering and terrorist financing risks, as well as reputational risks.

The European Insurance and Occupational Pensions Authority (EIOPA) promotes a sound regulatory framework for and consistent supervision of insurance and occupational pensions sectors in Europe. In the regular EIOPA Risk Dashboard risks are assessed in the following breakdown: macro risks, credit risks, market risks, liquidity and funding risks, profitability and solvency, interlinkages and imbalances, insurance (underwriting) risks, market perceptions (European Insurance and Occupational Pensions Authority, 2021). There are no special considerations for digital-related trends in this report. Meanwhile, the matters related to digital transformation are analysed in some other reports and publications. For example, to assess the risks and key vulnerabilities for the insurance sector, EIOPA conducted a survey among national competent authorities (see Table 2 below).

Table 2. Top risks for insurance and occupational pensions sectors

<i>Top six risks in terms of materiality for the insurance sector</i>	<i>Top six risks in terms of materiality for the occupational pensions sector</i>
Macro risks	Macro risks
Market risks	Market risks
Credit risks	Profitability/Portfolio performance
Profitability and solvency risks	Credit risks
Risks related to digitalisation	Reserve and funding risks
Underwriting risks	Risk related to digitalisation

Source: European Insurance and Occupational Pensions Authority (2020).

The inclusion of risks related to digitalisation into the top risks was mainly triggered by cybersecurity risk. At the same time, the number of cybersecurity insurance products is increasing. This trend contributes to mitigating the negative effects of cyber-attacks on financial stability.

The European Securities and Markets Authority (ESMA) contributes to safeguarding the stability of the EU’s financial system by enhancing the protection of investors and promoting stable and orderly financial markets. The ESMA Risk Dashboard provides an assessment of risk in the following categories: liquidity, market, contagion, credit, operational and assessment of the following risk drivers: macroeconomic environment; interest-rate environment; sovereign and private debt markets; infrastructure disruptions; political and event risks (European Securities and Markets Authority, 2021a).

In addition to the traditional framework of risks, ESMA Report on Trends, Risks, and Vulnerabilities (European Securities and Markets Authority, 2021b) provides financial innovation

scoreboard. The ESMA financial innovation scoreboard is a framework that provides a ranking relating to product financial innovations that require deeper analysis and potential policy responses.

The ESMA financial innovation scoreboard includes the following dimensions:

- crypto-assets;
- distributed ledger technology;
- machine learning, artificial intelligence, and big data;
- the cloud and digitalisation;
- regulatory and supervisory technology (RegTech and SupTech);
- crowdfunding.

The Joint Committee (JC) has been established by the three European Supervisory Authorities (EBA, EIOPA, and ESMA) as a forum to strengthen cooperation between the authorities.

Under the umbrella of the JC, the European Forum for Innovation Facilitators was established. The forum provides a platform for supervisors to share experiences from engagement with firms

through innovation facilitators (regulatory sandboxes and innovation hubs), to share technological expertise, and to reach common views on the regulatory treatment of innovative products, services, and business models, overall boosting bilateral and multilateral coordination.

The JC publishes Report on Risks and Vulnerabilities in the EU Financial System regularly (Joint Committee, 2020, 2021). In these reports, the JC highlights that rapid technological developments in the area of crypto-assets and distributed ledger technology accompanied with the changes in business processes of financial institutions due to the COVID-19 pandemic result in more pronounced information and communications technology risks, including cybersecurity risks.

5. DISCUSSION AND POLICY IMPLICATIONS

The review of the existing risk monitoring system established by policy-makers provided in Section 4 and summarized in Appendix, Table A.1 allows the following assessment:

- Although policy-makers express more and more concerns that risks associated with the digital transformation are becoming progressively pronounced, the monitoring system remains to be mainly focused on monitoring the financial system risks from the perspective of the traditional risks paradigm. Risks associated with the digital transformation of the industry are monitored in a fragmental way, mainly through topic-focused ad-hoc reports.

- There are numerous monitoring reports prepared by different bodies for various purposes, which are based on disparate sets of data. As a result, reports provide to some extent a comprehensive but narrowed view on risks.

- The typical frequency of regular reports is quarterly, semi-annual or annual. The frequency of macroeconomic trends monitoring can be assessed as adequate. Meanwhile, reassessment might be needed in case of generation of demand needs by fast changes in the financial system and supply capabilities as a result of the implementation of new reporting tools in the process of the digital transformation.

In order to identify the requirements for monitoring of risks associated with the digital transformation in finance, an analysis of trends and properties of structural changes triggered by digital technologies is needed.

“Going digital” is becoming a dominant unavoidable trend of social development. The trend is facilitated by policy measures and as a result, digital innovations are becoming more and more pervasive, and there is hardly a single aspect of life that is not affected by digital technologies.

The research literature (Verhoef et al., 2021) identifies three phases of using digital technologies (ordered from less to more advanced):

- *digitization* (the encoding of analog-form information onto a digital format);
- *digitalisation* (using of IT technologies to alter existing business processes);
- *digital transformation* (the most pervasive phase, which affects the whole company and its ways of doing business).

From the risk perspective, the evolution of the financial system to digital finance implies the evolution of risks as well. Thus, the risk monitoring structure should include digital transformation progress indicators. Examples of such progress indicators may include a share of digitally generated revenue, a share of digitally distributed products and services, a share of digitally onboarded clients, a share of financial institutions using cloud computing, etc.

Three stages of “going digital” are applicable to all industries. The financial service industry is in an advanced position in comparison with many other industries. The current status of finance can be assessed as a transition from the “digitalisation” stage to the “digital transformation” stage. The digital transformation affects the whole company, organization of business processes, corporate governance, the ways of doing business in general. At the industry level, the process of digital transformation can be monitored by soft indicators, like a share of financial institutions having a digital transformation strategy, the inclusion of issues related to digital technologies into the agenda of the board of directors.

It should be made clear that “going digital” is a one-way transformation process. There is no chance to switch back to old technologies. For example, when a bank closes its physical branch network and starts using Internet-based distribution channels for providing products and services to clients, in case of a temporary disruption of digital technologies the bank will not be able to restore the branch network within a reasonable time.

All three global technological risks, highlighted by the World Economic Forum (see Subsection 4.1), are in substance refer to risks of not having access to new digital technologies. They are differed by a reason of access disruption:

- *Digital inequality* — risks of unequal access to critical digital networks and technology. The digital transformation of the economy might increase the gap between developed and poor countries. Countries, which start the process of digital transformation later or at a slower pace, will face a growing inequality gap in comparison with more advanced economies. This statement is a simple consequence of a basic exponential over time development model, an assumption regarding higher exponential power as a result of the digital transformation and properties of the exponential function. This risk can be monitored by progressing indicators set up at a country level.

- *Digital power concentration* — risks of access to digital technologies disruption due to someone’s discretionary decision. The risk can significantly contribute to the systemic risk of the financial services industry. The risk can be monitored by technology reliance indicators.

- *IT infrastructure breakdown* — risks of a systemic dependency on an IT technology. Once we started to rely on digital technology we cannot stop doing this. Any interruption or limited access to technologies constitutes a material risk for business. The risk of IT infrastructure breakdown can be classified as a type of operational risk² under the conventional risk management framework.

² Operational risk is defined as the risk of loss resulting from inadequate or failed internal processes, people and systems or from external events. This definition includes legal risk, but excludes strategic and reputational risk (Basel Committee on Banking Supervision, 2011).

The risk should be monitored at an entity and industry levels. The risk can be addressed by the duplication of crucial importance systems, business contingency planning, and other operational resilience measures.

We live in a three-dimensional space evolving over time. However, there is no “physical distance” dimension in the space of the digital world. All geographical locations are equally distant. One of the priorities of the European digital finance strategy is to tackle fragmentation in the digital single market for financial services, thereby enabling European consumers to access cross-border services and helping European financial firms’ scale up their digital operations (European Commission, Financial Stability, Financial Services and Capital Markets Union, 2020b). National and regional regulatory regimes are not adequate to address globalization risks in the world of digital finance. The risk can materialize in a geographical location and spread all over the world. There are two main systemic risk distribution channels: liquidity channel and insolvency channel (Vanini & Broumandi, 2018). Both channels remain after the digital transformation in finance. In connection with this, cooperation between regulators should be improved (unified regulations, common databases, consistent monitoring, using AI for supervision, etc.).

Time is also altered by digital transformation. Many business processes are executed faster. A digital transforming economy can be approximated by a basic two-segment model: a traditional (not transformed yet) part of the economy with a normal speed of time; and a digitally transformed part of the economy, in which time is ticking faster. The phenomenon could be illustrated by the following example. Digital giant Google grew by about 20% per year (in terms of total assets); meanwhile, the USA’s GDP grew by about 4% per year. This could be reworded as Google experiences “five annual cycles per year” or, in other words, Google experiences fivefold faster time. The co-existence of traditional and transformed companies in the same economy will challenge the most fundamental principle of finance — the time value of money: the innovative companies can accept a higher discounting rate, so investment flows will be forwarded to these companies.

The traditional multi-layer analysis of risk at the level of economy, industry, and a particular company is not fully applicable with respect to the digital transformation process because the financial services industry boundaries are disappearing. The dilution of boundaries of the financial services industry was caused by the appearance of the FinTech companies, emerging of new forms of intermediation in the financial system (open banking, banking as a service (BaaS)), penetration into financial markets companies from other industries (Remolina, 2019). This phenomenon takes place for other industries in the process of digital transformation as well. Platform companies operate across multiple industries (transportation, finance, healthcare, food, etc.) and use networks to deliver new business models and disrupt incumbents. From the risk perspective, this trend implies a possibility of imagination of financial system risks outside formally regulated and supervised perimeter of licensed companies.

Even corporations as a form of business organization are questionable. The rise of digital technologies is forcing companies to reconsider how they organize themselves. They cannot be static hierarchies anymore. Digital technologies have changed consumer behaviour (consumers do not appreciate mass production anymore). They also change the expectations of employees and investors (the owners of corporations).

A “linear” business model traditionally adopted by corporations whereby the company gathers together various “inputs” (raw materials, components, or knowledge/information), which are then combined, thus adding value is not sustainable anymore. Digitalisation supports increasing returns to scale and scope in the form of network effects. Corporations have to interact with their customers. Companies need to become innovation machines, and this means that every firm needs to become a “tech” company and a “media” company (Fenwick & Vermeulen, 2019).

The rise of a platform-based business model promises a more decentralized, efficient, and less formal style of business management. Examples include a “social” platform (Facebook, Instagram), an “exchange” platform (Amazon, Airbnb), a “content” platform (YouTube, Medium), a “software” platform (GE’s Predix, Microsoft’s GitHub), or even a “blockchain” platform (Ethereum, EOS) (Fenwick & Vermeulen, 2019). A technology-driven ecosystem is not simply a “company that uses technology”. A technology-driven ecosystem adopts a business model that is characterized by economies of scale and network effects, deriving from the centrality of software in all of its operations.

Decentralized, high-performance teams are driven by a culture of entrepreneurship, and tech-driven innovations are the focus of this style. The competitive advantage of companies is not determined internally anymore but by the strength of partners and ecosystems that they work with (Verhoef et al., 2021). Companies become complex, dynamic ecosystems comprising diverse, interacting elements. The growing complexity of interconnections and the accelerating pace of changes create a risk of losing management control by centralized bodies (or decentralized structures, like in the case of distributed ledger technology).

Any decision-making process should be supported by appropriate data available in a timely manner. It was observed during the global financial crisis 2008–2009 that financial institutions were unable to manage their risks properly and react to a fast-changing environment because of weak risk data aggregation capabilities and reporting practices (Basel Committee on Banking Supervision, 2013). These deficiencies had severe consequences to the financial institutions themselves and the stability of the financial system as a whole. Due to the digital transformation in finance, this risk becomes even more pronounced and as a consequence should be properly monitored.

From the strategic risk point of view, the high speed of the digital transformation and deep structural changes, when even core structures, processes, concepts, and principles are subject to review and reengineering, create a situation where our prior experience has limited applicability, which

in turn raises significant management challenges and introduces serious risks.

The digital technologies allow the very low marginal costs for serving additional customers and because of that facilitate the appearance of the concentrated market structures and result in a “winner-take-all” network effect. Therefore digital technologies create a huge potential for concentration risk. Concentration risk is well studied in traditional risk management. Diversification is the main tool of concentration risk mitigation, but in the world of digital finance, the concentration risk might take new features. The new systemic risk stemming from the concentration of data, i.e., market power, in the hands of dominant BigTech firms enforces the old systemic risk represented by banks that were “too-big-to-fail” or “too-connected-to-fail”.

The problem of data and market power concentration is particularly relevant for developing economies in which major companies can undermine local competition and innovation. In this context, data privacy laws can help to address the risks of data monopolies by limiting the rights of private companies regarding the collection and use of data (Sergeev, Arner, & Charamba, 2021).

One of the digitally transformed processes is the process of extracting information from data.

The process evolves from the paper-based encoding of data, where data can be processed by humans, through analog encoding to digital encoding of data, which could be processed by computers. To the human mind, big data is meaningless noise; to computers, it is an information mine (Ciurak, 2018). The ability of computers to extract systematic information out of this noise underpins the value of data in emerging society. The economy becomes a data-driven system and data becomes a new factor of economic production along with raw materials, tangible or intangible assets, and human capital. Therefore the digital transformation provides a new level of prosperity by more optimal distribution of existing resources and adding value by using data as a production factor. The related risks are presented by the cyber risk, in particular, risks of data integrity, availability, and confidentiality.

The financial intermediaries perform important economic roles like credit intermediation and maturity transformation. By undertaking what types of risks the incumbent banks can prove their economic value and generate their profits? The data published by the EU supervisors allows addressing this question.

Table 3. Aggregated statistical data of EU Banking System as of December 2019

<i>Capital requirements¹</i>		<i>Assets composition²</i>		<i>Profitability³</i>	
Liquidity risk	0%	Cash balances	8%	Net interest income	58%
Credit risk	85%	Loans and advances	64%	Net trading income	10%
Market risk	3%	Equity and debt securities	15%	Net fee and commission income	29%
Operational risk	10%	Derivatives	8%	Other income	3%
Other risks	2%	Other assets	5%		
Total	100%	Total	100%	Total	100%

Notes: ¹ Capital requirements for a particular risk to total capital requirements, %.

² Particular type of assets to total assets, %.

³ Particular income to total net operating income, %.

Source: European Banking Authority (2019a, 2019b).

From Table 3 one can conclude that the major risk undertaken by the European banks is the credit risk. The share of this risk varies in the range of 60–85% in terms of different metrics (capital allocated for a particular risk, assets, or income). The share of the market risk is much lower in the range of 5–15%. The operational risk as a rule is not undertaken on purpose, but it is unavoidable as it is embedded in all business processes of a bank. The operational risk, which occupies the range of about 10–30%, can be considered as the risk associated with fees and commissions services like processing of payments, issuance of debit cards, etc. On average investment firms have a different risk profile (Federal Financial Supervisory Authority & Deutsche Bundesbank, 2019). The indicative distribution is thereby: credit risk about 30–40%; market risk 30–60%; operational risk 10–30%.

Advances in digital technology are changing the very nature of banking, and therefore they change the characteristics of the financial and operational risks. The banking process of loan granting and credit risk undertaking is changing by the Internet peer-to-peer lending platforms (crowdlending). Diversification of credit exposures moves from an entity (bank) level to the level of particular funds provider. Due to automation of the lending process granularity of the credit exposures effectively goes to zero. Instead of having

one million euro exposure to a borrower, using a crowdlending platform, it is possible to create a portfolio of one million exposures amounting to one euro each. Algorithmic and high-frequency trading change characteristics of market risk: trading positions open just for a few fractions of a second subject to limited volatility, i.e., risk, due to limited potential for price changes during a very short period. Operational risk increases significantly due to the significantly increased number of interconnections between elements of the system and the transformation of the business processes into a digital form. Cyber risk becomes very pronounced.

Attention should be given by academics and policy-makers to the changing nature of banking risk (Broby, 2021). New indicators, which substitute risk metrics presented in Section 4 (see Appendix, Table A.1 at the end), should be introduced.

6. CONCLUSION

Digital innovations bring to the financial system incredible changes. The core concepts of the world of finance are subject to critical reassessment and modification: corporate governance principles, agency problem, time value of money, etc. New actors appear in the financial services industry: FinTech companies, mixed activity groups provide

both financial and non-financial services, the so-called process of “platformisation” in finance. New products, which are designed for funds, income, as well as risks, are enabled by digital technologies. These products are becoming data-driven, customized, and targeted. Network effects are a core part of digital finance.

These changes are not free of risks; they change the nature, complexity, and magnitude of risks anticipated by the finance institutions. These new risks, which may be characterised by higher concentration, variability of characteristics, greater spreading speed, require close monitoring because of the threats they could pose to financial stability. The monitoring system should adapt to be able to incorporate ongoing amendments in inherent risks imposed by the digital transformation in finance.

Our findings show that the monitoring system established by the policy-makers remains to be mainly focused on monitoring the financial system risks from the perspective of the traditional risks paradigm (credit, market, operational, etc.). Risks associated with the digital transformation of the industry are still monitored in a fragmental way. It is recommended to introduce into the risk monitoring framework the digital transformation progress indicators as discussed in Section 5.

There are dozens of risk monitoring reports published by regulatory authorities, some of which are presented in Appendix, Table A.1: summary overview of risk assessment reports. On one hand, it is reasonable to have a specific report designed by a policy-maker for its particular objectives. On the other hand, such an approach is not consistent with the nature of risks introduced by digital transformation. In the digital space, all geographical locations are equally distant. National and regional

regulatory regimes might not be able to properly address risks of the digital finance. Thus, to ensure proper digital transformation risks monitoring and prevention of future financial crises, global cooperation between regulatory authorities shall be improved by using common methodologies, consistent risk indicators, and unified databases.

Another finding of the study is that the current risk profile of the financial institutions, when commercial banks undertake mainly credit risk and investment firms undertake mainly a market risk for income generation purposes is going to be changed. The competition among human experts in lending and trading is substituted by the competition among lending and trading bots empowered by artificial intelligence. Various IT-related forms of operational risk, as well as concentration risk, are becoming more pronounced. The intermediary role of the traditional financial institutions is challenged by FinTech companies and distributed ledger technologies. The increased competition might be a reason for excessive risk undertaking.

The active phase of the digital transformation, dynamic appearance of new innovative technologies, and quick evolution of the related risks impose significant limitations on the research outcomes. The forecast analysis cannot be comprehensive at this stage of digital transformation due to numerous unforeseen changes. From the policy-making perspective, the implication is that the risk monitoring framework shall be designed as an evolving dynamically adjustable system. The progressively growing importance of risks associated with digital transformation presents a great challenge and an interesting scope for further research.

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APPENDIX

Table A.1. Summary overview of risk assessment reports at the global and the EU levels

Report name/Institution	Frequency of reports	Digital transformation risks/issues mentioned in recent reports
Global level		
Global Risks Report/World Economic Forum	Annual	<ul style="list-style-type: none"> Digital power concentration risk and digital inequality risk (N6 and N7 in the list of top risks by likelihood). IT infrastructure breakdown risk (N10 in the list of top risks by the impact).
Global Monitoring Report on Non-Bank Financial Intermediation/Financial Stability Board	Annual	<ul style="list-style-type: none"> New risks due to reliance on new digital processes, such as crypto-asset-based lending, credit intermediation by digital-only non-banking financial companies, consumer credit provided by FinTech companies.
Global Financial Stability Report/International Monetary Fund	Annual	<ul style="list-style-type: none"> The pandemic will likely induce structural changes and digital transformation in many economies. Fiscal policies should enable a green, digital, and inclusive transformation of the economy.
World Development Report 2021: Data for Better Lives/World Bank	Ad-hoc 2021	<ul style="list-style-type: none"> Focused on how the data, rather than the adoption of digital technology, can improve the lives of poor people and how the data can also harm people.
EU level		
The Digital Economy and Society Index (DESI)/European Commission	Annual	<p>The DESI is composed of 5 principal dimensions:</p> <ul style="list-style-type: none"> connectivity (types of broadband connection); human capital (basic and advanced skills); use of the Internet (content, communication, transactions); integration of digital technology (business digitization, e-commerce); digital public services (eGovernment, eHealth). <p>The digital transformation in finance is monitored by the e-Banking indicator, which captures the propensity of Internet users to perform online banking transactions (% individuals who used the Internet in the last three months).</p>
Risk Dashboard/European Systemic Risk Board	Annual	Risks related to digital transformation are not presented among a set of quantitative and qualitative indicators of systemic risk in the EU financial system.
EU Non-Bank Financial Intermediation Risks Report/European Systemic Risk Board	Annual	<p>The risks associated with the digital transformation are considered in the report in the context of:</p> <ul style="list-style-type: none"> So-called "global stablecoins", which are the second generation of crypto-assets, are focused on addressing the high volatility common to many crypto-assets. Risk mitigating mechanisms should be implemented in all components of the ecosystem of stablecoin arrangements. Faced with the rapid and global digitalisation and technological advances, policymakers and regulators will have to continue to monitor and coordinate closely. The continued transition towards automated, digital operations, algorithmic trading, the automation of transactions tailored to customer preferences supports the strong growth of the European ETF market and involvement of that a growing number of institutions, which are willing to trade, as well as related risks.
Systemic Cyber Risk Report/European Systemic Risk Board	Ad-hoc 2020	Cyber risks as new risks
Lower For Longer — Macroeprudential Policy Issues Arising from the Low Interest Rate Environment/European Systemic Risk Board	Ad-hoc 2021	Risks related to the profitability and resilience of banks due to the prolonged environment of low (and even negative) interest rates can be addressed by banks' digital transformation and improving cost efficiency.
Financial Stability Review/European Central Bank	Semi-annual	<p>The digital-related risks are considered in the following context:</p> <ul style="list-style-type: none"> Given the low interest rate environment and profitability challenges may limit the required digital transformation. Crypto-assets are still not used widely for payments in the EU, so financial stability risks appear limited at present. Cyber incidents reported to the ECB increased mainly driven by incidents with malicious intent.
Risk Dashboard /European Banking Authority	Quarterly	<p>In the latest available Risk Dashboard (European Banking Authority, 2020) the risks of digitalisation in the EU Banking industry are discussed in the context of operational resilience:</p> <ul style="list-style-type: none"> Phishing attempts and other types of cyber-attacks are becoming more common. Due to the increasing share of digital-savvy clients and remote working banking staff, technology-related disruptions might have a significant impact. The increase in remote customer onboarding may expose banks to additional money-laundering and terrorist financing risks, as well as reputational risks.
Risk Dashboard/European Insurance and Occupational Pensions Authority	Annual	There are no special considerations for digital-related trends in this report.
Financial Stability Report/European Insurance and Occupational Pensions Authority	Annual	The inclusion of risks related to digitalisation into the top risks was mainly triggered by cyber-security risk.
Report on Trends, Risks, and Vulnerabilities/ European Securities and Markets Authority	Semi-annual	<p>Includes the financial innovation scoreboard, which is a framework that provides a ranking relating to product financial innovations that require deeper analysis and potential policy responses.</p> <p>The ESMA financial innovation scoreboard includes the following dimensions:</p> <ul style="list-style-type: none"> crypto-assets; distributed ledger technology; machine learning, artificial intelligence, and big data; the cloud and digitalisation; regulatory and supervisory technology (RegTech and SupTech); crowdfunding.
Report on Risks and Vulnerabilities in the EU Financial System/Joint Committee	Annual	Rapid technological developments in the area of crypto-assets and distributed ledger technology accompanied by the changes in business processes of financial institutions due to the COVID pandemic result in more pronounced information and communications technology risks, including cybersecurity risks.