Financial engineering of business processes and investment of industrial companies in the innovation system of megacity

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Abstract.

Research background: The UN usually defines cities with more than 1 million inhabitants as megacities. As of 2019, over 55% of the world's population lives in metropolitan areas. Nowadays, rapid population growth and urban growth have created many socio-economic problems, but also created enormous potential for opportunities. On the one hand, risks, depletion of urban resources, industrial isomorphism, environmental pollution and environmental damage, and, of course, we must not forget about the global virus that is adjusting urbanization processes. On the one hand, risks, depletion of urban resources, industrial isomorphism, environmental pollution and environmental damage. And, of course, we must not forget about the global virus that is making adjustments to the processes of urbanization. On the other hand, megalopolises reduce the costs of doing business, stimulate the process of the birth of new types of business, create new forms of organizations, and create jobs. Megacities are a generator of innovation.

Purpose of the article: to develop proposals for the creation of a scientific center of a representative megacity for financial support of innovations and for monitoring information flows and risks.

Methods: used in the research: financial engineering, mathematical modeling, robo-advising, crowdfunding, big data technologies.

Finding & Value added: Based on the results of the research, a digital platform model and methodology for creating innovative financial products will be created. The model will allow administrative staff to monitor and shape the financial policy of the metropolis. Innovative financial products will be used on the investment platform and will help solve the problem of credit deficits for companies in the early stages of their life cycle.

Keywords: *blockchain-technologies; megacity; financial engineering; roomdining; crowdfunding; IoT*

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1 Introduction

According to the UN definition, a city with a population of over 1 million has the status of a metropolis. The number of megacities is growing. As of 2019, more than 55% of the world's population lives in metropolitan areas. There are 15 megacities in Russia, 130 cities in China, 45 in the USA, 36 in Europe and 46 in South America. The number of megacities with a population of more than 10 million people increased from 28 in 2014 to 33 in 2018 that is, more than tripled. Currently, the rapid population growth and urban expansion have created many social problems, but also opportunities [1]. On the one hand, risks, depletion of urban resources, industrial isomorphism, environmental pollution and environmental damage, and others. Moreover, of course, we must not forget about the global virus that is adjusting the processes of urbanization.

The number of megacities with a population of more than 10 million people increased from 28 in 2014 to 33 in 2018 that is, more than three times more, and continues to increase now, although in 1990 they began to talk about the decline of megacities. Currently, the rapid population growth and urban expansion have created many social problems, but also opportunities risks such as depletion of urban resources, industrial isomorphism, environmental pollution and environmental damage, and others. These problems have created unprecedented pressures and challenges for economic and social development. Many urban areas are growing at the expense of rural decline, forcing impoverished rural residents to move to cities in search of work.

Usually newcomers become urban poor and they face the following problems: lack of housing, lack of necessary infrastructure (example of Detroit and the homeless town of New York) lack of property rights. Over the past 50 years, the number of slum dwellers has increased from 35 million to over 900 million. Over the next 30 years, it could double - according to forecasts by the World Bank.

But it should be noted, in this regard, the reforms of China, as a result of which, from 1978 to 1989, the number of rural poor fell from 250 to 34 million [2,7].

The modern world is characterized by a constant transformation of various factors against the background of a qualitative change in the lifestyle of megacities. In recent years, financial markets have been changing a lot, the role of non-bank financial intermediaries is growing, the variety of financial products is increasing, and the role of robo-advising, block chain, crowd funding and other financial innovations is growing. One of the observable trends in the development of national innovation systems is the formation of innovative megalopolises, which become their core. The role and place of megalopolises in the economic development of the country lies in the fact that they create optimal conditions for economic activity, and are also stabilizers and, at the same time, the engines of the entire socio-economic system of the country [3].

2 Statement of the problem

In the modern economic structure, the core of the regional economy is the urban economy. The rapid development of the region's economy largely depends on the development of the economy of the metropolis. Most of the innovation resources of the regional innovation system are practically concentrated in cities, especially in megalopolises. This naturally makes the metropolis an innovative center of the region. However, as a special economic region, the city's innovation theory has rarely been studied in the literature. From the point of view of theoretical studies, Glushchenko V. M., Novikov A. N., Pronkin N. N., Prokofiev A. I., Shilova G. F. (2012) believe that the analysis of the innovation system is best based on the scale of a metropolis, since its scale and resources are more consistent with the scale of modern transnational corporations. This is in line with the theoretical

hypothesis that an efficient urban form allows enterprises to enter the broader labor market and expand employment opportunities. Romanova A. P. (2016) and Vulfovich R. M. (2007) compare the path of development of the innovation system in several European megacities. They also offer a fresh perspective on regional innovation and networking.

By combining the definition of the national innovation system and the regional innovation system, as well as the characteristics of urban innovation, it is possible to define the urban innovation system as follows: the urban innovation system is a subsystem of the national innovation system. It is a structure that supports urban development driven by market demand and streamlined development of a national (regional) strategic framework and serves as a source of innovation, both technological and institutional.

Among the various factors supporting the construction of innovative cities, financial support plays an irreplaceable role. Research on the impact of finance on urban innovation is mainly focused on four areas:

- 1) State policy. Based on the experience of building many famous cities such as Austin and Seattle in the US, Bangalore in India and Helsinki in Finland, the government plays a very important role in financially supporting the construction of innovative cities;
- 2) Banking financial system. Strategic banks are often the main source of financing for the construction of innovative cities. Commercial banks provide many financial instruments for urban development. In addition, they also contribute to the efficient allocation of resources. Non-bank financial institutions help dissipate risks and insure risks in urban construction;
- 3) Market financial system. The financial market can efficiently collect and distribute funds, effectively regulate the distribution of social funds, and contribute to the coordinated development of the urban economy, as well as the optimization of the economic structure. The complete financial market should include the money market, capital market, foreign exchange market and gold market. Each market is indispensable for financial support for innovative urban development;
- 4) Financial service and support system. The development of innovative cities is inseparable from financial services, financial products and financial instruments such as credit, insurance, trust, securities issuance and trading, financial derivatives transactions, venture capital, foreign exchange management, etc. In addition, new financial technology tools in this area also provide strong support for urban innovation.

3 Methodology

Financial innovations in megacities not only contribute to the development of the local financial industry and economy, but also the development of local markets through agglomeration and economies of scale. A regional financial center can support local industry and stimulate economic development; they can carry out international capital lending, bond issuance, foreign exchange trading, insurance and other financial services. Currently, the largest financial centers are located in metropolitan areas: New York, London, Hong Kong, Singapore, Shanghai, Tokyo, Toronto, Zurich, Beijing and Frankfurt, most of which are metropolitan areas. The most interesting methodology for such an analysis is the methodology for calculating the Global Financial Centers Index (GFCI), which has been published since March 2007 at the request of the City of London. Thus, the study of the role of financial innovation in the development of financial centers in metropolitan areas can help formulate and adjust solutions in the field of financial innovation from a scientific point of view and improve the level of development of the economy as a whole [7].

Currently, the world is experiencing a slowdown in economic growth. Financial risk can be imported, so the risks of metropolitan areas often spread to nearby cities. If not neutralized, they can cause national and even global economic fluctuations. If a set of accurate measurement methods can be created, it becomes possible to effectively control the financial risks of megacities and surrounding areas. In the era of big data, the Internet of Things, artificial intelligence, blockchain technologies and virtual reality, this complex network structure and dynamic changes have acquired new characteristics such as high complexity, high endogeneity, and rapid change over time. They set new challenges in research on the innovation system, business processes, financial risks, and the pricing of financial products in megacities. These include the study of the complex structure of the network and the process of its development, the study of driving factors and dynamic development, the identification and processing of cause-and-effect relationships, and the description of risk aggregation mechanisms. At the same time, it is transforming the control mode thanks to digital regulation. This process is aimed at: improving the quality and efficiency of financial regulation through mathematical modeling, big data technology and artificial intelligence [8,9].

The algorithm for the impact of research centers on the economy is shown in Figure 1:

Fig. 1. Algorithm for managing a megalopolis scientific center

In accordance with the algorithm presented in Figure 1, the sequence of the megalopolis management processes can be described:

- 1) Analysis of key indicators of financial innovation and their typification, systematically studies the impact of financial innovation on the development of financial centers in megacities around the world. For example, such indicators as the level of economic development, financial management and financial concentration are assessed. These indicators are used in models.
- 2) Local markets are then selected (eg, the energy and equity markets in China and Russia) to empirically analyze information transfer and risk propagation effects. Thus, it is possible to further discuss the evolution dynamics affecting the factors, as well as risk management strategies. Information dissemination effects can be tested

using the Granger model. It will be necessary to assess the impulses between the financial markets (securities market, energy market, foreign exchange market) of Chinese, Russian, European and American megacities.

- 3) Secondary spread statistics can then be used in the sliding window model to calculate the evolutionary relationship between securities, crude oil and other financial markets in metropolitan areas. Thus, it is possible to assess the "support" for preventing the spread of risks in international financial markets.
- 4) With the advent of the big data era, huge strategic assets such as text data, image data, audio data, online shopping platform data, search engine data, social media data, and mobile data have become available. This readily available, complex data contains important information about the operation of financial markets. From this information, enough data can be extracted to build indicators for monitoring. Taking into account the characteristics of metropolitan areas, it is possible to develop a comprehensive system for monitoring, forecasting and early warning of risks, suitable for metropolitan research.

The system can be divided into six blocks:

- 1) A monitoring and forecasting system based on the objective function and constraints - characteristics of megalopolises in different economic financial systems in different countries. The used method of econometric modeling is based on the method of econometric modeling with time-varying and discontinuous characteristics;
- 2) An econometric model of macroeconomic forecasting for megalopolises. By incorporating big data into economic modeling, such as Internet search data, public opinion data, online shopping data, and high frequency financial metrics, the timeliness of macroeconomic forecasting and decision making can be improved;
- 3) Model of participation in global economic integration. To create it, you can use the VAR panel, directed acyclic graph, GARCH models and Copula models to compare and analyze the similarities and differences in economic financial risks, as well as the mechanism of their transmission in different countries and metropolitan areas of different types;
- 4) Indices for measuring economic and financial risks and the corresponding system of risk forecasting and warning, which will allow you to track potential risks in real time in the operations of megacities. Thus, it is possible to provide effective decision support to prevent and control systemic risks in the economic and financial areas;
- 5) A system of regular publication of real-time economic indicators, such as high frequency leading index, consistent index, lag index, surprise index and uncertainty index, to provide decision-makers and policymakers with important background information for understanding financial development trends in metropolitan areas and formulating timely regulatory policy;
- 6) The theory of modeling a financial risk network, which includes [9]:
 - Machine learning algorithms and methods of econometric modeling, large-scale network data, based on which it is possible to assess the trends of the financial network;
 - An integrated game-theoretic econometric model, to identify the mechanism of aggregation, transmission and enhancement of systemic risks, on the basis of which new tools for early warning and prevention of financial risks can be effectively provided;
 - The theory of evolutionary complex networks for the study of metropolitan networks, for the use of methods of statistical analysis of risk factors;
 - Method of causality in big data models with factors and networks.

4 A method for modeling complex data in the financial markets of a metropolis

In the era of big data, such shown as large volume, large size, structural, heterogeneous, time-varying variables and rarity are becoming relevant. As a result, the traditional time series model and panel data model cannot provide a reliable analysis framework and theoretical basis. In most cases, interval data will be incorrect due to limitation of micro data aggregation, incomplete information and design. In addition, global trading companies still have an impact on the entire market. Therefore, financial and technological innovation is a priority: in the pricing of assets, in determining the price of financial risks in any innovation. Modeling and applying complex data can provide new methods for future financial technologies based on Block chain, Ethereum and other digital platforms and traditional econometric methods such as EMD, BEMD and MEMD. In particular, when describing the ecosystem of a metropolis, one can describe the social ecosystem characteristics of generating financial data and choose a method for aggregating innovative capital, then, one can proceed to a digital description of the business model of the innovative system of a metropolis. The next step is to diagnose the impact of multi-source and multimodal financial data on the financial innovation system. Finally, you can explore methods and ways to improve the efficiency and quality of financial management.

Today, the Internet of Things (IoT) has become an important foundation for the development of an exchange economy in metropolitan areas. The development of IoT can provide a more complete infrastructure for sharing economies in metropolitan areas. Analysis of the regulatory impact of various systems, cultures, scientific and technical environment of megalopolises on the development of the sharing economy can provide scientific support for decision-making.

The application of block chain technologies in financial engineering focuses on the area of risk prevention and control. For example, in the area of supply chain finance, both ends of the chain can be extended with Block chain + IoT + Artificial Intelligence, which improves the quality and level of credit for suppliers or distributors. The main block chain technology is a distributed database. In the context of big data, the key is how to extract timely information useful for decision-making. Traditional statistical training methods are usually based on full samples to ensure training accuracy. However, block chain data is often scattered across a large number of servers and is updated in real time, which inevitably leads to significant bandwidth costs and data security issues. On the other hand, the cost of complex data operations (such as principal component analysis, clustering, variable selection, etc.) is often exponential with scale. Since the scale of financial data is extremely large, this easily leads to unacceptable transaction costs [10].

5 Results

In theory, the results of existing research focus on either the national and regional innovation system or the competitiveness of the city. Research combining the two from a financial innovation perspective is rare. According to the authors, the symbiosis of these two directions will allow obtaining the following results:

- Creation of a system for monitoring and early warning of financial risks for megacities.
- Creation of a platform for modeling and designing the financial policy of the metropolis;
- Development of a methodology for the design of innovative financial products to overcome the problem of a shortage of credit funds and the elimination or leveling of problem debts;

- Get an algorithm for assessing and ranking the constraints and threats to financial innovations in a megacity;
- To develop a comprehensive model of an indicative mechanism that stimulates the innovative activity of industrial corporations in the context of the digitalization of the economy;
- Develop a block chain technology for scheduling financial transactions;
- Develop a strategy for financing innovative projects based on digitalization to strengthen the competitive position of companies.

4 Discussion

In recent years, economic zoning has become more and more priority for the national economy. For a country, its ability for regional innovation is directly related to its international competitiveness. The theory of the national innovation system is not new, but it has become relevant in a new way in recent years. For example, Bjorn et al. (2016) and others emphasize the importance of this system [11]. Zhou et al. (2011) and Paajanen et al. (2002) highlight the state of the innovation network [12,13]. Cooke was a pioneer in (1992) proposing to strengthen the priorities of the interests of industrial enterprises in the region when defining the mission of the regional innovation system, noting the need to include in the innovation system research institutions and higher education institutions that are geographically separated but related to each other by a common, above all, a social problem. This kind of association supports and creates innovations. Many scientists have tried and are trying to determine its optimal structure. Two points of view were formed. On the one hand, some scholars, such as Coke and Wang focus on the need to have promising innovative subsystems in the structure. On the other hand, scholars such as Zhou et al. (2011) and Paajanen et al. (2002) are focusing on promising organizations and related support institutions [12,13]. This situation is reminiscent of the ancient Roman discussion about the main factor of victory: having an experienced army or a worthy military leader. However, most researchers believe that an effective innovation system should consist of a main subsystem (the main elements include industrial organizations, universities, research institutions, intermediary agencies and local governments) and a structural subsystem consisting of functional and environmental subsystems. These subsystems interact with each other to form a synergistic amplifier for the regional innovation system.

The polycentric development of cities, and their effective management, is inextricably linked to the increase in their number and size. This structure provides functional diversity and variability in the consumption of urban space by residents. Determining the centers of coordination of urban life based on indicators of competitiveness, researchers Bezdudnaya et al. (2018), Gryzunova et al. (2019) say that the true urban sub-centers are the centers of attraction of “voluntary visits” and the “Internet of things” [14, 15]. Places of concentration of connections and interests between various subjects of urban life and ordinary people are understood as “institutional centers. The spatial structure of a polycentric metropolis is determined by the location of these centers, and this structure is dynamic.

In the literature, much attention is paid to the study of the national innovation system, but the rarity is the innovation system of the megalopolis. Most researchers consider the urban innovation system as a special form of regional innovation system, ignoring the distinctive characteristics. Most of the research is devoted to the description of elements and their functionality. Research on the interaction of elements, the mechanism of the system's operation and the principles of construction, as the authors of the article suggest, is still carried out quite rarely, so the research functionality is still limited.

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