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# Development and Validation of a Model for Assessing Potential Strategic Innovation Risk in Banks Based on Data Mining-Monte-Carlo in the “Open Innovation” System

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**Abstract:** Innovation risk in banks, a formalized instrument that is part of banks’ financial and innovative strategies, influences the assessment of innovative activity, demonstrating the importance of forecasting and assessment models of potential innovation risks. Our research into general scientific and specific methods allowed us to: (1) distinguish hierarchical concepts and their order—namely, “banking innovation”, “economic effects of innovational activities”, “financial and innovative strategy”, and “innovation risk”; (2) identify links between innovative and strategic bank management, since bank innovations are carried out in conjunction with strategies and imply positive strategic economic effects, making the assessment of potential innovation risk necessary for the current moment and the future; (3) note that the launching and use of new technologies on economic cycles and phases involving a necessary correlation between innovative profit and these phases; (4) provide preferable measurements of banks’ innovative activity and financial performance against commission income; (5) assess the potential financial performance of banks’ financial and innovative strategies within economic cycles and phases and in accordance with the nature of income; (6) present general areas for the practical application of an adapted data mining–Monte Carlo method, based on a proprietary software product. The model’s application in the “open innovation” system exhibits its multipurpose nature and allows for the selection of alternative strategic innovative solutions within economic cycle phases. It also serves in the promotion of Big Data technology in relation to finance and innovation, which is a promising area, and determines the values of the desired indicators for the “bank of the future” concept.

**Keywords:** open innovation; strategic innovation risk; big data mining–Monte Carlo; financial technologies; bank innovations

## 1. Introduction

The successful operation of commercial banks in the modern international and national competitive financial market, which is filled with various users of digital services and products, is based on continuous development processes, innovation, the creation of a flexible regulation system, and the assessment of innovative risks. The innovative development of banks is complicated, since there is a lack of a mutual glossary tool defining financial innovation and the relations between banks and digitization providers, as well as a lack of studies on innovation and development in accordance with economic cycle phases. One methodologically unsolved issue is the provision of a toolkit for regulating and

assessing banks' innovation risks, which accompanies the introduction of new technologies, operations, services and products, throughout the entire credit institution's operation, while comprehensively influencing, transforming, modernizing and modifying it. This limits the development of innovative processes in banks. Foreign and Russian researchers have considered only certain theoretical and methodological aspects of evaluation methods for innovations in banks and the risks arising from the introduction and implementation of those innovations, without taking into account the strategic component. In this regard, the creation and validation of theoretical and methodological provisions, as well as practical directions in the development of assessment tools for banks' innovation risks, are important tasks for national and international researchers. The solution of this problem is an important scientific research task, which determines the relevance of the current study.

The theoretical and methodological basis of this study includes works by international and Russian scholars, financial experts, and practicing bankers, as well as the internal regulatory frameworks of financial institutions. The methodological basis of this area of research includes scientific, logical, systemic, situational, and process approaches in order to study the assessment and development processes of banking innovations.

The working hypothesis of the study is grounded in the need for the development of a scientifically based tool for the assessment of both current and potential innovation risk levels of banks based on an adapted data mining–Monte Carlo method and a proprietary software product, which aims to ensure the efficient innovative activities of Russian banks in the context of the current period of digitization and in the long term. The theoretical significance of the study lies in deepening and expanding the theoretical understanding of assessment and regulation processes to define banking innovation risks in the context of digitization. Certain theoretical and methodological aspects of this research can be applied as educational and methodological materials for certain subjects in educational programs, as well as for the advanced training of specialists in financial and banking innovation areas. The practical significance of the studies lies in the development and application of specific methods, models, and practical provisions that can shape the methodological and practical basis for the assessment and regulation of banks' innovation risks.

The object of this research consists of financial and management reporting data from Russian commercial banks. In-depth research was carried out on the country's leading banks, i.e., PJSC Sberbank, PJSC "Stavropolpromstroybank", and Post Bank JSC. Their innovative activities were studied, along with the best practices of European and American banks, which will allow for gradual improvement and development, and therefore bring the innovative activities of Russian banks to a new, internationally accepted level. It is a positive trend that in Russia, financial technologies significantly influence the achievement of the UN Sustainable Development Goal 9: "Industrialization, Innovation and Infrastructure". Considering the joint principles of objectivity, relevance, prospects, and complexity, the research periods relating to the formation and evaluation of practices in regard to banking innovations are: current (2012–2019) and strategic (2020–2022); in the context of economic cycle phases, we provide a full demonstration of the research issue, and the period of the research is sufficient to suggest conclusions and proposals.

The novelty of the study lies in the development of a new model for the assessment of the potential strategic innovation risk of banks, based on an adapted data mining–Monte Carlo method and a proprietary software product. This method aims to ensure the efficient innovative activities of Russian banks in the context of current digitization and in the long term.

The purpose of the current research is to contribute to the development of a scientifically grounded toolkit for the assessment of potential strategic innovation risk levels and the identification of its application areas in commercial banks. The achievement of this research goal achievement implies the fulfillment of the following tasks: the establishment of hierarchical order for the concepts of "banking innovation", "economic effect of innovational activities", "financial and innovative strategy", and "innovation risk", denoting connections between innovation and strategic management in commercial banks;

the clarifications of problematic methodological issues in the research process, and the assessment of retrospective and current levels of innovation risk in commercial banks based on the adapted data mining–Monte Carlo method and a proprietary software product.

## 2. Literature Review

The economic content of innovations in banks in various modifications and at each stage of innovative development was studied by scholars: [Mensh \(1971\)](#), [White \(1982\)](#), [Barras \(1986\)](#), [Rose \(1995\)](#), [Cooke and Mayes \(1996\)](#), [Dodgson \(2000\)](#), [Sundbo and Gallouj \(2001\)](#), [Dundon \(2006\)](#), [Tucker \(2006\)](#), [Hansen and Birkinshaw \(2007\)](#), [Drucker \(2009\)](#), [Sinkey \(2016\)](#), [Omarini \(2017\)](#), as well as Russian economists: [Vykupov \(2001\)](#), [Muravyova \(2005\)](#), [Zverev \(2008\)](#), [Kokh et al. \(2009\)](#), [Podlozhenov \(2010\)](#), [Doliatovskiy \(2011\)](#), [Rodin \(2013\)](#), [Prosalova and Nikolaeva \(2014\)](#), [Nazarenko \(2014\)](#), [Desyatnichenko et al. \(2017\)](#), and others.

The world's economists noted the connection between the banks' innovative and strategic development: [Barras \(1986\)](#), [Cooke and Mayes \(1996\)](#), [Sundbo and Gallouj \(2001\)](#), [Tucker \(2006\)](#); Russian researchers: vs. [Prosalova and Nikolaeva \(2014\)](#). The content and the process of innovation risks in banks were studied by foreign researchers: [Dodgson \(2000\)](#), [Sinkey \(2016\)](#), [Omarini \(2017\)](#); Russian scholar—[Nazarenko \(2014\)](#).

The role of knowledge management in radical innovations, especially with reference to Internet banking in the European Union, is explained by [Apak et al. \(2012\)](#); service innovations in the Malaysian banking industry leading towards sustainable and competitive advantages are studied by [Hong et al. \(2016\)](#). [Fontin and Lin \(2019\)](#) evaluate innovations in banks in the low-income countries applying the meta-frontier approach. While studying innovations in banks, it is important to take into account the specifics of the regions where the banks operate. Thus, the studies of [Klyton et al. \(2021\)](#) refer to complications related to the introduction of the innovations and mobile banking in rural Colombia. A unique study conducted by [Naseer et al. \(2021\)](#) considers open innovations as a mediator between informational pro-activity motivation and the operational performance of a company. It is obvious that each of the presented studies influences the development and testing of the special model for assessing potential strategic innovation risk in banks in the “open innovation” system.

While the results obtained by foreign and Russian researchers received certain appraisal, it must be admitted that, despite the state policy of each country with regard to the rapid introduction of digital technologies in the economy, most scientific works only consider certain aspects of the economic content of innovations in banks, and do not take into account differences and opportunities related to the innovations in banks, with reference to their size and the phases of the economic cycle. Insufficient attention is paid to the study of the regulatory toolkit and the assessment of the innovations risks in banks, which ensures the commissioning, development, and implementation of the innovative bank products, services and operations by phases of the economic cycle, which complicates the innovative activities of a commercial bank in general. At the same time, most of the works describing innovations in banks and innovative risks do not take into account the strategic component, and neither do they differentiate the conduct of innovative activities by the phases of the economic cycles. The relevance, theoretical and practical significance, and fragmented elaboration of the problem in this study necessitated the development of tools for the regulation and assessment of innovation risks in banks, taking into account the strategic component, which was not reflected in the foreign and Russian literature.

## 3. Method

### 3.1. Study of the Terminology Applied to Characterize Innovation Activities in Banks

The term “innovation” originates from Latin *novatio*, meaning “update/change”. Its means “introduce something new”. Most of the definitions of innovation in national and international practices imply a certain level of efficiency.

Santo (1990) believes that innovation is a socio-economic process, the implementation of which supports determining products and technologies that are rational in their qualitative characteristics; if an innovation is aimed at achieving an economic result (profit), in the market it determines additional income.

Bezudny et al. (1998) consider innovation as a process of putting into life new ideas in different areas of human life that would meet actual needs in the market and have a certain economic effect.

Sokolov et al. (1997) view innovation as the final stage of creation and practical implementation of an absolutely new/modernized idea (innovation) that meets certain social requirements, and conditions different types of efficiency (economic, scientific, technical, social and technological).

Fatkhutdinov (2014) defines innovation as an ultimate result of introducing improvements in order to enhance the object and acquire economic, social, environmental, scientific and technical or other types of effect.

Vykupov (2001), Vodachek and Vodachkova (1989), Zverev (2008) stipulate that innovation is any change or enhancement in all areas of bank operations with a certain positive economic or strategic effect.

The following economists recognize the inclusion of certain types of effect into bank innovations' interpretation within bank management systems:

Drucker (2009) views innovations in banks as new/radically modified services/products brought to and accepted by the clients; modern technologies introduced into banking processes, including information and communication technologies that lead to economic/social effect.

Kurakov (2012) characterizes innovation by a new/improved product sold on the market—practically useful and leading to the final innovation result—and brings up efficiency (economic, technical, social, etc.) resulting from innovations as an argument proving that innovation is an economic category, and a factor of the production process which is renewable and inexhaustible, progressively being visualized in the application of new technologies. The result of innovations utilized in production is viewed as a boost of its efficiency.

Lavrushin (2016), Muravyova (2005) view innovations in banks via the synthesis of considerably new bank products and services and as an integral concept of the goal and the result of banking with the application of new technologies that are aimed at income generation while creating favorable conditions for setting up new resource potentials by means of innovations that would help clients to make profit. The definition of innovations in banks by O.I. Lavrushina and A.V. Muravyova specifically underlines one of the parameters—receipt of additional income—as a key target condition for the application of innovative research.

Desyatnichenko et al. (2017) believe that innovations in banks are innovations in all areas of banking business with a certain positive economic and strategic effect, i.e., a new banking service, a product/technology provision, a new/modernized process.

Dundon (2006) specifies the implementation of innovations in banks as an economically and strategically profitable outcome. According to him, innovation is “a profitable implementation of the creative strategy”, based on a capacity to release fresh ideas and acquire maximum profit from new technologies. The Director of Strategic Business Development at Bell Integrator, A. Ezrohi (Tadviser 2019), notes that the insufficient commercial motivation of banks complicates the development of innovative technologies, since they use political rather than technological methods of market redistribution. It is fair to assume that a financial innovation should have a positive strategic economic impact.

All the above definitions identify a certain component of the innovative activity management process which justifies the need to study it via the synthesis of strategic and innovative management. The implementation of innovations implies having a positive economic effect achieved by means of modern technologies.

Rodin (2013) compares innovative activity with a compound process that includes elements such as strategies, management models, business processes for introducing innovations, their types, and results.

The theoretical essence of innovations entry, as stated by Prosalova and Nikolaeva (2014), does not guarantee economic efficiency, and eventually links innovations with risky dynamic opportunities rather than with competitive privilege. In their opinion, the innovation process is a subject of management with a high degree of risk. V.S. Prosalova and A.A. Nikolaeva note the similarity of the processes in strategic and innovation management and characterize the process of introducing innovations as a component of the banks' strategic management. Strategic development should be grounded in the innovative activities since any strategy ultimately leads to qualitative changes in banking business. International economists, Barras (1986), Cooke and Mayes (1996), Sundbo and Gallouj (2001), Tucker (2006), note a close connection between innovation and strategic levels of banks' development. That means that strategic and innovation levels may merge and form strategic innovative administration over banks' operations, which ensures its stable innovative performance and highlights the following comparison criteria—as shown in Table 1.

**Table 1.** Comparison of strategic and innovative management in commercial banks.

Features	Management	
	Strategic	Innovative
Purpose	Strategy implementation	Innovation implementation
Implementation period	Over 3 years	Within 3 years
Bank engagement level	All bank divisions	Divisions engaged in innovation processes/product/service
Implementation stages	Management stages	
Risk level	Minimum risks due to lengthy implementation period	High
Analyzed resources	External, internal	
Organizational process opportunities	Due to lengthy implementation period are maximally structured and arranged	Due to prompt sales are less arranged and adjusted
Regulatory Body	Bank management, including top management	

Source: research materials by Prosalova and Nikolaeva (2014).

Assuming that innovation processes cannot be carried out without strategic management, innovation (financial and personnel management) and strategic management are linked together. The achieved competitiveness of banks determines the introduction of innovations on the certain stage of the strategic management that is specifically efficient in accumulating innovative programs, where the latter evolve strategic management into strategic innovation management.

Doliatovskiy (2011) stipulates that the selection of a strategy is based on the degree of environment uncertainty, provided that the process of innovative strategies adaptation is viewed through the evolutionary matrix which compares banks' innovative changes and the main financial indicators.

It should be noted that with the development of FinTech Association and the ecosystem approach, it is fair to use the term of "financial and innovative" strategy, which determines the efficiency of innovations in banks in the context of digitalization.

Since innovations are characterized with risky dynamic opportunities, financial and innovative strategies should be implemented along with the development of tools to regulate innovations risks; its creation and implementation should be supported by the risk management that carries out strategic consulting. Criterion for assessing compliance of the financial and innovation strategy to the level of uncertainty and risk is timely and would complete the achievement of the main business strategic goal. Johnson (2018),

Chief Operations Officer of Fannie Mae, defines innovations risks as a strategic issue, stipulating that innovations rejection is as high in risk as their introduction, if not more. The banks that effectively regulate innovations risks are more efficient in the introduction of innovations. The inextricable link between innovations, efficient risk management and growth is highlighted in the study carried out by [Management School at Northwestern University \(2021\)](#). It is evident that the complexity and uncertainty of innovations in banks cause innovation risk that leads to certain losses.

According to [Eroshkin \(2013\)](#) innovations risk means the probability of undesirable deviations from the targets identified for newly introduced products (services), which were indicated by the bank for a specific period of time and further. The comparison of the actual and planned values of indicators obtained as a result of introducing innovations in a bank is the parameter that evaluates risks. Yu. V. Eroshkin, identifying strategic parameters of innovation activity, admits that banks' innovative activity may serve in both helping to meet regularly changing market requirements remaining in demand among clients, and to "work for the future" in a regular mode, increasing its competitive advantages over time.

[Kokh et al. \(2009\)](#) separate risks depending on the impact level caused by the result of banks' innovative activities: positive/negative, decrease/increase in risk impact resulted from the introduction of innovations; innovations' impact is uncertain and depends on the external environment, it may minimize risk in the preferable economic environment, and have the opposite outcome within an unfavorable market background.

[Nazarenko \(2014\)](#) assesses the innovation risk level "by the degree of uncertainty for attainability of banks' innovative evolution goals and losses caused by the deviation from the identified goal".

International researchers pay special attention to the banks' innovation risk regulation process: [Dodgson \(2000\)](#), [Sinkey \(2016\)](#), [Omarini \(2017\)](#).

Innovation risk in banks, in our opinion, is a possibility of wrong strategic innovative decision making, i.e., taking a wrong choice and the implementation of a financial and innovative strategy that excludes dynamic opportunities and flexibility.

In view of this, a hierarchical order of the concepts is presented as follows: "banking innovation", "economic effects of innovational activities", "financial and innovation strategy", "innovation risk"; consideration of the order allows for the development and promotion of a verifiable toolkit for the assessment of innovations.

### 3.2. Assessment of Innovations in Banks: Threats and Opportunities

The best foreign banking practices (Citigroup, Bank of America, and Royal Bank of Canada) indicate that innovation efficiency depends on the adequacy of the innovation assessment system. However, in foreign and Russian practice of innovations management in banks, there is no standard toolkit for assessing innovation.

[Podlozhenov \(2010\)](#) rightly notes that official statistics do not provide sufficient information data describing the scale of innovation activities in credit institutions. Additionally, it is challenging that the official statistics do not directly demonstrate information which would characterize the innovative activities in banks.

Historically, the development of innovations in a country is assessed with the help of the global innovation index, which expresses the cost-benefit ratio ([INSEAD 2021](#)).

[Popova \(2010\)](#) denotes a set of criteria to define innovative business performance by means of the scientific, technical, social and environmental effects, which are components of the economic effect (potential and real). She also highlights it as a key factor which is a ground for financial innovations. The evaluation of innovative activities efficiency in banks by means of the effects, in our opinion, can be accepted, since it is characterized by the results, i.e., effects.

[Pertseva \(2018\)](#) precisely recognizes the value of the net profit as a criterion for active digitalization.

When selecting a toolkit for innovations assessment in banks, it is advisable to take into account specifics of commercial banks' operations in conditions of uncertainty and risks.

According to [Koshevenko \(2018\)](#), economic downturn accelerates the transition to new technologies. Growing markets create a demand for new technologies to drive growth. Progressive markets are using new methods to minimize costs and stimulate innovations. In the conditions of instability due to the increased competition and tough wrestle for customers, a decrease in classic banking operations margins, services and new products will push banks to optimize business processes and develop products of either low cost or increased profitability. K. Markelov ([Tadviser 2019](#)) shares the opposite opinion and believes that a decrease in the traditional operations, products and services profitability reduces IT budgets, which naturally reduces demand for IT innovations which require the attraction of financial and human resources.

I. Kukhnin ([Deloitte 2018](#)), Director of Risk Management, Head of the Sustainable Development Services Group (Deloitte Company, CIS) defines financial technologies dynamically developing in the modern market as means for sustainable development that can improve financial industry performance and contribute to the achievement of sustainable development goals, creating significant value for society. I.e., financial technologies represent a powerful tool for the achievement of sustainable development goals and improvement of life quality, as well as ensuring an increase in business competitiveness, leading to its profitability improvement. In Russia, financial technologies significantly influence the fulfillment of UN sustainable development goal 9 "Industrialization, Innovation and Infrastructure". Notable activities are carried out to ensure the execution of sustainable development goal "Decent Work and Economic Growth". It is noted that online issued loans, P2P lending, crowd funding, electronic wallet, online payment service play a considerable role in the achievement of these goals in Russia, whereas in Kazakhstan, online loans, P2P lending, crowd funding play their part.

The revealed dependence of the introduction and application of new technologies (depression—accelerated transition to new low-cost technologies or those with increased profitability, recovery—demand of new technologies in growing markets, etc.) on the economic cycle phases determines the relevance of profit regulation by the phases of the cycle, i.e., innovations demand is predetermined by the cyclical nature of economy:

- Thus, the net profit by phases of the economic cycle is recognized as an important qualitative indicator for the assessment of the financial performance of innovative activities in commercial banks. In our opinion, the commission income may represent the level of innovations' efficiency in the banks' financial performance, and its preferable generation is justified with the following: it is the most stable source of obtaining financial results, it is resistant to market fluctuations, it is used to diversify risks provided by unfavorable market conditions are anticipated;
- The growing demand for remote banking services and non-credit transactions in the environment of products and services digitization, created ecosystems and expanded side business services;
- An increase in borrowers' debt burden aggravated with the enhanced premiums to loan risk ratios;
- The expansion of the income base without increasing the share of risky assets;
- Additional income generation;
- The improvement of banks' profit indicators without pressure on capital;
- The creation of partnerships of the banks and financial technical companies in financial bank ecosystem.

Taking into account that the key qualitative indicator for assessing the financial performance of innovational activity is net profit, its composition is estimated in dynamics by the phases of the economic cycle—shown in Table 2—and by considering the determination of potentials for development of the innovational activities.

Commercial banks with a gap in innovational activities were selected as the objects for the research.

- PJSC Sberbank is a large financial bank ecosystem, a leading bank with state capital support ([Sberbank 2021](#));
- Post Bank JSC is a medium-sized bank with state capital support ([Pochtabank 2021](#));
- PJSC “Stavropolpromstroybank” is a regional bank ([Stavropolpromstroybank 2021](#)).

**Table 2.** Assessment of potential financial performance of financial and innovative strategies in selected commercial banks.

Period	Economic Cycle Phases	Share in Net Profit. %			Net Profit	Commission and Net Interest Income Ratio. %
		Net Interest Profit	Commission Income	Other Types of Profit		
PJSC “Sber”						
01.01.2013	Expansion	56.2	231.3	−187.5	100	24.3
01.01.2014		57.8	216.9	−174.7	100	26.7
01.01.2015		89.8	242.3	−232.1	100	37.1
01.01.2016	Trough	116.6	248.9	−265.5	100	46.8
01.01.2017		32.2	223.5	−155.7	100	14.4
01.01.2018	Growth	57.0	171.6	−128.6	100	33.2
01.01.2019	Growth	63.0	155.7	−118.7	100	40.4
01.01.2020	Trough	74.0	167.8	−141.8	100	44.1
Post Bank JSC						
01.01.2013	Expansion	16.5	0.8	82.7	100	4.8
01.01.2014		13.8	26.1	60.1	100	188.7
01.01.2015	Trough	−37.0	104.7	32.3	100	−283.1
01.01.2016		−317.4	423.8	−6.4	100	−133.5
01.01.2017		3284.2	14,495.4	−17,679.6	100	441.4
01.01.2018	Growth	571.5	596.4	−1067.9	100	104.3
01.01.2019	Growth	420.2	407.7	−727.9	100	97.0
01.01.2020	Trough	277.3	589.5	−766.8	100	212.6
PJSC “Stavropolpromstroybank”						
01.01.2013	Expansion	138.0	250.6	−288.6	100	55.1
01.01.2014		447.7	889.6	−1237.3	100	50.3
01.01.2015		192.0	281.9	−373.9	100	68.1
01.01.2016	Trough	165.5	−56.3	−209.2	−100	−294.1
01.01.2017		807.8	1222.8	−1930.6	100	66.1
01.01.2018	Growth	3522.5	4771.1	−8193.6	100	73.8
01.01.2019	Growth	354.0	477.0	−931.0	−100	74.2
01.01.2020	Trough	2957.3	3201.8	−6259.1	−100.0	92.4

Source: calculation provided by the authors V.V. Manuylenko, A.I. Borlakova.

In the leading bank of the country—Sberbank of Russia—in the period of 2012–2019, net interest income prevails in the net profit, and the largest share of commission income is observed in the trough phase of the economic cycle—89.8%, 116.6%, and 74%. The best ratios of commission and net interest income are observed on the dates of 01.01.2016—46.8%, and 01.01.2020—44.1%. The net profit of Post Bank in 2014–2019 commission income prevails over the net interest income, the largest share of which falls on trough phases of the economic cycle—14495.4%, 589.5%; expansion—596.4%. Commission profit and net interest income ratios prevail towards commission income on the dates of 01.01.2014–01.01.2018, and 01.01.2020.

In Stavropolpromstroybank, during the trough phase of the economic cycle, commission income prevails in the net profit only on the date of 01.01.2016, whereas commission and net income ratio is negative due to the negative value of the net interest income.

Provided that the most favorable structure of income is when interest and commission incomes prevail—95%, in Sberbank of Russia during the retrospective period total share of both significantly exceeds 95%; in Post Bank, that is noted to begin from 01.01.2017, and in Stavropolpromstroybank, that is throughout the entire study period.

Understanding that in conditions of banks' exposure to risk, changes in interest rates and inflation, commission income is stable and constitutes at least 30% of total income, it should be stated that in Post Bank its share is only 0.8% and 26%, respectively, during the period of 01.01.2013–01.01.2014; in Sberbank of Russia on the date of 01.01.2017, it is 32.2%.

The determination of the commission income and the net interest income share in banks' net profit, as well as the ratio between the commission and the net interest income by the phases of the economic cycle allows the identification of the banks' income nature, and provides the opportunity to promptly implement new projects that grow up on the ground of dynamic changes in external and internal innovation environments, that in the end would assess the potential financial performance of the financial and innovative strategy of banks by the phases of the cycle (provided, introduced bank innovations bring commission income in future periods).

Based on the above, it would be fair to conclude that commercial banks, specifically regional—Stavropolpromstroybank—clearly do not generate preferable commission income in an unstable environment.

### *3.3. Development and Validation of Assessment Model for Potential Strategic Innovative Risk in Banks Based on Adapted Data Mining–Monte Carlo Method and Special Software*

It is evident that the introduction of innovations in banks is linked to uncertainty and a high risk level. Specifics of the profit received from innovations in banks and its volatility can be explained with the following:

- Adequately sensitive interest of financial technologies' consumers to the market changes, including those initiated by the regulator; low loyalty of consumers to specific financial and technical services can be a reason for them to easily discard certain financial and technical products when new ones come up or various regulatory state restrictions are introduced, etc.;
- Dynamism of offers, i.e., constant emergence of new operations, products and services;
- Level of uncertainty and risk at the heart of strategic choice;
- Uncertainty of the actual situation for taking strategic decisions.

$$\text{Future Profit} = \text{Profit of current activities (adjusted to cyclical nature of economics, type of economic activity and bank risks)} + \text{financial bank innovations profit}, \quad (1)$$

Investors' decisions on the first element are based on the linear extrapolation of profits, excluding the scale effect, and on the second element, those are based on news and published business plans of banks.

The connection revealed between innovations in banks and strategic activities, as noted in clause 2.1, suggests obtaining positive strategic economic effect from the implementation of the innovations.

Large, medium, and small banks, including regional ones, carry out strategic forecasting and assessment by means of financial and innovative Big Data technology, adapting the McKinsey data mining method, which integrates various methods of analysis and the construction of mathematical forecasting, regression models, analysis of past indicators and planning results, assuming search, transparency of new knowledge in the factual base, and its certain intellectual analysis. As a result, the adapted data mining method of financial and innovative Big Data technology provides for strategic forecasting and the assessment of potential innovative risk.

Leading banks in Russia (top 10) and around the world are the driving force for the Big Data industry. Mid-tier banks began the active integration of these technologies into their business processes (McKinsey Global Institute 2011) (pp. 27–31), (McKinsey Global Institute 2016). All groups of banks associate their growing efficiency with Big Data analytics and the e-commerce platform. Big Data and predictive analytics transform the service industry via the creation of innovative information products and services to increase the efficiency of all types of economic activities and improve business analytics. The UN defines high quality data as “the source of decision making and the feedstock of reporting” (Wright 2017). Market leaders, applying advanced analytical methods, actively use data from external sources—from mobile operators, arranging large amounts of information on consolidated platform—Data Lak.

According to KPMG (2019), Ustyugova (2019), Big Data and predictive analytics prevail among all digitalization technologies tested by financial institutions. Big Data and predictive analytics solutions bring the greatest impact.

It should be noted that Big Data technologies are used in “Sberbank” to segment consumers, build cross-selling, and regulate and prevent risks of fraud. “Sberbank” applies stored arrays, both for its own divisions and for external use, proposing statistical and predictive models—anonimized data about the bank’s clients, retail chains, etc.

Taking into account the specifics of innovations in banks that incorporate uncertainty, risk and volatility of profits, the Monte Carlo method, which describes uncertainty, is selected for strategic forecasting and assessment. Its characteristics are: the holistic inclusion of the retrospect distributions, potential inclusion of assumed volatility, assessment of difficult situations, etc.

The most suitable combination of the adapted data mining method of financial and innovative Big Data technology and the Monte Carlo simulation (data mining–Monte Carlo) is demonstrated in the potential synergy effect: the Big Data array of data determines forecast accuracy, and Monte Carlo provides predictive analytics in retrospect and future, which determines past and predictive behavior as per the key indicator, the interval nature of boundaries for optimal indicators’ values, which serve to determine their values by economic cycle phases, investing profits of new technologies, taking into account cycle phases, and financial and innovative bank strategies.

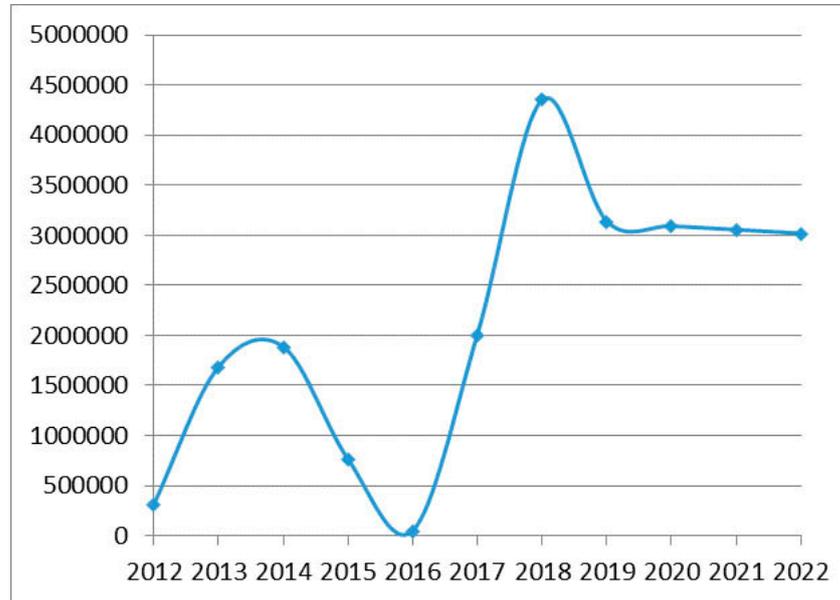
The random selection of the value of a commission income share in the net income is explained by:

- Its high volatility from period to period, which proves its exceeding permissible value;
- The main development trend emerging in terms of commission income amount during the researched period, specifically in Post Bank;
- Random fluctuations of the commission income values, and the commission income share in the net profit.

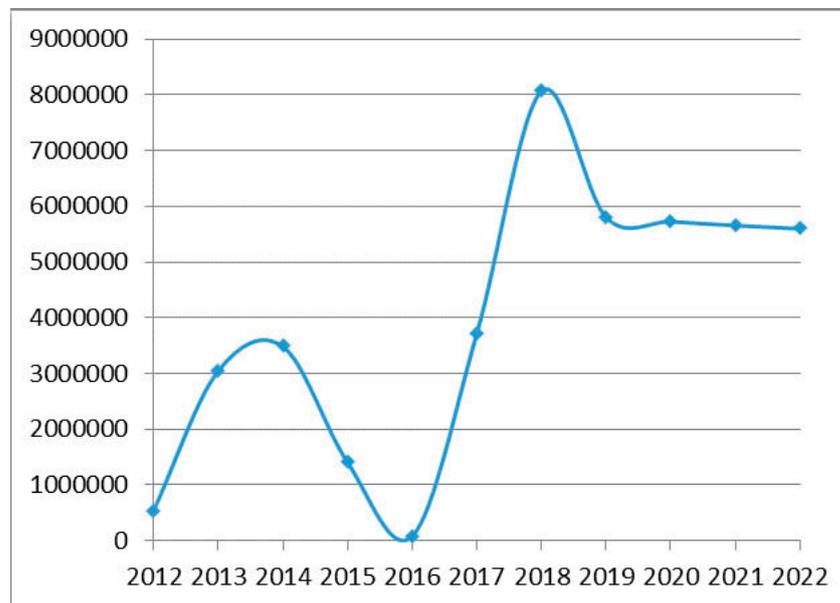
The simulated forecast level of a bank’s potential strategic innovation risk is determined with a proprietary software Excel-VBA in VBA programming language “Software for determining potential strategic innovation risk in commercial banks” (Manuylenko and Borlakova 2020). Based on the analytical results of 80,000 Monte Carlo cases, the values of the commission income and its share in the net profit can be modeled, and strategic values of the bank’s net profit are presented in Figures 1–3.

Modeling reflecting a set of generated random scenarios (simulation models) based on assumptions with established constraints requires the involvement of specialists with new competencies.

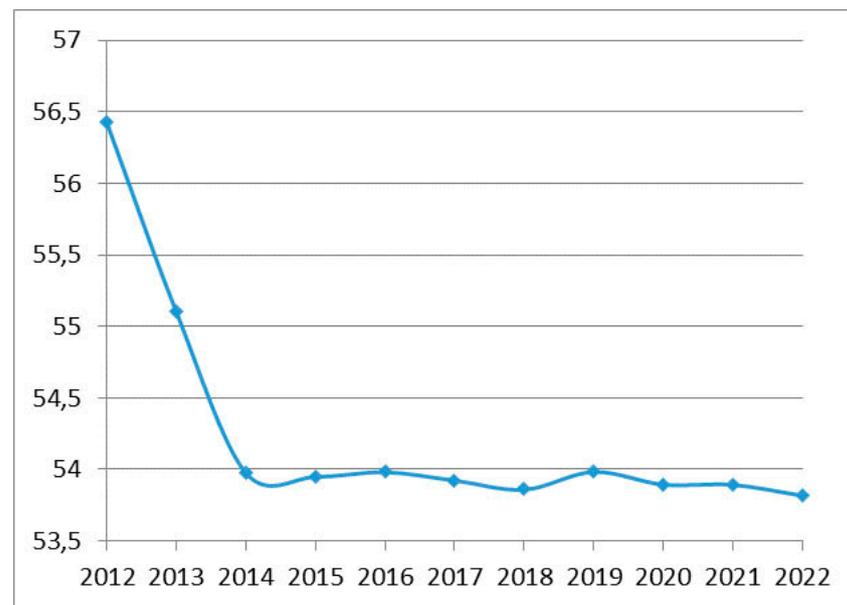
The described combined method represents an unbiased measuring instrument for potential strategic innovative risk in commercial banks.



**Figure 1.** Modeled strategic values of commission income for Post Bank, in thousand rubles (developed by authors V.V. Manuylenko, A.I. Borlakova).



**Figure 2.** Forecast strategic values of net profit, in thousand rubles (developed by authors V.V. Manuylenko, A.I. Borlakova).



**Figure 3.** Modeled strategic values of commission income share in net income, % (developed by authors V.V. Manuylenko, A.I. Borlakova).

## 4. Results

### 4.1. In Theoretical Block of the Research

- Hierarchical order was proposed for the concepts: “banking innovation”, “economic effect of innovational activities”, “financial and innovative strategy”, and “innovation risk” that will establish a foundation for the development of an unbiased tool for innovation activity assessment;
- The link between innovative and strategic management in commercial banks was identified, proving that innovations in banks cannot be carried out without a strategy, the selection of which should be based on the analysis of the external and internal banking environment; the implementation of innovations in banks should be followed with a positive strategic economic effect.

The merging of strategic and innovative activities in banks requires the need for the assessment of potential strategic innovation risk in a moment in time and in the future, whereas the parameter for assessment is the comparison of the actual and strategic values for indicators obtained after innovations were introduced in a bank.

### 4.2. In Practical Block of the Research

- It is determined that the input and implementation of innovations is influenced by the cyclical nature of economy, which requires the regulation of innovation activity profit according to the economic cycle phases;
- It was stipulated that in Russia, financial technologies make a significant contribution to the fulfillment of the UN sustainable development goal 9: “Industrialization, Innovation and Infrastructure”; notable activities are carried out to ensure the execution of the sustainable development goal: “Decent Work and Economic Growth”;
- It is proved that the evaluation of the financial performance of banks’ innovative activities in terms of commission income is more preferable. It can be reasoned as follows: it is the most stable source for obtaining financial results, it is resistant to market fluctuations, is applied to diversify risks in unfavorable market conditions; it is justified with growing demand for the remote services and non-credit transactions in the context of the digitization of products and services, emerging ecosystems and the expansion of non-core services; enhanced clients’ debt burden, aggravated with an increase in interest related to loans risk ratios; expanding income base without

- increasing the share of risky assets; participation in additional income generation; the improvement of bank's profit indicators without pressure on capital;
- The potential financial performance of bank financial and innovative strategy was assessed in the context of the economic cycle phases (provided that the introduced innovations ensure future commission income), in accordance with the nature of income (commission income share, net interest income in bank net profit, commission and net income ratio), which contributes to a rapid implementation of new projects arising from dynamic factor changes in the external and internal innovation environment.

#### 4.3. In Methodological Block of the Research

- Practical value was proved for the banks' potential strategic innovative risk assessment model, based on the adapted data mining–Monte Carlo method with a proprietary software product.

Potential banks' strategic innovation risk parameter means the comparison of the simulated and actual interrelated values of the variable—commission income, relative value—commission income share in the net profit, which may come up as a result of the introduction of innovations in bank—as shown in Table 3. This comparison reflects the risk-prone character of the financial innovation strategy, whereas significant excess of the simulated values for the corresponding indicators over the actual values states that the innovation risk level is not taken into account in the financial innovation strategy. Accordingly, the potential strategic innovation risk of banks means the probable deviation of commission income and the commission income share in the net profit from strategic guidelines that are determined by the financial and innovative bank strategy.

**Table 3.** Determination of potential strategic innovation risk of banks based on adapted data mining method–Monte Carlo.

YY	Commission Income			Commission Income Share in Net Profit. %		
	Actual. Thousand Rubles	Modeled. Thousand Rubles	Modeled/Actual. %	Actual	Modeled	Modeled—Actual Values
Russian Sberbank						
2012	177,669,005	166,243,080	93.6	56.2	52.54563522	−3.7
2013	223,458,204	202,653,270	90.7	57.8	52.4529953	−5.3
2014	282,599,928	165,480,271	58.6	89.8	52.59234619	−37.2
2015	343,075,422	154,729,372	45.1	116.6	52.57389069	−64.0
2016	160,618,710	262,077,386	163.2	32.2	52.59541321	+20.4
2017	463,506,297	427,083,885	92.1	57.0	52.55768585	−4.4
2018	568,113,707	473,776,727	83.4	63.0	52.51610184	−10.5
2019	641,849,562	455,974,751	71.0	74.0	52.59677505	−21.4
2020 strateg.		431,729,639			52.53921509	
2021 strateg.		410,940,127			52.53772354	
2022 strateg.		392,104,358			52.48858261	
Pochta Bank						
2012	4253	302,031	7101.6	0.8	56.42550021	+55.6
2013	795,151	1,680,194	211.3	26.1	55.10329319	+29.0
2014	3,657,100	1,885,110	51.5	104.7	53.9784596	−50.7
2015	6,004,516	764,350	12.7	423.8	53.95013704	−369.8
2016	12,202,365	45,444	0.4	14,495.4	53.98316681	−14,441.4
2017	22,180,864	2,005,679	9.0	596.4	53.92526674	−542.5
2018	32,926,753	4,349,565	13.2	407.7	53.86145116	−353.8
2019	34,223,999	3,134,361	9.2	589.5	53.98525683	−535.5
2020 strateg.		3,088,019			53.89692085	
2021 strateg.		3,051,827			53.89463022	
2022 strateg.		3,015,548			53.8192169	

Table 3. Cont.

YY	Commission Income			Commission Income Share in Net Profit. %		
	Actual. Thousand Rubles	Modeled. Thousand Rubles	Modeled/Actual. %	Actual	Modeled	Modeled—Actual Values
Stavropolpromstroybank						
2012	318,598	121,318	38.1	138.0	52.54563522	−85.5
2013	290,201	33,997	11.7	447.7	52.4529953	−395.2
2014	319,705	87,568	27.4	192.0	52.59234619	−139.4
2015	385,815	−146,608	−38.0	165.5	62.88008264	−102.6
2016	350,040	27,294	7.8	807.8	62.98778174	−744.8
2017	378,101	6741	1.8	3522.5	62.79898886	−3459.7
2018	334,870	−92,902	−27.7	354.0	98.1988815	−255.8
2019	321,720	−40,365	−12.5	2957.3	371.0360806	−2586.3
2020 strateg.		−52,098			118.7778163	
2021 strateg.		−63,027			86.66780425	
2022 strateg.		−72,300			73.49400201	

Source: calculation provided by the authors V.V. Manuylenko, A.I. Borlakova.

The comparison of the simulated and actual values of commission income, and the commission income share in the net profit proves that Pochta Bank and Stavropolpromstroybank pay little attention to planning commission income value, which is undesirable in the trough phase of the economic cycle. Surveyed banks do not generate commission income by the phases of the economic cycle, increasing pro cyclical effect.

Software provision under which the commission income share and the net interest income in the net profit is not <95%, and the commission income share is not <50%, allows for systematically structured financial results with consideration of the economic cycle phases.

The presented method is a formalized tool for banks' financial and innovative strategy, which serves to model and assess their innovative activities, ultimately ensuring the implementation of financial and innovative strategy.

The developed combined and adapted data mining–Monte Carlo method is distinguished by its versatility—as shown in Table 4.

Thus, the adapted data mining–Monte Carlo method is found to be of practical significance, both for banks' operational development in the moment in time and in the future, presenting future profit values (Formula (1)). On the one hand, it promotes the application of financial and innovative Big Data technology; on the other hand, it serves to assess the potential innovative risk of banks. The adapted data mining method–Monte Carlo was tested with innovation activities in "Sberbank" of Russia, Post Bank, and Stavropolpromstroybank.

The development of a validation model for the potential strategic innovation risk of banks based on the data mining–Monte Carlo method resulted in the following:

- It was determined that banks' profit from innovational activity is prone to volatility, that is expressed by the selective interest of financial technologies consumers to the market changes (including those initiated by the regulator); the dynamism of offers; uncertainty and risk levels incorporated into strategic choice; the uncertainty of the environment from the standpoint of strategic decision making;
- The main elements of future profit are highlighted and considered in the adapted data mining–Monte Carlo method; they include profits from current activities adjusted to the cyclical nature of the economy, types of business activity, bank risks as well as bank innovation profits;
- The best combination of the adapted data mining method of financial and innovative Big Data technology and Monte Carlo simulation (data mining–Monte Carlo) was proved when it was applied to the forecasting and assessment of the potential

strategic innovative risk of banks expressed in the following: the array of the Big Data determines a forecast accuracy; Monte Carlo demonstrates predictive analytics retrospectively and for the future periods, and the intervallic nature of the optimum indicator values limits, which makes it possible to establish their values by the economic cycle phases, etc.;

- It was determined that a potential strategic innovation risk parameter means the comparison of the simulated and actual interrelated values of the variable, i.e., commission income, relative value–commission income share in the net profit, which may come up in business as a result of the introduction of innovations in banks;
- It was found that the adapted data mining–Monte Carlo method can be recognized as a formalized tool of banks’ financial and innovative strategy, which is applied for innovative activity modeling and evaluation;
- Universal application areas for the combined adapted data mining–Monte Carlo method were indicated, which include: the promotion of the promising financial and innovative Big Data technology; the creation of predictive analytics; the automation of the strategic forecasting processes and potential strategic innovation risks assessments; a range of alternative strategic innovative solutions; the consideration of external conditions’ influence on financial and innovative strategy development and implementation; application in research on banks’ financial performance in different situations; desired indicators’ values are applied in creation of the “bank of the future” conception, and the identification of the trends based on data mining–Monte Carlo.

**Table 4.** Main practical application areas of adapted financial and innovative technology Big Data.

Adapted Data Mining Method–Monte Carlo in the Moment of Time and Further	Big Data Perspectives
Promotion of promising financial and innovative technology Big Data, creating information support for innovation	Predetermines the development of predictive banking in terms of strategic value of the commission income, which is at inception level in Russia and around the world
Establishment of predictive analytics (past and predictive performance of commission income)	The creation of a forecasting model for credit risks to suggest individual clients offers, efficiently allocating resources (as a way of the rational supply of a region with a branches network or ATMs, taking into account dynamic modeling and the assessment of customer flows)
Automation of the strategic forecasting process and of potential strategic innovation risk assessment	More accurate client evaluation, which may minimize loan risks
The sselection of alternative strategic innovative solutions	The increase in forecasting accuracy with scoring models of credit risks forecast
Consideration of external conditions’ influence on the development and implementation of financial and innovation strategy	The administration of liquidity regulation platforms, demanding that banks build new data accumulation systems—“business sensors” at customers’ ecosystems levels, the creation of efficient ecosystems and availability of their status Big Data, which minimizes portfolio risks by means of “risk forward looking” systems
Applied for the assessment of banks’ financial dynamics in different situations (availability of large arrays of client data allows the bank to have the best knowledge of their customers and offer them the best financial solutions); desired indicators’ values are applied for the development of the “bank of the future” conception Identification of trends based on data mining–Monte Carlo	

Source: provided by the authors V.V. Manuylenko, A.I. Borlakova.

## 5. Discussion

The authors believe that the developed model for the assessment of potential strategic innovation risks in banks based on the adapted data mining–Monte Carlo toolkit and a proprietary software product is worth being further promoted with application of various forecasting periods and fulfillment of requirements by the national and international regulators. Hence, the Bank of Russia considers the possibility of attracting computer learning technologies and to introduce of Big Data methods, computer learning and chat bots for the robotic processing of notifications (Bloomchain 2019). A considerable portion of the national banking sector envisages the application of Big Data for businesses by 2030, implying the maximum accurate assessment of clients and significantly minimized loan risks. The comparison of the most popular technologies in 2019 according to the results of KPMG (2019): Ustyugova (2019) in Russia and Garther (2021) notifies that by 2023, Big Data tools and predictive analytics will be listed among top technologies.

The development of a promising financial and innovative Big Data technology, under requirements of the national and international regulators, may contribute to the creation of a model for the assessment of potential strategic innovative risk in banks based on the adapted data mining–Monte Carlo toolkit with a software product at a new level, and serve as an input to the creation of the “bank of the future” conception. Meanwhile, process modeling for strategic innovative decision making justifies an alternative development level for the presented model. Taking into account possibility of implementing the model by the phases of the economic cycle, each bank, depending on its size, financial potential or competencies, may plan and introduce innovative operations, services and products. The model’s automation process may be enhanced by possible combinations of Big Data application and artificial intellect technologies, as well as Big Data cloud computing and the Internet of Things, through which, collaborative implication may ensure a synergistic effect.

For the innovations that are described as being risky dynamic opportunities, financial and innovation strategy must be closely related to the development of tools that regulate and assess innovation risks. The developed adapted data mining–Monte Carlo method for the assessment of potential strategic innovation risk in banks emphasizes the close connection of the innovative and strategic management of banks and takes into account differences and opportunities for innovative activities of banks considering their size, and the phases of the economic cycle both for the current moment and the strategic perspective. The application of the adapted data mining–Monte Carlo toolkit makes it possible to evaluate and simulate the innovative activity of banks, eventually ensuring the implementation of financial and innovative strategies. Taking into account the universally positive practice of Russian financial technologies in achieving the UN sustainable development goal 9: “Industrialization, Innovation and Infrastructure”, those are focused at achieving the sustainable development goal: “Decent Work and Economic Growth”.

Thus, the adapted data mining–Monte Carlo method was developed based on the optimal combination of the data mining method of financial and innovative Big Data technology and the Monte Carlo simulation, the implementation of which promotes financial and innovative Big Data technology and serves to assess potential innovative risk in banks in the “open innovation” system. It is important to admit that the adapted data mining–Monte Carlo method based on financial and innovative Big Data technology and the Monte Carlo simulation is implemented in the “open innovation” system. Thus, it ensures its development during any moment in time and in the future by means of alternative technologies’ inclusion, and/or their possible combinations, such as Big Data, cloud computing, the Internet of Things, predicative analytics, etc.

## 6. Conclusions

Thus, the implementation of the model for potential strategic innovation risks in banks based on the data mining–Monte Carlo method resulted in the following:

- A glossary tool was compiled based on the study of the hierarchical order of the concepts: “banking innovation”, “economic effect of innovational activities”, “financial and innovative strategy”, and “innovation risk”, serving as a basis for the development and promotion of a potential strategic bank innovation risk assessment tool;
- The concept of “innovative risk” in banks was interpreted as a probability of wrong choices and the implementation of financial and innovative strategy that excludes dynamic opportunities and flexibility in making strategic innovative decisions, that served as methodological grounds for the development of tools for risk regulation and evaluation;
- An assessment method was suggested for the financial performance of the financial and innovative strategy of banks by the economic cycle phases, which includes partiality of the commission income generation under the condition of instability, assuming the determination of a bank’s income nature in financial totals, the ratio between commission and net interest incomes based on the expert professional judgment, the implementation of which would reveal potentials for banks’ innovative activities development that ensure the receipt of a positive strategic economic effect in the context of instability;
- A promising model was developed for the assessment of a potential strategic innovation risk of banks based on the adapted data mining–Monte Carlo toolkit with a software product, which describes modified strategic values of commission income, the commission income share in the net profit, deviations of the strategic and actual values; the application of the model allows for the selection of alternative strategic innovative solutions considering economic cycle phases, and forming possible scenarios for the development of the “bank of the future”.

The working hypothesis is proved in the study, i.e., the method for assessing banks’ potential strategic innovative risk was developed and tested based on the author’s software product and via the adapted data mining–Monte Carlo tool, the assessment indicator of which is probability of deviations in the values of the commission income and for the commission income share in the net profit from the strategic settings of banks’ financial and innovative strategy. Its implementation, on the one hand, makes it possible to determine promising strategic innovative solutions for the phases of the economic cycle and, on the other hand, to develop an innovative digital product strategy by means of financial and innovative Big Data technology.

The model for the assessment of the potential strategic innovation risk in banks was introduced into operations of Sberbank, Post Bank, VTB and Stavropolpromstroybank.

The efficient implementation of the adapted data mining–Monte Carlo method in different areas such as in the “open innovation” system would require the identification of prospects, which affect the financial and innovation strategy of banks and imply:

- The determination of the trends for intellectual capital development in the context of economic processes digitization; a certain study of intellectual capital in corporations was carried out by [Galazova et al. \(2017\)](#);
- The development of the toolkit for the regulation, assessment and forecasting of banks’ risks based on Big Data financial technology: [Voronova et al. \(2016\)](#);
- The development of the technology for assessment methods of potential strategic innovative risk in banks within an innovation system, [Kulagina et al. \(2019\)](#).

Considering the opportunity for developed method to be implemented in the open innovation system, it becomes possible for various financial institutions by their own initiative and based on the proposed scientifically grounded toolkit, to create and modernize any invention or recommendations for the creation and development of tools for the assessment of potential strategic innovation risk in banks based on data mining–Monte Carlo.

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