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RISK MAPPING AS A FORM OF BANKING IMMUNITY RESPONSE TO COVID-19 PANDEMIC

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Climate change and technological innovation expose banks to "new risks." The COVID-19 pandemic has accelerated and amplified these effects. This paper investigates how the traditional tool of the risk map can incorporate these "new risks" for banks. We develop the configuration of the risk map under the influence of the COVID-19 pandemic in the context of economy digitalization for an anonymous Bank X. We show that the risk map is still a useful tool for identifying risks in banks, appreciable for its simplicity and adaptability especially in evolving contexts. The main contribution is the construction of a methodological framework that is useful for operators and provides banking industry decision makers with a supporting tool to adequately respond to the changing environment.

Keywords: Risk management; risk map; banking industry; COVID-19 response.

JEL Classifications: G22, G17

1. Introduction

The particularly changeable external environment requires banks to adopt flexible strategies and structures that allow them to survive in a context of continuous transformation (Haeckel 1999). Banks are required to implement dynamic risk management systems capable of incorporating emerging risks and vulnerabilities (Bauer & Ryser 2004, Alexander 2019). An extensive literature shows that ICT has

significant impacts on the risk profile of banks (Berger 2003, Beccalli 2007, Delgado *et al.* 2007, DeYoung *et al.* 2007, Ciciretti *et al.* 2009, Laeven & Levine 2009, Ho & Mallick 2010, Cornaggia *et al.* 2015, Del Gaudio *et al.* 2021). Furthermore, the banking context has undergone dramatic transformations in recent years following the COVID-19 pandemic. Many authors have provided evidence of an increase in the banks' riskiness as a result of the pandemic (Rizwan *et al.* 2020, Duan *et al.* 2021, Rizwan *et al.* 2022, Twum *et al.* 2022).

Ifwealso consider the ongoing situation of climatechangeand the urgency of moving towards sustainable finance, it becomes necessary for banks to intervene in their management structures to make them adequate with respect to such new external stimuli. ESG factors determine the emergence of new risks to be mapped, monitored, and managed (Cosma *et al.* 2023). In this new scenario, supervisors and decision makers are called upon to monitor the sound and prudent management of banks, to identify possible new risks, and, where necessary, to intervene and improve the banks' ability to deal with ongoing global changes.

This paper thus investigates how banks can incorporate "new risks" into their risk management systems deriving from the massive use of ICT, under the influence of the COVID-19 pandemic. We develop a configuration of the traditional risk map tool for an anonymous Bank X. In order to develop the risk profile of the banking industry under the impacts of COVID-19, we applied the recommended approach for developing a Corporate Risk Profile (Government of Canada 2016) as well as ISO (2009) 31000:2009 Risk Management — Principles and Guidelines. We show that the risk map is still a useful tool for identifying risks in banks, appreciable for its simplicity and adaptability especially in evolving contexts.

The contributions of our paper are twofold. First, we construct a methodological framework to help banks manage risks in a continuously changing scenario. The second contribution is in providing a supporting tool for decision makers to identify and analyze prospective risks and to take them into account when establishing the priorities and the actions to be implemented.

The paper is structured as follows. Section 2 discusses the theoretical background to formulate the research hypotheses. Section 3 describes the applied methodology. Section 4 provides the empirical research results, and Sec. 5 discusses the main findings. The last section states the conclusions, implications, and future lines of research.

2. Literature Review and Hypothesis Development

Matrix tools are widely used in risk management and at the governmental level. For example, the Australian risk management "Guide for Business and Government" complements the Australian and New Zealand Standard for Risk Management, AS/NZS 31000:2009, and international standard (AUS/NZ31000:2009; MITRE Risk Management Toolkit). They are applied in public and private sectors to guide strategic, operational, and other forms of risk management. The use of such risk matrices is useful for setting priorities and guiding resource allocations (Cox 2008).

For planning strategy in the insurance industry, the respondents' inquiry for the influence of 10 competitiveness factors related to market performance, enhanced opportunities, and profitability were used: Customer care, structural changes, strategy type, marketing effort, product strategy, insurance process management, reputation, organizational redesign, expense management, distribution strength, and staff skills (Steinle & Eggers 1994, Petroni 2000). The risk map is a tool for portraying the risk analysis results (Conrow 2003); the risk matrix is the simplest method for classifying and prioritizing the risks based on the assigned risk level. With the help of the matrix, it is possible to convert subjective values into an equivalent risk level. Conrow (2003) also suggests how to solve the common problem of assigning the cardinal meaning of each matrix cell and matrix cell representation. Johnston (2003) depicted risk mapping as a two outcome model of the expected values, using a possible reward and risk to illustrate the expected monetary theory. Dell'Atti & Trotta (2016) described the stakeholders' materiality matrix, where the business risk management of the banking industry was the high priority. Dell'Atti *et al.* (2020) proposed the use of the matrix tool of Franchon & Romanet (1985) for insurance industry forecasting. Lam (2014) considered a risk-based process map to show that various risk exposures can arise in each business unit. The map shows the problem spots but requires risk quantification and reporting.

Bonini & Taatian (2021) highlighted the vulnerability of the banking sector approach to decreasing risk with the ownership of dual holders who own the bank's bonds and shares in order to simultaneously hold bank debt and equity. Brumarova *et al.* (2020) represented the resulting risk map as a union of the vulnerability dangers and preparedness maps, which are built based on coefficient analysis. They suggest that these coefficients should be based on procedures to assess quantitative and qualitative risks and summarize the necessary risk indicators to prevent the overall risk of bankruptcy. Qualitative evaluation is an expert analysis of the level of risk on loan deals, the amount of own working capital, the liquidity of assets, profitability, receivables, the volume of the enterprise's financial investments, and the probability of bankruptcy. Quantitative assessment visualizes results by using the range-ball method on indicators of financial sustainability, solvency, business activity, assessment indicators of balance sheet structure, profitability, and indicators of the probability of bankruptcy in the models of Lis, Springeyt, Conan, and Holder (Nyenno 2015).

Many authors showed the great potential of risk maps in banks (Scandizzo 2005, Colletaz *et al.* 2013, Sakti *et al.* 2018; Miao *et al.* 2022, Abduroziqovich 2023). A smaller strand of literature instead highlighted limitations and possible solutions (Schuermann 2014). A large part of the literature investigated the interconnections between banks' risk profile and ICT. The majority provide evidence that the more intensive use of technology in banks leads to growing risks (Sarma & Singh 2010, Ndlovu & Sigola 2013, Omariba *et al.* 2012, Osunmuyiwa 2013, Zanoon & Gharaibeh 2013), Sakti *et al.* 2018; Udin *et al.* 2021).

Chemmanur *et al.* (2020) presented the recent development in the fintech industry as divided into the following eight industry segments: (i) Payments and

money transfers, (ii) digital banking, (iii) digital wealth managers, including robo-advisors, (iv) capital market innovations, including algorithmic trading, high-frequency traders, and market analytics, (v) FinTech lending, including P2P and marketplace lenders, (vi) equity crowdfunding, (vii) InsureTech, which refers to innovations in the insurance industry, and (viii) PropTech, which refers to innovations in the property and real estate industry. The authors discovered that fintech companies are active in banking infrastructure, business lending, consumer and commercial banking, consumer lending, consumer payments, crowdfunding, equity financing, financial research and data, financial transaction security, institutional investing, international money transfer, payments backend and infrastructure, personal finance, point of sale payments, retail investing, and small and medium business tools. Scholtens & van't Klooster (2019) affirmed that sustainability affects bank default risk. Spitaels (2020) suggested that business model sustainability is the main risk that euro area banks will be facing.

Valverde & Fernández (2020) found out that competition between traditional banks and fintech companies is mostly generated by their inactive ability to manage information sharing. Ding *et al.* (2021) mentioned among other conclusions about COVID-19 immunity development, that the firms controlled by families showed better pandemic response in the stock price change. The same tendency is tracked as a small part of managerial ownership as a factor of resilience. Padhan & Prabheesh (2021) demonstrated the importance of a high level of macroprudential regulation, where the central banks respond more counter-cyclically by lowering policy rates to maintain stability in exchange rates and capital outflows. They showed the positive impact of counter-cyclical monetary policy along with macroprudential regulation in response to global financial shocks.

The risk map of the European Central Bank (2021) was built to illustrate the fall in euro area economic activity. Prominent downside risks to the recovery stem from potentially renewed geopolitical tensions. Financial asset prices have rebounded. High private debt-to-GDP ratios are expected, and there is a growing risk of correction in real estate markets, which cannot be neutralized by state protection measures due to surging public debt ratios and exposure to domestic government debt. Banks therefore need to ensure credit risk management, solvency, and profitability. During a pandemic, the necessity to transform the banking business model to manage the risks of overcapacity and lingering cost inefficiencies should be considered. The risk of non-bank competition was also highlighted under the impact of digitalization, with the simultaneous growth in importance of cybercrime and operational disruptions and thus concerns with IT risks and data quality management.

In summary, the literature largely agrees on the adequacy and usefulness of the risk map in banks to identify and manage risks, the banks' risk profiles have changed profoundly due to the spread of ICT, and the global COVID-19 pandemic has impacted the riskiness of banks in various ways, also amplifying technological risks. Thus, this work intends to test (i) whether the risk map can be a useful tool capable

of incorporating the changed risk profile of banks, with specific reference to technological risk in the period of the global pandemic, and (ii) whether, in a broader perspective, it can be considered as a dynamic tool adaptable to changing risk contexts. In this sense, this paper can have useful implications for both banks and decision makers in supporting risk-based decisions in contexts of high uncertainty.

3. Research Methodology

The assessment of bank risks is usually based on the assessment results of a number of parameters for each separate risk. Risk consists of two independent components: The probability of risk and the potential loss (impact). Taking into account the probability of the realization of risks/the risk occurrence and the amount of potential damage, there arises an opportunity to explore the qualitative aspects of the risk burden of the bank industry in order to apply a specific list of risk management methods. Both of these components need to be quantified in some way so that they can characterize different risks, compare them with each other, and set priorities. The absolute magnitude of each risk is not useful in itself. Therefore, it is important to determine how significant the overall risk exposure is. The list of risk priorities can be formed by constructing a risk map. Depending on the position in the list of priorities — in other words, depending on the relative value of its exposure with reference to a similar indicator of other places — adequate methods will be used to respond to risk. The quantitative approach assumes that the probability of risk can be calculated if there is a statistically relevant database of experience of similar events in the past, on the basis of which the distribution function is formed. For the distribution function, the probability, prediction, variance, confidence interval, and all other important statistical parameters can be calculated using statistical methods. The qualitative approach in the suggested structure allows for establishing a rating of estimated dangers system for banks. As there is a lack of experience for determining the weight of individual parameters, qualification risk analysis can be used.

Oncethe risk probability and risk impact aredetermined foreach identified location in the matrix, the risk impact can be calculated as the multiplied risk probabilities on its potential impact. Based on the risk, a list of management priorities is formed for deciding how to respond to risks and to provide and allocate resources for response.

Expert assessments must comply with the following requirements: Completeness, reliability, and completeness of information regarding the results of a particular bank within the integrated risk management system, identification of periods analyzed by experts, uniformity of terms of expert assessment, availability of professional competence and experience in the banking industry, objectivity, lack of personal interest in the evaluation results, and no consequences for experts depending on the results of the assessment. Expert probability estimates are applied according to the categories

Table 1. Impact assessment scale 1.

Category of consequences	Description of the category of consequences	Scope of possible consequences
Category 1	Insignificant	1–9% of revenue
Category 2	Acceptable	10–19% of revenue
Category 3	Sensitive	20–29% of revenue
Category 4	Critical	30–49% of revenue
Category 5	Catastrophic	More than 50% of revenue

Note: Developed by the authors.

of consequences. Each risk is assigned a risk probability by the expert, with "5" corresponding to the highest probability and the largest number of consequences. The recommended scales for assessing the consequences and probabilities are given in Tables 1 and 2, respectively. The following methods were used to identify and assess the risks of Bank X: Interviews, analysis of primary documents on management and financial reporting, financial and economic data, organizational structure of the bank, risk fields, and expert evaluation.

These scales are based on the subjective impressions of Bank X's potential losses by top managers and owners (experts). They demonstrate the individual's own attitudes toward risks on a dimension (criteria) of the more extreme reference point of "Category 5" for the impact assessment and the probability for this bank. In order to make this scale "honest" and not dependent on a single intuitive judgment, it was based on cumulative patterns of all the relevant decision makers' evaluations.

Risks are distributed in the cells of the map in accordance with the expected loss from their implementation and their probabilities of occurrence. The map is divided into several zones in such a way that the risks indicated in one of them are equally dangerous for the bank on the whole. Propensity for risk is classified into three zones:

(1) Categories 1–2, in which the risk is acceptable.
(2) Categories 3–4, in which it is desirable to use risk management methods.
(3) Category 5, in which risk management is a necessity.

Table 2. Probability assessment scale 1.

Probability category	Category description	Probability of risk
Category 1	Unlikely: 1 time in 5 years	Most likely will not occur (10%)
Category 2	Rare: 1 time in 4 years	Manifested rarely (20%)
Category 3	Possible: 1 time in 3 years	The probability of occurrence/non-occurrence is the same (50%)
Category 4	Frequently: 1 time a year	Most likely to appear (75%)
Category 5	Very often: >1 time per year	Probably realized (95%)

Note: Developed based on the results of an expert survey by the authors.

Depending on the level of risk, each identified risk is classified as insignificant, acceptable, sensitive, critical, or catastrophic. This classification influences the decision on how to respond to it. If the risk is considered unacceptable (the critical and catastrophic categories), the response may be to prevent or transfer the risk. If the risk is classified as undesirable, the response may be to prevent, transmit, reduce the risk, or allocate the risk with proper risk monitoring. If the risk is classified as acceptable, the response may be to preserve the risk through proper risk monitoring. If the risk is classified as insignificant, no response is required.

In addition, the vulnerability of bank operations is gradually increasing due to economic instability and social change. It is necessary to increase the integration of interbank networks and build extremely resistant systems to ensure that bank operations can withstand the effects on safety. The risk mapping approach can help planners not only with comprehensive understanding of the foundations and tools of risk management but also in determining whether risk management responses to COVID-19 pressure are relevant.

It is necessary to take into account various criteria for the organization of infrastructure based on physical vulnerability, to develop methodology for testing the proposed mass entropy, to test performance based on analytical results with evidence, and to improve the mechanism for evaluating the vulnerability assessment approach. In addition, a framework must prioritize resource allocation by considering interdependencies, calculate bank performance, and adhere to the effectiveness of vulnerability-enhancing policies; thus, it is appropriate to introduce a risk map for bank emergency management.

4. Data Analysis and Empirical Findings

Global economic and environmental changes are increasing the risk of burdens on banks. The principles of risk prevention in the banking industry are to increase their ability to cope with extreme conditions by raising awareness and identifying sensitivity to them. The implementation of bank risks affects the sustainability of day-to-day operations. Among various types of interbank systems, banks provide significant employment and production activities, which contribute to regional development. In addition, banks integrate supply chain functions — such as logistics, information, and business services — to become the location of industrial clusters. It is therefore important to consider the risks in terms of vulnerabilities. Despite the variety of approaches to risk classification, their main drawback is that they do not provide a comprehensive picture of the existing risks of the banking industry. In addition, there is no clear correspondence between the factors of origin and the management methods.

Marrison (2002) distinguished the ways for banks to lose money in their unrealized hope to earn money by taking risks into three categories: Market risks, credit risks, and operating risks. They are trying to manage risks on three levels: The transaction level, the business unit level, and the corporate level. In particular, three

proposed risk groups of the bank industry are assessed: Level 1 involves risks that are virtually impossible to control, as they belong to the elements of the environment in which the bank operates; level 2 consists of risks that banks cannot control but which may be impacted by state policy; and level 3 involves in-house risks that can be managed by the bank. All the risks should be overseen by the bank's board to balance the stakeholders' interests by deciding the target debt rating, determining the amount of available capital, and allocating the risk limit to each business unit within the bank.

In this context, risk maps can help industry leaders assess vulnerabilities and develop appropriate strategies to minimize bank risks. Assessment and monitoring of the bank's risk load can be performed using a graph-analytical tool: A risk map. Risk maps allow for the clear depiction of the impact of each risk on the bank's activities in the coordinates "probability of occurrence — potential damage." These risks form a map of its profile. Each risk is presented in terms of probability (%) and the amount of potential loss in monetary terms in the relevant categories. To create a risk map, there are ready-made software products — Crystal Ball, RiskMetrics, or especially developed on the basis of Excel. When constructing the map, it is necessary to enter the initial data of the expert assessment (experts: Director, deputy director of economics and finance, deputy director of operations, risk manager) according to the criteria "probability of occurrence — potential damage." An example is the risk map as a tool for monitoring bank security management. This tool is based on the industry's vision as one of the key elements of its safety. The expected knowledge of the experts and the assessments of possible situations are described and presented as details on one graph and require certain explanations.

In order to develop the risk profile of the banking industry under the COVID-19 impact framework, we applied the recommended approach for developing a Corporate Risk Profile (Government of Canada 2016) as well as ISO (2009) 31000:2009 Risk Management — Principles and Guidelines. Saunders & Millon Cornett (2006) distinguished interest rate risks I and II, credit risk, individual loan risk, loan portfolio and concentration risk, liquidity, foreign exchange, sovereign, market, off-balance-sheet, technology, and operational risks. Based on this research, we suggest the following classification of the banking risk map for the chosen anonymous Bank X. Bank X belongs to one of the most influential banking groups, with more than 10,000 customers, a solid capital position, and leading digital propositions. To describe the mission of Bank X, we should mention that it is strongly oriented toward sustainable development. It actively widens the service relations both with enterprises and with physical persons. At the same time, Bank X is globally competitive for cross-border services. The pandemic initiated intensified competition for banks and fintech companies. Fintech companies became attractive because of their higher flexibility and stronger because of their easy distant access to their services banking substitutes in a digital format. This is why, as a response to introducing digital transformations, Bank X even considered the option of digital bank creation. In terms of risks, Bank X is oriented toward the proactive

de-risking approach and decreasing the risk costs based on technological innovations. Riskswereidentified, distributed, and numbered by the author on three levels, respectively:

- Level 1: Risks that practically cannot be controlled; they belong to the elements of the environment in which the bank operates — 1.1 regulation risk, 1.2 macro-social risk, 1.3 fundamental risk, 1.4 risk of prolonged economic downturn, 1.5 macroeconomic and fiscal risks,1.6 COVID-19 risks, 1.7 climate-related risks, 1.8 forcemajeure risks, 1.9 geopolitical tensions and corresponding outlook impacting supervised institutions risk, 1.10 cybercrime and IT disruptions risk, 1.11 disruptive digital innovations and non-bank competition (fintech risk), 1.12 systemic risk across countries, 1.13 contagion risk of interbank linkages, and 1.14 corrections in the real estate market.
- Level 2: Risks that that banks cannot control but which may impact them — 2.1 market risk, 2.2 foreign exchange risk, 2.3 consumer risk, 2.4 competition risk, 2.5 risk of ownership, 2.6 risk of repricing in financial markets, 2.7 money laundering and terrorism financial (ML/TF) risk, 2.8 cybercrime and IT deficiency, 2.9 tax risk, 2.10 trading techniques risk, 2.11 risk of settlement failure, 2.12 hedge funds risk, and 2.13 non-performing loan risk.
- Level 3: In-house risks that can be managed — 3.1 risk of overcapacity, 3.2 reputational risk, 3.3 personnel risk, 3.4 technology risk, 3.5 investment risk, 3.6 social risk, 3.7 operational risk, 3.8 lingering cost inefficiency risk, 3.9 portfolio risk, 3.10 structural business challenges risk, 3.11 business model sustainability risk, 3.12 financial risk, 3.12.1 liquidity risk, 3.12.2 reduced ROE, 3.12.3 reduced ROA, 3.12.4 reduced profitability, 3.12.5 risk of inadequate valuation and depreciation of assets, 3.12.6 risk of inadequate costing and operating cost overruns, 3.13 credit risk, 3.14 physical security risk, and 3.15 the occurrence of aggregate bankruptcy risk (see Table 3).

The investigation about the sources of risk under policy risk management was already started and presented in detail for the energy industry (Nyenno *et al.* 2020). For the banking industry, it is important to go into detail about the manifestation of risks consequences.

Level 1: Risks that practically cannot be controlled.

- 1.1. Regulation risk: Interference in the internal activities of the bank, loss of market freedom, possibility of total or partial loss of funds, expropriation of property of private investors (concessionaires), and limited use of facilities, including natural resources.
- 1.2. Macro-social risk: Failure of the government to fulfill its contractual obligations,violation of stateguarantees, social unrest that caused damage to the company's property interests, hindering the implementation of the banking projects.
- 1.3. Fundamental risk: Risk of collapse of the entire banking system triggered with the interconnected institutions.

Table 3. Risk profile of the anonymous Bank X under the COVID-19 framework.

No	Risk event (risk description)	Probability	Risk impact
	Level 1. Risks that are virtually impossible to control		
1.1	Regulation risk	2	2
1.2	Macrosocial risk	1	3
1.3	Fundamental risk	1	4
1.4	Risk of prolonged economic downturn	3	3
1.5	Macroeconomic and fiscal risk	1	3
1.6	COVID-19 risk	3	5
1.7	Climate related risk	3	5
1.8	Force majeure risk	1	5
1.9	Geopolitical tensions and corresponding outlook impacting supervised institutions risk	2	4
1.10	Cybercrime and IT disruptions risk	2	4
1.11	Disruptive digital innovations and non-bank competition (fintech risk)	2	3
1.12	Systemic risk across countries	2	2
1.13	Contagion risk of interbank linkages	2	2
1.14	Correction in the real estate market	1	2
	Level 2. Risks that banks cannot control but which may impact them		
2.1	Market risk	4	3
2.2	Foreign exchange risk	4	3
2.3	Consumer risk	3	2
2.4	Competition risk	2	3
2.5	Risk of ownership	2	2
2.6	Risk of repricing in financial markets	4	3
2.7	Money laundering and terrorism financial (ML/TF) risk	2	2
2.8	Cybercrime and IT deficiency	2	3
2.9	Tax risk	2	2
2.10	Trading techniques risk	3	3
2.11	Risk of settlement failure	2	2
2.12	Hedge funds risk	1	2
2.13	Non-performing loan risk	2	2
	Level 3. In-house risks that can be managed by banks		
3.1	Risk of overcapacity	3	3
3.2	Reputational risk	3	3
3.3	Personnel risk	3	1
3.4	Technology risk	4	3
3.5	Investment risk	3	3
3.6	Social risk	4	2
3.7	Operational risk	4	4
3.8	Lingering cost inefficiency risk	4	3
3.9	Portfolio risk	3	3
3.10	Structural business challenges risk	3	2
3.11	Business model sustainability risk	2	2
3.12	Financial risk	3	3
3.12.1	Liquidity risk	3	3
3.12.2	Reduced ROE	2	2
3.12.3	Reduced ROA	2	2
3.12.4	Reduced profitability	3	3
3.12.5	Risk of inadequate valuation and depreciation of assets	1	2
3.12.6	Risk of inadequate costing and operating cost overruns	2	2
3.13	Credit risk	5	3

Table 3. (*Continued*)

No	Risk event (risk description)	Probability	Risk impact
3.14	Physical security risk	1	1
3.15	The occurrence of aggregate bankruptcy risk	1	4

Note: Developed based on the results of an expert survey by the authors.

- 1.4. Risk of prolonged economic downturn: Changes in the volume and structure of banking service, reduction of the banking industry's GDP share.
- 1.5. Macroeconomic and fiscal risks: Insufficiency of real available cash flows, reduction of loading and unloading work.
- 1.6. COVID-19 risk: Stability interruption, breaks in work operations, communication technology diversification necessity.
- 1.7. Climate-related risks: Adverse changes in environmental use patterns, necessity of decarbonization and rapid green energy transition.
- 1.8. Force majeure risk: Loss of fixed assets; delay or failure to perform banking obligations due to causes beyond its reasonable control, such as but not limited to fire, flood, strikes, labor disputes or other industrial disturbance, (declared or undeclared) war, embargoes, blockades, legal restrictions, riots, insurrections, and governmental regulations (Taeymans *et al.* 2013).
- 1.9. Geopolitical tensions and corresponding outlook impacting supervised institutions risk: Risk of geopolitical country interest contradicting the strategy of territorial bank development.
- 1.10. Cybercrime and IT disruptions risk: Risk of losses due to imperfect legal frameworks for personal data defense, and access to information in the country.
- 1.11. Disruptive digital innovations and non-bank competition (fintech risk): The emergence of new non-banking financial IT-based players.
- 1.12. Systemic risk across countries: Risk of exposure of bank divisions to economic crisis in the country of operation.
- 1.13. Contagion risk of interbank linkages: Risk of the accumulation of banking losses, risk of exclusion from global interbank financial telecommunication systems.
- 1.14. Correction in the real estate market: Risk of real estate market regulation consequences for the ank.

Level 2: Risks that banks cannot control but which may impact them:

- 2.2. Foreign exchange risk: The impact of exchange rate fluctuations on profitability; an increase in the interest rate on loans (accounting rate), if the current market rate condition is prescribed in the agreement.
- 2.3. Consumer risk: Decrease in demand for bank services, loss of customers, and sharp fluctuations in demand.
- 2.4. Competition risk: Expansion of competitors, price wars, dumping emergence of new competitors, mergers and acquisitions, change in cost and price competitiveness.

- 2.5. Risk of ownership: Inconsistency of the owners is possible when forming the bank's development strategy.
- 2.6. Risk of repricing in financial markets: Increase in banking tariffs.
- 2.7. Money laundering and terrorism financial (ML/TF) risk: A threat to be involved in money laundering and financial crimes, evaluated based on the Basel AML Index.
- 2.8. Cybercrime and IT deficiency: Risk of unprotected communication channels, hacking.
- 2.9. Tax risk: Obstacles to further capital investment and profitable business, termination of contracts due to reasons independent of the bank, increase in tax payments and other deductions as a result of changes in the tax rate.
- 2.10. Trading techniques risk: Invalid banking trade desk, which may cause disruptions in internal risk transfer and risk management; errors in the models of trading techniques.
- 2.11. Risk of settlement failure: Not in time or unfulfilled obligations of settlements.
- 2.12. Hedge funds risk: Risk of superficial choice of the hedge fund and its hedge tools.
- 2.13. Non-performing loan risk: Violation of the payment schedule of the loan, resulting in late or missed principal or interest payments.

Level 3: In-house risks that can be managed:

- 3.1. Risk of overcapacity: Creation of excess capacities (offices, subsidiaries), untimely performance and/or low quality of services, the possibility of undemanding services, miscalculations in the amount of the forecasted demand for the provided services.
- 3.2. Reputational risk: If a loss occurs in banking capitalization because of reputational damage.
- 3.3. Personnel risk: Growth of the wage fund, personnel turnover, non-fulfillment of planned tasks in terms of scope within the established time limits, financial losses.
- 3.4. Technology risk: Lack of competitive advantages, mismatch of technologies, loss of resources, and increase in operating costs.
- 3.5. Investment risk: Risk of the investment portfolio, violation of payback terms, excess of actual costs over project costs, low payback of the project, and unprofitability of the project.
- 3.6. Social risk: Costs related to staff training and retraining, compliance with social guarantees for employees, increased requirements, and possible strikes.
- 3.7. Operational risk: "The risk of loss resulting from inadequate or failed internal processes, people, and systems or from external events" (The Basel Committee on Banking Supervision).
- 3.8. Lingering cost inefficiency risk: Reduction of prices (revenues) decline in sales volume and profit; an unforeseen reduction in the volume of purchases compared

to the volume planned, which reduces the scale of the entire operation; reduction of orders.

- 3.9. Portfolio risk: Risk dependence from clients, projects, and sanctions.
- 3.10. Structural business challenges risk: Changes in the cost of doing business, which require an increase in credits and financing.
- 3.11. Business model sustainability risk: Conflict between the business model value proposition and sustainable development goals.
- 3.12. Financial risk, including:

– 3.12.1. Liquidity risk: Threat of liquidity decrease.
– 3.12.2. Reduced ROE: Risk of ROE reducing.
– 3.12.3. Reduced ROA: Risk of ROA decrease.
– 3.12.4. Reduced profitability: Risk of profit decrease.
– 3.12.5. Risk of inadequate valuation and depreciation of assets: Reduction in the volume of current and non-current assets, decrease in capitalization.
– 3.12.6. Risk of inadequate costing and operating cost overruns: Incorrect cost accounting and pricing of services, decrease in profit.

- 3.13. Credit risk: Non-fulfillment of contractual obligations by counterparties and credit institutions.
- 3.14. Physical security risk: Threat of an unauthorized access to bank facilities and assets.
- 3.15. The occurrence of aggregate bankruptcy risk: Bankruptcy procedure starting.

The risk map is an important tool for decision makers in various practical areas, such as bank performance appraisal, operational management, and international activities. Therefore, to monitor the risk load, a special format for using this tool for decision making in risk management systems in general has been proposed. Decision making is much more difficult in cases where the situation changes over time and when decisions must meet certain requirements not only in the moment but also in the medium and long term. Many vaguely described situations arise when considering awareness as well as bank security. The whole range of problems in this area can be assessed by analyzing the relevant documents and comprehensive materials prepared by government agencies and bank security agencies. Business model risks related to the elements under Canvas may be assessed according to the ROE decomposition (see Table 4), namely: Key partners and stakeholders by gross margin, key activity by the effect from commercial and managerial costs, value proposition by the effect from financial activity, customer relationship by the receivables management, customer segment by debt load, key resources by the stock management, channels by other current assets management, cost structure by the tax effect, level of interest-free liabilities in the equity by revenue stream, and cash funds management by other non-current assets management (Nyenno & Nitsenko 2017).

ROE = return on equity, ROA = return on assets, and EM = the equity multiplier. Return on equity is net income divided by total equity capital,

Table 4. Elements of the three-factor DuPont model calculation for Bank X, 2018–2020.

No	Indicator	Marking	Unit	2018	2019	2019/2018 variation, %	2020	2020/2019 variation, %
1	Net income	NI	million €	4050	4182	3.3	3277	−22.6
2	Total asset	TA	million €	787,790	816,102	3.6	1002,614	22.9
3	The equity capital	TEC	million €	54,350	56,215	3.4	66,321	18.0
4	Return on equity	ROE	%	7.45	7.44	−0.2	4.94	−33.6
5	Return on assets	ROA	%	0.005	0.005	−0.3	0.003	−36.2
6	The equity multiplier	EM	—	14.49	14.52	0.2	15.12	4.1

Note: Developed based on the results of the authors' calculations from Bank X's consolidated financial statement.

and return on assets is net income divided by total assets. The equity multiplier is the ratio of total assets and total equity capital.

$$\text{ROE} = (\text{NI})/(\text{TEC}) \text{ (formula 1)},$$
$$\text{ROA} = (\text{NI})/(\text{TA}) \text{ (formula 2)},$$
$$\text{EM} = (\text{TA})/(\text{TEC}) \text{ (formula 3)},$$

where NI = net income,
TA = total assets,
TEC = total equity capital.

Changes in ROE and ROA indicators were insignificant in 2018 in comparison to 2020; they did not exceed 0.3% of their values in 2018. In 2020, the value of ROE and ROA indicators decreased by 33.6% and 36.2%, respectively, due to a decrease in net income and an increase in total assets and total equity capital. Net income decreased by 21.6% in 2020 as net income from banking activities decreased, as well as due to the growth of recoveries for credit risks associated with financial assets by almost two times and an increase in operating expenses. Total equity capital increased by 10,106 million due to an increase in reserves and equity instruments. Total assets grew by 22.9% due to an increase in financial assets.

Such a managerial decision will be formed on the basis of some verbal qualitative characteristics (after their normalization) and quantitative parameters obtained from the environment, action plan, or situation during the investigation, or from other sources of information. Therefore, in information systems that support bank security, there are many decision-making points in the whole chain of activity. However, modern experience allows us to expand the idea of using risk maps, including additional vague expertise and consideration of real situations.

The decision-making process required to optimize the risk load depends on a systematic study of influencing factors, the adequacy and quality of information, the

number of alternatives, and the use of appropriate models and methods for selecting the optimal alternative. Quantitative risk analysis is performed if it is possible to estimate the probability of a certain event on the basis of available information about similar events that have occurred in the past, or information collected in another way, as well as on the basis of personal experience. In theabsenceof such experience, the proposed structure allows for a qualitative risk analysis under constant control of the consistency of subjective decisions.

Risk analysis is performed to assist decision makers in understanding vulnerable systems. Thus, the bank management adopts appropriate strategies to prevent and reduce the risks of the banking industry. The public sector needs to formulate strategies for bank vulnerabilities (i.e. high and extreme vulnerabilities) based on long-term considerations. In order to optimize the level of risk, public regulators should develop integrated regional planning to reduce infrastructure vulnerabilities and impacts on bank security, as well as to provide robust early warning systems to prevent cumulative risks and improve self-protection. Uncertainty and risk are important aspects that are closely related to the adoption of management solutions for creation and implementation for the bank. In contrast to the first approach, the cause-and-effect model defines the future as predictable. In this decision, the evaluation uses approaches from the field of strategic planning. Thus, causal logic is based on the choice of means to create a previously detected effect, arguing that management is able to handle it depending on the degree of foresight.

A combination of several tools and approaches to the implementation of risk management in the banking industry ecosystem is proposed. In particular, new results have emerged at the crossroads of qualitative and quantitative methods in an iterative environment of effective approaches to respond to new COVID-19 risks, when innovation is tested in a prototype and through development analytics.

A specific idea might consider a scenario plan that provides qualitative and quantitative criteria, including the financial costs of implementing any type of ecosystem. The full potential of such scenarios can only be identified if it is combined with the development of roadmap-supported tactics. However, a tool has been created that allows such tests to be performed on the bank's stress resistance to risks while testing the ecosystem.

Thus, risk management and risk mapping have been identified as an additional field for implementing tools in the banking industry. The presented criteria and assessment methods can be applied to risk management in the ecosystem framework in order to identify and assess promising ways of development. Strategic forecasting can help reduce the number of observations by eliminating unreliable assumptions about expected revenues with reliable scenarios. This helps to increase the reliability of risk load calculations and the choice of risk management methods, which thus increases transparency about the possible decision-making results of those responsible. In addition, it was suggested when and how to integrate risk management in the development of the bank ecosystem.

Focusing on risk in the banking management system, a more precise introduction of the practical control concept could also be introduced. The bank's business efforts are essentially risky, so it is impractical to avoid a detailed risk assessment and determine whether the management risk response is in perspective. Most risk assessment can be initiated to attract investors and be put for sourcing. Unfortunately, a comprehensive risk assessment is a rare case.

An organizational structure with established roles and responsibilities, a system of powers and responsibilities, defined business processes, and company resources balances demonstrates how effective bank management is and how the bank adapts to developments in the external environment. The interaction between the elements of the ecosystem determines what resources are needed and the extent to which they are implemented to realize benefits in service and market innovation. It also specifies how the ecosystem generates shared value, the extent and dynamics of it, and the stage of the life cycle it is in. The financial structure of the ecosystem determines the logic of making a profit: Through pricing for unique products, including logistics, or due to low costs, and the efficiency of the service delivery process. That is, the risk structure of the ecosystem is presented on the following levels: The level of its elements, the level of their interaction, and the level of interaction with stakeholders of the banking industry. Better detail of the risks of the bank ecosystem helps to identify its promising design and ability to generate common value for stakeholders. The ecosystem itself captures the strategic activities of the bank in various areas, such as focusing on a particular market or product, providing additional benefits of loyalty to consumers, organizational structure, processes, resources, and the logic of profit. The ecosystem must take into account the risks of interaction with competitors and the risks of unequal or difficult market access, the introduction of new services, and the need for investment. At the same time, it is necessary to form alternative ways of ecosystem development, as the strategy may lead to the realization of the risk of inflexibility. The aggregate assessment of the bank's risks and the risks of its ecosystem, which arise on three levels, is a tool for balancing strategic development and the degree of adaptation or late response to change.

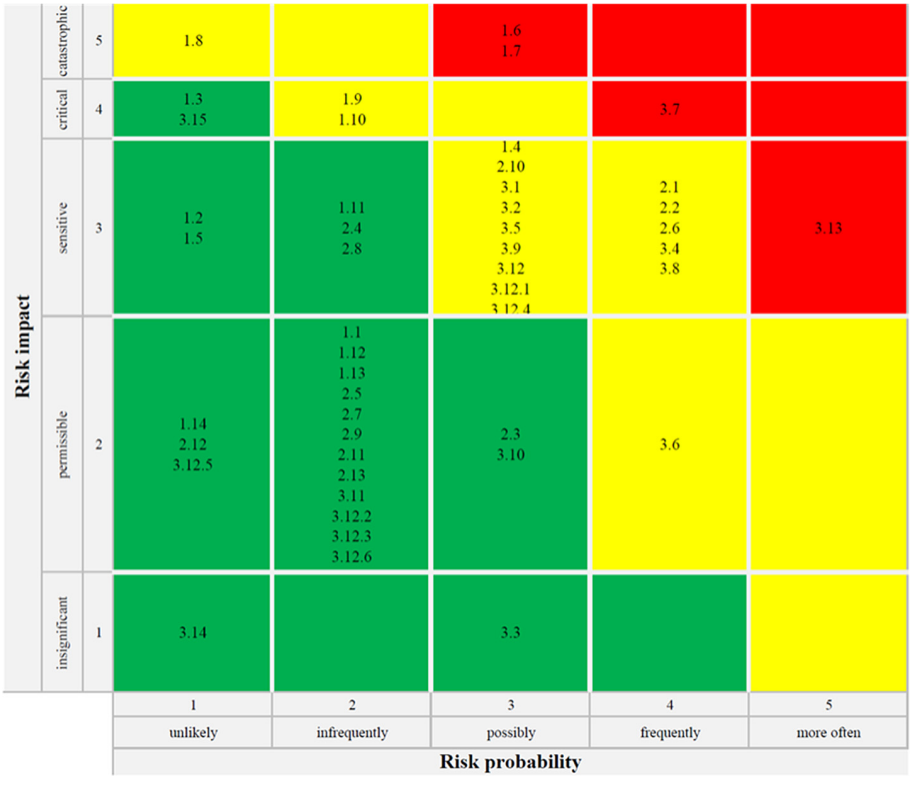
This method of risk analysis is not based on a revenue-cost approach, evaluating the cash flows, or the efficiency of investment. In a strategic sense, maximizing the utility received by all stakeholders in the banking industry arises from maximizing the added value that is considered in the study as increasing the market value of the bank, as well as future shareholder value. The sustainable growth of this value and the share of the international market of bank services are key processes for maximizing utility.

In general, sustainable development should be based on the compliance of the chosen methods of risk management, which will affect the risks of the ecosystem and the bank's sustainable development goals. Structural analysis of the risks of the banking ecosystem in terms of its elements, the relationship between them, and the relationship of stakeholders allows for determining the priorities of ecosystem transformation and a critical path to the planned development outcome by optimizing the impact of risks.

5. Discussion of the Results

The hypothetical situation related to certain input information, which covers the characteristics of the bank risk management state, is illustrated in a simplified way. In hierarchical systems, the entire decision-making process may involve several levels of decision making by interacting experts. Thus, even this simplified example of bank security and awareness allows us to perceive the idea of the decision-making process using differentiation of expertise; it shows the versatility of the map and its capabilities as a useful tool for decision support systems. Figurer 1 shows a map of the risks of the EU banking sector in the case of Bank X. Graph analytical assessment shows that the greatest risk burden is inherent for COVID-19 risk, climate-related risks, and operational and credit risks.

The risk map is a risk analysis tool for consolidating results that can be used to increase the certainty of the environment for management decisions. Managers have the opportunity to determine whether the level of probability and loss inherent in each risk is acceptable. This is especially important in the sense that, depending on the level of risk, methods of managing it are identified. Therefore, the main purpose



Note: Developed on the basis of authors' calculations and expert assessment.

Fig. 1. Bank X risk map.

of using a risk map is not to quantify the probability and consequences of adverse events but rather to determine whether the actual level is acceptable. It should be noted that the consolidated approach is characterized by the variability of rating scales. Risk assessment criteria should also be reviewed in the context of the prospects for management decisions and the receipt of new information on the origin of risks. Thus, the risk map is a matrix in which the results of the risk assessment are consolidated. The valuation process must take into account the situation when several risks are on the same level of impact or affect one asset or process. In this case, they must be evaluated in aggregate.

In particular, we will illustrate the situation with regard to risks 1.6, 1.7, 3.7, and 3.13 (COVID-19, climate, operational, and credit risks). The combined effect of theserisksleads to aggregation. That is, even in conditions of constant probability of risk occurrence, the consequence of realization is potentially aggregated. The reason for aggregation for COVID-19, climate, operational, and credit risks may be found in the strong orientation of Bank X toward the implementation of SDG strategy. This is why the higher importance was underlined on the new risk map (namely, the impact of "Category 5"). The SDG 13 "Climate Action" call requires the bank to strengthen resilience and adaptive capacity to climate-related disasters (Target 13.1), integrate climate change measures into policies and planning (Target 13.2), and build knowledge and capacity to respond to climate change (Target 13.3). All these changes should be implemented globally for the bank because of its international presence. Operational risk danger increased after the pandemic because of the rapid necessity of filling the gap in distant online technologies and the loss of personal communication continuity with the bank's stakeholders (partners, clients, and certain staff). The banks with high pre-COVID investments in information technologies suffered less and became more market adjusted (Fayman 2023). Credit risk emergency occurred in the same aggregated group, showing the threat of interruptions for banking corporate clients, which could lead to their default because of disruptions in cash flows from their business. The borrowers missed payments of their loans as well.

An alternative scenario is the cumulative impact of risks on a particular asset, leading to an increase in the consolidated level of damage to the asset or process. Risk aggregation occurs by determining the aggregate probability and extent of the consequences in monetary terms. If the risks are in one cell of the matrix, the summation is impractical. The probability and consequences of aggregate risk are determined — i.e. the aggregate assessment of accumulated risks, which can be changed to a critical category in accordance with Table 2. The risk profile of Bank X has been significantly changed in light of COVID-19 risks, above all, because of the new architecture of the risk map under COVID-19 exposure.

In any case, the purpose of using a risk map is to choose a rational method of risk management. In the selection process, it is recommended to take into account the fact that risk management methods, established in accordance with individual risks, give rise to the consequences of increased costs for their implementation. If it is necessary to reduce the costs of risk management, it is advisable to group risks

and form a portfolio of methods of influencing them by groups. Thus, bank risk management will be comprehensive.

6. Concluding Remarks

Because of this study, we can see the difference in risk profile of the anonymous Bank X before and after the pandemic. We may argue that the reason for this was that the COVID-19 pandemic was all over the world. Any globalization issue brings irreversible changes. The communication of human resource was limited and even closed for certain cases, strict quarantine rules were in place, and regular transport connection was stopped. Further measures included the strong development of distant communication technologies to avoid operation risk. After the cancelation of quarantine measures, the advantages of this kind of technology became obvious from the perspective of saving time and money. "Time is money" — this is a fact! We adopt the perspective that the next stage of post-COVID digitalization will be the active introduction of artificial intelligence (AI) as a capital asset that leads banks to better risk assessment and management. AI is strongly based on software algorithms and big data analytics, which became available because of active digitalization after the COVID-19 pandemic. These are our future lines of research — to investigate how the risk-mapping methodology may be enlarged based on the AI driver of risk mapping.

This study proves that the risk map application in the bank's everyday life can save time and financial resources. It also allows banks to take into account expert opinions when making decisions, as well as develop a strategy for the future development of the bank in the context of the requirements of the Basel Committee on Banking Supervision Risk Management, the new architecture of risks after the global changes of the COVID-19 pandemic, and the new calls for digital technologies and Sustainable Development Goals as the priorities of future banking strategy. It represents a secure roadmap of financial scenarios for the operation of the bank. Furthermore, the risk map is demonstrated to be a useful tool for decision makers in supporting adequate policy and actions in response to the changing environment.

Authors' Contributions

Stefania SYLOS LABINI and Iryna NYENNO conceived the study and were responsible for the research design, development of the data analysis, supervision, and project administration. Iryna NYENNO was responsible for the conceptualization, formal analysis, data collection, methodology, and data interpretation. Iryna NYENNO wrote the first draft of this paper. Stefania SYLOS LABINI and Iryna NYENNO were responsible for editing this paper.

Disclosure Statement

The authors declare no competing financial, professional, or personal interests from other parties and no conflict of interest.

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