

**INFLUENCE OF PEER-TO-PEER LENDING ON TRANSFORMATION OF  
FINANCIAL ARCHITECTURE AND ECOSYSTEM**

**INFLUÊNCIA DO EMPRÉSTIMO PEER-TO-PEER NA TRANSFORMAÇÃO  
DA ARQUITETURA FINANCEIRA E DO ECOSISTEMA**

**INFLUENCIA DE LOS PRÉSTAMOS PESICOS EN LA TRANSFORMACIÓN  
DE LA ARQUITECTURA Y EL ECOSISTEMA FINANCIEROS**

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## ABSTRACT

The goal of the study is to determine the impact of peer-to-peer lending on transformation processes in the financial architecture and ecosystem. The study hypothesizes that peer-to-peer lending is transforming the financial architecture and ecosystem of the financial market, creating additional positive effects for both consumers and businesses. To investigate these problems, the authors rely on the methodology of the systems approach, emphasizing the importance of using the case-based method and scenario simulation methods to understand the place, role, and prospects of peer-to-peer lending in the developing financial ecosystem as well as in the transformation processes of the financial architecture. The study results in the following conclusions. It is revealed that the peer-to-peer lending market is part of the financial market and has the most significant points of contact with the credit market and the market of microfinance and microcredit organizations.

**Keywords:** Peer-to-peer lending, Ecosystem, Architecture, Finance, Funding rounds.

## RESUMO

O objetivo do estudo é determinar o impacto do empréstimo peer-to-peer nos processos de transformação na arquitetura e no ecossistema financeiro. O estudo levanta a hipótese de que os empréstimos peer-to-peer estão transformando a arquitetura financeira e o ecossistema do mercado financeiro, criando efeitos positivos adicionais para consumidores e empresas. Para investigar esses problemas, os autores contam com a metodologia da abordagem de sistemas, enfatizando a importância de usar o método baseado em casos e métodos de simulação de cenários para entender o lugar, o papel e as perspectivas do empréstimo peer-to-peer no desenvolvimento financeiro. ecossistema, bem como nos processos de transformação da arquitetura financeira. O estudo resulta nas seguintes conclusões. Revela-se que o mercado de empréstimos peer-to-peer faz parte do mercado financeiro e possui os pontos de contato mais significativos com o mercado de crédito e o mercado de microfinanças e organizações de microcrédito.

**Palavras-chave:** Empréstimos peer-to-peer, Ecossistema, Arquitetura, Finanças, Rodadas de Financiamento.

## RESUMEN

El objetivo del estudio es determinar el impacto de los préstamos entre pares en los procesos de transformación en la arquitectura y el ecosistema financiero. El estudio plantea la hipótesis de que los préstamos entre pares están transformando la arquitectura financiera y el ecosistema del mercado financiero, creando efectos positivos adicionales tanto para los consumidores como para las empresas. Para investigar estos problemas, los autores se basan en la metodología del enfoque de sistemas, enfatizando la importancia de utilizar el método basado en casos y los métodos de simulación de escenarios para comprender el lugar, el papel y las perspectivas de los préstamos entre pares en el sector financiero en desarrollo. ecosistema, así como en los procesos de transformación de la arquitectura financiera. El estudio arroja las siguientes conclusiones. Se revela que el mercado de préstamos peer-to-peer es parte del mercado financiero y tiene los puntos de contacto más significativos con el mercado crediticio y el mercado de microfinanzas y organizaciones de microcrédito.

**Palabras clave:** Préstamos entre pares, Ecosistema, Arquitectura, Finanzas, Rondas de Financiación.

## 1 INTRODUCTION

Currently, the development of the Russian market of peer-to-peer lending is determined primarily by the difficult epidemiological situation and high geopolitical risks, which in turn negatively affects macroeconomic indicators, including the real disposable household income. With high inflation and limited attraction of bank financial resources, individuals and legal entities - small businesses are forced to turn to unorthodox financial mechanisms to borrow funds, which gives impetus to the development of the Russian peer-to-peer lending market.

According to the changed legislation of the Russian Federation, most entities providing peer-to-peer platform services are currently registered as investment platforms (for example, such companies as "Penezha", "Gorod Deneg", "Modul Dengi"). However, there are still players in the market who provide their services based on intermediary agreements without registration in the register of the Central Bank of the Russian Federation (for example, "BezBanka"). Nevertheless, changing the legislation does not prevent the development of the Russian peer-to-peer lending market but only regulates it, primarily to reduce risks for unqualified investors.

The combination of specific challenges in the form of the global pandemic phenomenon and general trends in digitalization has accelerated the transformation of the general mentality of Russian business in understanding the importance of using modern technologies. This development trend corresponds to the global trends in the digitalization of the economy (Zimmermann, et al., 2020; Jawad et al., 2021). The large-scale forced transition to online or remote relationships with customers and partners contributes to the emergence of a new format of the business industry based on the use of innovative technologies in conjunction with financial products. Not only technology companies but also the largest players in the financial world, for example, such as Synchrony Financial, Bank of China Limited, UBS Group AG, Sberbank have shown increased interest in such solutions. One of the most promising areas for the development of the financial market and the financial system as a whole is, first, the creation of new financial services for small and medium-sized businesses, including sole proprietors and individuals, and second, attention to using the capabilities of these new technological services from potential investors.

We believe that with the active development of fintech startups, consumers, under the influence of lockdown effects, urgently master digital technologies and acquire new experience of living in a digital environment, and the vector of business development is shifting towards functioning on different technological platforms (Sempere, 2020; Siek, Sutanto, 2019; Haddad, Hornuf, 2019).

The ecosystem and architecture of the financial system also do not remain static but gradually change under the influence of almost ubiquitous digitalization and the development of financial technologies. One of the innovative funding mechanisms, which is a consequence of the transformation processes in the credit market, is peer-to-peer lending. "Peer-to-peer lending implies the provision of funds by one person to another person on loan without the participation of traditional intermediary lending systems, such as banks. The necessary amount of money that the borrower wants to receive through peer-to-peer lending can be accumulated from several lenders at once. As part of peer-to-peer lending, the lender-investor can provide financial resources (invest) immediately in the pool of borrowers to diversify risks. At present, peer-to-peer lending involves the provision of financial resources on a short-term or medium-term basis" (Zhdanova et al., 2019, p. 117).

The goal of the study is to determine the impact of peer-to-peer lending on transformation processes in the financial architecture and ecosystem.

The study hypothesizes that peer-to-peer lending is transforming the financial architecture and ecosystem of the financial market, creating additional positive effects for both consumers and businesses.

To achieve the goal and prove or refute the hypothesis, we solved the following tasks: we studied the concepts of financial architecture and financial ecosystem; showed the role of peer-to-peer lending in the system of funding the operations of economic entities; proved the need to introduce peer-to-peer lending into the financial system; showed the place of peer-to-peer lending in the financial architecture and ecosystem on the example of Russia.

## 2. LITERATURE REVIEW

Determining the place of peer-to-peer lending in the ecosystem and architecture of the digital financial system requires disclosing the essence of the financial architecture and indicating the role of digitalization in the financial market, as well as studying the general characteristics of the ecosystem.

Although the term "financial architecture" is currently quite popular among analysts and in the financial business environment, there are no unified approaches to defining its economic content. In most cases, "financial architecture" is understood as a set of institutions and established rules for the circulation of capital. One of the first to introduce the concept of "financial architecture" was S. Myers. The scholar proposed the concept of the financial architecture of the company: "the financial design of the business, including ownership, the legal form of organization, incentives, financing and allocation of risks among investors" (Myers, 1999, p. 134). According to another approach, financial architecture is a set of its subjects and their interrelationships. At the same time, the subjects are individual, institutional, and qualified investors, government agencies, and other organizations participating in the financial market (Ivanov, n.d.). In this case, one can find signs of analogy with the essential characteristics of the concept of "financial system": from the perspective of considering the system as a set of structural elements that represent a whole. There is a point of view according to which financial architecture is understood as "the structuring of financial resources according to the sources of their occurrence and use" (Baranova, 2016, p. 220).

The world financial architecture can be considered as a set of economic relations, through which the principles of building the world financial system and national financial systems are determined, as well as financial institutions based on which national and world financial systems are built (Trifonov, 2016). In particular, the International Monetary Fund defines the international financial architecture as a set of institutions, markets, rules of interaction, and practices that government bodies, companies, and individuals carry out in their economic and financial operations (Finansovaya arkhitektura postkrizisnogo mira..., 2009). In other words, there is an obvious institutional approach in this case. Foreign researchers adhere to a similar view: for example, R.D. Germain presents the international financial architecture as "a set of institutional organizations that determine who makes the rules, which rules, when and how" (Rzhevskaya, Ivanov, 2014, p. 115). A well-known world-renowned financier, G. Soros, focuses on international institutions, understanding international financial architecture mainly as international financial institutions and their interconnections, as well as their role in the financial system.

Summarizing the definitions of financial architecture, it can be stated that the institutional approach dominates if the majority of the authors believe that various financial

institutions are one of the main elements of financial architecture. Financial institutions are the pillars of financial architecture. Moreover, it is obvious by revealing the essence of financial architecture, a non-institutional approach also attracts attention from the position of studying special principles, rules, and procedures for the interaction of economic entities within it.

In turn, ecosystems are considered as open self-organizing, self-regulating, and self-developing systems (Karpinskaya, 2018). One of the reputable Russian researchers, G.B. Kleiner (2018, p. 10), focusing on socio-economic ecosystems, notes that the systems "are currently becoming the central element of the country's socio-economic landscape". In general, the ecosystem approach is not new; it is successfully applied in the analysis of various areas of the life of society, for example, in the study of venture capital funding (Berman, Cano-Kollmann, Mudambi, 2022). The ecosystem approach assumes that the object under study is considered as an open system, subject to the influence of exogenous and endogenous factors and continuous transformation (both evolutionary and degradative).

Similar to the concepts of "financial architecture", "financial ecosystem", there is no single, universal approach to the essential features of the digital economy. Digital financial architecture is not just a collection of information but a mechanism aimed at the exchange of information, including non-financial information, in electronic form between people and organizations. "Digitalization of society and knowledge is key to sustainable development" (Mishakov et al., 2021, p. 268).

### 3. METHODS

Achieving this goal and testing the formulated hypothesis is primarily based on the methodology of systems analysis which formed the basis of the study. This is because a systemic approach, including a combination of the comparative and factor analysis, the grouping method, formalized simulation, and diagnostic assessments used in the work, made it possible to optimally assess the possibilities and prospects of embedding peer-to-peer lending into new financial ecosystems in the study of the potential of peer-to-peer lending.

The comparative analysis was logically complemented by the case-based method, which involved the consideration and analysis of real economic and business situations. In this case, the method was used to study the features of using peer-to-peer lending. In this part of the issue, the consideration of alarm signals from government institutions is also of interest

to researchers. Thus, according to the Bank of Russia, there is currently a challenge in terms of ensuring competition between financial institutions to create an efficient financial ecosystem. Indeed, many players in the financial markets find it difficult to compete with such large and technologically advanced financial institutions of the international level as Sberbank. The use of the case-based method helped to reveal the specific features of the influence of peer-to-peer lending on further transformation processes of the entire architecture of the Russian financial system.

To assess the standard-expected and actual orientation of the innovative mechanism of peer-to-peer lending to the current needs, we used the structural-functional method. We discovered that peer-to-peer lending could give an impetus to increasing the return on existing ecosystems and contribute to the formation of new ones. The application of the method made it possible to identify that peer-to-peer lending could be useful to solve the problem of a shortage of financial resources for small and medium-sized businesses, and the phenomenon also corresponds to the general trends of digitalization and has reserve capabilities for its implementation on blockchain platforms using smart contracts.

To assess the possibility of seamless integration of peer-to-peer lending into the current financial system, we used the materials and methods for building a credit risk model, namely the loan scoring method built on the ensemble methods.

Ensemble methods have become extremely popular in credit risk analysis. This method is based on the integration of a set of individual models of different nature to reflect the best characteristics of each algorithm. Z Huang et al. (2004) demonstrated a significant difference between statistical methods and machine learning approaches. Ensemble methods are preferable to individual models in terms of accuracy prediction (Zhu et al., 2017).

However, in the scoring-related literature, the topic of time-varying parameters is very popular in time series forecasting, for example, in the works by Bitto and Frühwirth-Schnatter (2019), Chan and Eisenstat (2019). Since most economic time series are subject to parameter volatility, such models usually provide increased accuracy. To illustrate this statement about time-dependent parameters when working with scoring models in the economic environment, we present the results of an empirical study for a microfinance organization.

The form of an online survey that we used as a modern way of communicating with the market for quickly fixing the need for this technology or repelling a potential client,



determining the client's expectations, was aimed at obtaining objective development factors of the Russian peer-to-peer lending market. More than 300 people were surveyed. Based on the data obtained, conclusions were drawn about the market demand for peer-to-peer lending and its possibilities for inclusion in a company's financing system, which is presented below in Section 4.1.

## **4. RESULTS**

### **4.1. Peer-to-Peer Lending in the System of Sources of the Company's Financial Resources**

Any economic entity, be it an individual or a legal entity, is a priori the bearer of financial resources that, within the framework of its consumer behavior, can determine what, how, and for whom to produce, considering the market conditions. Accordingly, the needs for financial resources change over time which requires the choice of their specific sources, forms, and funding mechanisms. Financial resources act as material carriers of economic relations and form the demand for borrowed funds. When an economic entity does not require relatively large funds, borrowing from "personal" sources has been exhausted, turning to banks is impossible and equity financing is not available, peer-to-peer lending can fill its stable niche in the modern financial architecture of the digital economy.

It is interesting to study the place of peer-to-peer lending in the general system of sources of financial resources for an organization's operations, considering the life cycle of its development: from a small start-up to an organization participating in an initial public offering (IPO).

Considering funding companies' operations through peer-to-peer lending, one should remember that globally, each company passes through the seed and start-up stages, the stage of early growth, the stage of sustainable growth, and the stage of extinction. At the same time, the need for financial resources at the seed and start-up stages is usually lower than at the stages of early and sustainable growth, but it is much more difficult for a company to get capital at the beginning of its operations because of the risks generated by uncertainty factors and negatively assessed by potential investors – backers – lenders.

It seems possible and expedient to fund operations through peer-to-peer lending at the seed stage. The seed stage involves performing an analysis of the predicted demand for the proposed innovative product or service, considering their characteristics and specific features,



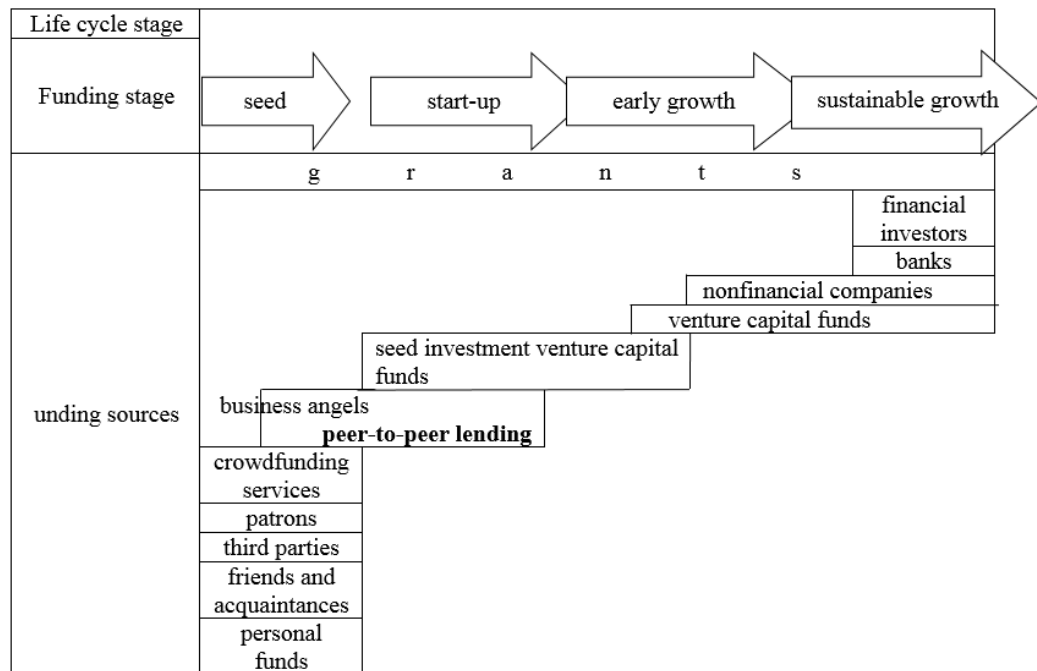
creating a model of the final innovative product or recreating a situation close to the implementation of an innovative service, carrying out additional work on an independent assessment of the failure risk for such a project, and forming the final model based on the research results. At this stage, financial resources usually consist of their own funds (as well as funds of acquaintances, friends, third parties), grants, funds received from business angels, and through crowdfunding services.

The start-up stage usually lasts one to two years and involves, on the one hand, solving legal and organizational issues of the company's functioning, and on the other hand, conducting marketing research, organizing production, finalizing the product and its initial offer on the market. Funding at this stage is obtained from business angels, venture capital funds, and seed investments.

At the next stage – the stage of early growth – the company launches mass production but on a small scale, gradually occupies its niche in the market, expands its customer base, and improves product quality. The company does not have stability in such operation indicators as revenue, profit, or working capital. At the stage of early growth, the company has the opportunity to raise capital from venture capital funds, non-financial companies.

The stage of sustainable growth presupposes the organization of mass production, all-around expansion of operations, including territorial expansion, the development of marketing strategies, diversification of the product range, and increasing the competitiveness of products through their improvement. At this stage, the company is characterized by stable growth in revenue and profit indicators as well as an increase in its value. The main entities financing the company are venture capital funds, non-financial companies, and banks. It is also possible to attract funds from financial investors, especially at the junction of the investment and post-investment stages within the framework of the IPO.

Peer-to-peer lending in the chain will look the most organically at the seed and start-up stages, when the required volumes of attracting financial resources are still relatively small (Fig. 1).



**Figure 1.** The place of peer-to-peer lending in the system of sources of the company's financial resources

Source: Compiled by the authors

Thus, we can conclude that peer-to-peer lending transforms the existing system of stages of financing the company's operations by expanding the range of sources and mechanisms for obtaining financial resources and organically takes its place in the architecture of the financial market, considering its digital component. Peer-to-peer lending allows one to expand the range of potential sources of funding for the activities of an economic entity, allows one to meet the constantly growing needs for financial resources, which is the fundamental role of peer-to-peer lending and which necessitates its implementation in the Russian financial system.

#### 4.2. Architecture and Ecosystem of the Russian Financial Market: the Place of Peer-to-Peer Lending

Today, financial companies have intensified their investment in the development of modern financial technologies to catch up with technology companies that are becoming leaders in the modern financial market. When it is necessary not only to assess the risks and the possibility of adopting new technologies in an existing business but also finance such a project, commercial banks look the most promising. It is such banks that have now started actively building a new architecture and ecosystem for the financial market. In view of this,

peer-to-peer lending in the architecture and ecosystem of the financial system has a point of intersection with the banking sector both in the "traditional" part – lending, and in the "digital" part – the area of application of digital technologies to ensure its activities.

In addition to having points of contact with banks, peer-to-peer lending has similar points with microfinance and microcredit organizations which have been present in the financial market for a relatively long time and are part of the Russian financial architecture. At the same time, peer-to-peer lending, although it differs from the activities of microfinance and microcredit organizations: in particular, is not yet subject to supervision by the main regulator, but it is very alike. Similar to interaction with banks, peer-to-peer lending "intersects" in its activities with microfinance and microcredit organizations in terms of lending operations and the use of digital technologies when concluding transactions and performing calculations.

Some factors can be identified that hinder and facilitate the integration of peer-to-peer lending into the emerging architecture of the Russian financial system, considering the almost total digitalization.

Peer-to-peer lending can be used to attract financial resources in the so-called "dead area" of financing when the sources of capital are sharply limited. Bank lending is currently unable to fully satisfy the demand for financial resources, both from individuals and from legal entities: there are many reasons for this, including stringent requirements for borrowers. Peer-to-peer lending is much less strict and can satisfy the needs of a wide variety of clients, including those who were rejected by banks and other traditional financial market participants due to non-compliance with the basic requirements of credit scoring. The flexibility of peer-to-peer lending facilitates its integration into the financial system.

Let us evaluate the flexibility of peer-to-peer lending as a form that makes it possible to attract financial resources in a constantly changing environment.

Let  $\{\mathbf{y}_t, \mathbf{X}_t: t = 1, \dots, T\}$  be the considered real-valued sample, where  $\mathbf{y}_t = (y_{1t}, y_{2t}, \dots, y_{nt})^T$  is a binary target variable that is equal to one if the peer-to-peer credit has been defaulted, otherwise it is equal to zero, and  $\mathbf{X}_t = (1, \mathbf{x}_{1t}, \mathbf{x}_{2t}, \dots, \mathbf{x}_{mt})$  is a countable longitudinal dataset of possible explanatory variables, where  $\mathbf{x}_{it} = (x_{1it}, x_{2it}, \dots, x_{nit})^T$ . Let us assume that the probability of default can be modeled by a logistic function as follows:

$$p(1|X_t) = \frac{1}{1+e^{-X_t\beta_t}} \quad (1)$$

where  $\beta_t$  is a vector of time-varying parameters.

We can model the dynamics of each  $\beta_{it}$  using an ARIMA class model, the classic representation of which is presented below:

$$\hat{\beta}_{it} = \alpha_0 + \alpha_1\hat{\beta}_{i(t-1)} + \dots + \alpha_p\hat{\beta}_{i(t-p)} + \gamma_1\hat{\epsilon}_{i(t-1)} + \dots + \gamma_q\hat{\epsilon}_{i(t-q)} + \hat{\epsilon}_{it}, \quad (2)$$

where the sign "hat" corresponds to the estimates obtained from the analyzed sample.

Thus, it is stated that when using predictive parameters instead of those obtained, see Formula (2), the model will be more efficient.

$$p(1|X_t) = \frac{1}{1 + e^{-X_t\hat{\beta}_t}} \quad (3)$$

Moreover, two independent estimates of the vector of true parameters  $\beta_t$  are obtained on each time interval – one from the prediction equation (3), and the other from fitting the model according to formula (1). Thus, these two Kalman filter estimates can be combined to obtain a more accurate parameter vector. The probability density function for such parameters can be calculated as shown below.

$$f(\beta_t|\hat{\beta}_{t-1}, \dots, \hat{\beta}_{t-p}, X_t) = \frac{f_1(\beta_t|\hat{\beta}_{t-1}, \dots, \hat{\beta}_{t-p})f_2(\beta_t|X_t)}{\int_{\mathbb{R}} f_1(\beta_t|\hat{\beta}_{t-1}, \dots, \hat{\beta}_{t-p})f_2(\beta_t|X_t)d\beta_t}, \quad (4)$$

where:

$$f_1(\beta_t|\hat{\beta}_{t-1}, \dots, \hat{\beta}_{t-p}) = (2\pi)^{-\frac{m+1}{2}} \det(\Sigma_t)^{-\frac{1}{2}} e^{-\frac{1}{2}(\beta_t-\hat{\beta}_t)^T \Sigma_t^{-1}(\beta_t-\hat{\beta}_t)}, \quad (5)$$

$$f_2(\beta_t|X_t) = (2\pi)^{-\frac{m+1}{2}} \det(\Omega_t)^{-\frac{1}{2}} e^{-\frac{1}{2}(\beta_t-\tilde{\beta}_t)^T \Omega_t^{-1}(\beta_t-\tilde{\beta}_t)}, \quad (6)$$

The covariance matrix of the parameter vector  $\Omega_t$  from equation (6) is usually estimated by the Fisher information matrix as follows:

$$\Omega_t = X_t^T \tilde{W} X_t, \quad (7)$$

where:

$$\tilde{W} = \text{diag} \left( \frac{e^{\sum_{j=0}^m \tilde{\beta}_{jt} x_{1jt}}}{(1+e^{\sum_{j=0}^m \tilde{\beta}_{jt} x_{1jt}})^2}, \dots, \frac{e^{\sum_{j=0}^m \tilde{\beta}_{jt} x_{njt}}}{(1+e^{\sum_{j=0}^m \tilde{\beta}_{jt} x_{njt}})^2} \right), \quad (8)$$

The covariance matrix of the parameter vector  $\Sigma_t$  from equation (5) can be obtained using a slightly modified DCC-GARCH model.

$$\Sigma_t = D_t R_t D_t, \quad (9)$$

$$\mathbf{D}_t = \begin{bmatrix} \sqrt{h_{1t}} & 0 & \dots & 0 \\ 0 & \sqrt{h_{2t}} & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \dots & 0 & \sqrt{h_{mt}} \end{bmatrix}, \quad (10)$$

where each  $h_{it}$  is the variance of a numerically generated probability density function ( $pdf_{it}(\beta_{it})$ ), which is the mean of  $N$  probability density functions for the predicted value  $\beta_{it}$  obtained from model (2). The reason for numerical generation in this case is that we never have the true values of  $\beta_{it}$ , only their estimates with some uncertainty. This is why the results of  $\beta_{t-1}, \dots, \beta_{t-p}$  based on their pdf obtained in the previous steps to get  $pdf_{it}(\beta_{it})$  as follows:

$$pdf_{it}(\beta_{it}) = \sum_{j=1}^N pdf_{ijt}(\beta_{ijt}) / N. \quad (11)$$

As  $\mathbf{R}_t$  is a conditional correlation matrix for  $\beta_t$  as looks as follows:

$$\mathbf{R}_t = \begin{bmatrix} 1 & \rho_{12t} & \dots & \rho_{1nt} \\ \rho_{21t} & 1 & \ddots & \rho_{2nt} \\ \vdots & \ddots & \ddots & \vdots \\ \rho_{n1t} & \rho_{n2t} & \dots & 1 \end{bmatrix}, \quad (12)$$

then from (10) and (12) each element  $\Sigma_t$  can be presented as:

$$[\Sigma_t]_{ij} = \sqrt{h_{it}h_{jt}}\rho_{ijt}. \quad (13)$$

Here  $\mathbf{R}_t$  is decomposed into  $\mathbf{Q}_t^{*-1}$  and  $\mathbf{Q}_t$  to ensure that the absolute values of all entries are less than or equal to one. To estimate the parameters of the DCC-GARCH model, in this case, the maximum likelihood estimation method is used.

After getting the pdf for  $\beta_t$ , the adjusted estimates are calculated by maximizing the likelihood (14):

$$\hat{\beta}_t = \operatorname{argmax}_{\beta_t} f(\beta_t | \hat{\beta}_{t-1}, \dots, \hat{\beta}_{t-m}, \mathbf{X}_t). \quad (14)$$

These adjusted estimates and pdf are then used in the prediction formula (2) to generate predictions for the next values of the true parameters of  $\beta_{t+1}$ . It is worth noting that if each  $\beta_{it}$  follows or can be approximated by a normal distribution, and  $\Sigma_t, \Omega_t$  are diagonal, the adjusted probability density is also normal. Then pdf for  $\beta_{it}$  from formula (14) can be rewritten as follows:

$$pdf(\beta_{it}) = \frac{\frac{1}{2\pi\sigma_1\sigma_2} e^{-\frac{(\beta_{it}-\mu_1)^2}{2\sigma_1^2} - \frac{(\beta_{it}-\mu_2)^2}{2\sigma_2^2}}}{\int_{\mathbb{R}} \frac{1}{2\pi\sigma_1\sigma_2} e^{-\frac{(\beta_{it}-\mu_1)^2}{2\sigma_1^2} - \frac{(\beta_{it}-\mu_2)^2}{2\sigma_2^2}} d\beta_{it}}. \quad (15)$$

After integrating the denominator of the fraction in (15) and canceling the factors, we get the following expression for the probability density function:

$$pdf(\beta_{it}) = \frac{1}{\sqrt{2\pi\sigma_1\sigma_2}} e^{-\frac{\left(\beta_{it} - \frac{\mu_1\sigma_2^2 + \mu_2\sigma_1^2}{\sigma_1^2 + \sigma_2^2}\right)^2}{2\frac{\sigma_1^2\sigma_2^2}{\sigma_1^2 + \sigma_2^2}}}, \quad (16)$$

which proves that the adjusted pdf for  $\beta_{it}$  is also normal with the mean shown in (17) and the variance shown in (18).

$$\mu = \frac{\mu_1\sigma_2^2 + \mu_2\sigma_1^2}{\sigma_1^2 + \sigma_2^2}, \quad (17)$$

$$\sigma^2 = \frac{\sigma_1^2\sigma_2^2}{\sigma_1^2 + \sigma_2^2}. \quad (18)$$

From formula (18), it is obvious that  $\sigma^2 < \min(\sigma_1^2, \sigma_2^2)$ , which clearly indicates that by applying this method, a better estimate of  $\beta_{it}$  can be obtained. Thus, in this study, it is proved that expression (4) can be replaced by a direct and easier to calculate form, subject to the above assumptions.

This parameter prediction approach will provide a better financial outcome for the financial institution compared to the traditional way of fitting a model on a data set available for period  $t-1$  and simply applying the obtained parameters for period  $t$ . To illustrate the above statement about time-dependent parameters when working with scoring models in an economic environment, we present the results of an empirical study for a microfinance institution.

The study utilizes Thomson Reuters data from 2016 to 2020. For the experiment, only two factors, "paid loan amount" and "ratio of the number of payments to loan term", were used to build 10 models for five consecutive years, each fitted to a dataset covering only six months. All sample results are shown in Table 1.

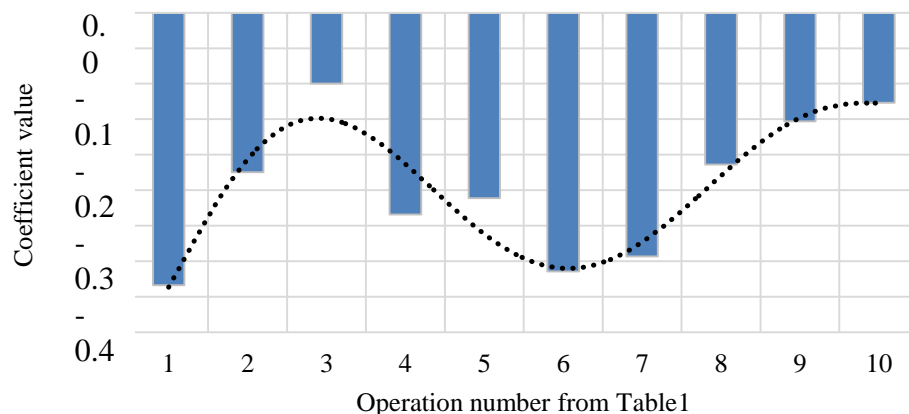
**Table 1**  
**Trend of the coefficients of the two-factor logit-model**

Operation number	Time interval		Paid loan amount		Ratio of number of payments to loan term	
	start	finish	coef.	p-value	coef.	p-value
1	01.01.2016	29.06.2016	-0.767	0.039	-0.147	0.718
2	01.07.2016	30.12.2016	-0.449	0.061	-0.432	0.126
3	01.01.2017	30.06.2017	-0.200	0.479	-0.375	0.225
4	01.07.2017	31.12.2017	-0.569	0.002	-0.505	0.011
5	01.01.2018	30.06.2018	-0.522	0.003	-0.403	0.038
6	01.07.2018	31.12.2018	-0.729	0.000	-0.521	0.001
7	01.01.2019	30.06.2019	-0.687	0.000	-0.462	0.000
8	01.07.2019	31.12.2019	-0.427	0.000	-0.386	0.000
9	01.01.2020	30.06.2020	-0.306	0.000	-0.304	0.000
10	01.07.2020	31.12.2020	-0.254	0.000	-0.188	0.000

Source: Authors

As can be seen from Table 1, the subsample size grows as the organization under consideration expands. The resulting coefficients are mostly significant, except for a couple of subsamples where the number of observations was relatively small.

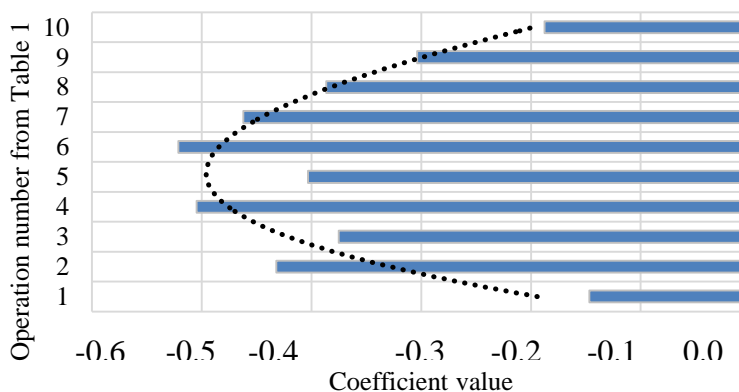
Figures 2 and 3 show the trends of the coefficients for the above two factors and their polynomial approximations. It is easy to track the cyclicity of the tested parameters, which proves that the true parameters are time-dependent.



**Figure 2.** Trend of the coefficient value "Paid loan amount"

Source: Authors





**Figure 3.** Trend of the value of the coefficient "Ratio of number of payments to loan term Coefficient value"

Source: Authors

Such a simple empirical experiment shows that scoring methods used for peer-to-peer lending can significantly improve the performance of scoring models when developing a system for analyzing credit risk in the real economy when forming a peer-to-peer loan (credit).

The development of peer-to-peer lending is also promoted by the general processes of financial turbulence, both in the world economy and in the national economy, accompanied by a decrease in the level of confidence in the established institutions of bank lending. If until 2020, geopolitical factors were singled out among the main exogenous factors for the transformation of the financial institutions' system in the national economy, then since March 2020 the entire financial system has faced the unique challenge of COVID-19. The effects of "the emotion of fear and panic" were reflected not only in the rush demand for essential goods but at the same time shook the stability of banks in matters of savings as the basis of bank capital. It is hypothetically logical to assume that when withdrawing large sums from the banking sector, investors will think about alternative sources of income, including peer-to-peer lending, and will be included in the group of potential lenders.

The programs for the digitalization of the economy positively influence the process of integrating peer-to-peer lending into the Russian financial system; thus, new institutional conditions are created for the development of not only peer-to-peer lending but also the entire financial system. Also, we must note the adoption of Federal Law No. 259-FZ "On digital financial assets, digital currency and on amendments to certain legislative acts of the Russian Federation" dated 31 Jul. 2020, which establishes the basis for the circulation of digital

financial assets and provides a field for further transformation of the architecture of the financial system of Russia and peer-to-peer lending in particular.

One cannot ignore the aspects related to blockchain technologies and smart contracts, which can be successfully implemented in the operations of peer-to-peer platforms. Such adaptability of the financial mechanism contributes to its segmentation in the financial market.

The positive economic effects of peer-to-peer lending include the fact that it allows one to reduce transaction costs. This contributes to the involvement of a larger number of borrowers and lenders in the financial system; more active capital turnover and its potential work for the stability of the entire national economy. The appearance of peer-to-peer lending on the market and its inclusion in the digital ecosystem of the financial market, in general, is justified since peer-to-peer lending increases the potential for the development of the system as a whole.

The development of digital financial architecture and the financial market ecosystem is partly hampered by the fact that the innovative development of financial technologies and their use in practice is ahead of the formation of a regulatory framework that defines the basic rules of behavior and regulates new phenomena in financial markets. For peer-to-peer lending to firmly and fully enter the digital architecture of the financial market and its ecosystem, it is necessary to transform the management approach and subsequent legislative changes in terms of regulating peer-to-peer lending activities.

Currently, peer-to-peer lending in Russia is not regulated by specific legislative acts; all subjects of the peer-to-peer market operate within the framework of general civil legislation. The introduction of peer-to-peer lending into the digital financial architecture of Russia did not lead to any crisis phenomena arising from the ineffectiveness of existing regulatory mechanisms, however, the further development of this architecture and its sustainability, including within the peer-to-peer lending segment, will largely depend on directions for the development of digital technologies and the correct application of regulatory methods and financial instruments.

Among the main groups of factors holding back the development of peer-to-peer lending in the Russian market, the following are particularly noteworthy: the imperfection of the legal framework and general institutional conditions for the development of new financial

markets; nationwide issues with financial and digital literacy; a sharp asymmetry of information between certain segments of the population, which is manifested, among other things, in the insufficient level of awareness of individuals and legal entities about the possibilities, advantages and risks of peer-to-peer lending; uneven distribution of goals, objectives and indicators of digitalization of the country's economy in the context of individual entities, which entails a lack of coordination of actions and a decrease in the efficiency of measures taken; technical and technological problems, manifested in communication interruptions, including due to power outages, lack of high-speed Internet access, using outdated equipment.

As with all transformation processes, the transformation of the financial architecture of Russia, considering digitalization, is inherent in risks, among which the most specific and significant are cybersecurity risks. Such risks pose the greatest threat to the development of the emerging financial market ecosystem and digital financial architecture in both Russia and the world. In this context, peer-to-peer lending as an element of the digital financial architecture is most susceptible to these risks since peer-to-peer lending has been extremely digitized. However, at present, there is a tool for regulating these types of risks – cybersecurity insurance. Thus, according to forecasts of Sberbank Insurance, the Russian cyber insurance market by 2025 may amount to eight to ten billion rubles (Sukharevskaya, 2019), which for Russia, considering the experimental perception of the insurance system as a whole, is a rather significant volume but a small amount compared to the forecasts for the growth of the global cybersecurity insurance market – up to USD 20.4 billion by 2025.

## 5. DISCUSSION

The efficient development of the Russian economy, like any country today, is impossible without the comprehensive support of business entities, one of the important aspects of which is providing them with affordable sources of funding, which is most often understood as providing loans. We believe that peer-to-peer lending may contribute to this. This perspective is confirmed by other researchers in the field of peer-to-peer lending. For example, R. Reza-Gharehbagh, A. Hafezalkotob, S. Asian, A. Makui, and A. N. Zhang (2020) consider the possibility of using the potential of peer-to-peer platforms in the framework of supply chain restoration. Researchers testify to the growth and development of peer-to-peer lending and its potential: "Online Peer-to-Peer (P2P) lending platforms are becoming

increasingly popular globally in recent years" (Au et al., 2020, p. 1235); "Online peer-to-peer (P2P) business lending, where individual investors provide unsecured loans directly to individual business borrowers without the intermediation of banks, has experienced rapid growth in recent years" (Pierrakis, 2019, p. 246). Separate studies are carried out in the field of financing small and medium-sized businesses through peer-to-peer lending. "P2P lending Fintechs increase the access to finance for SMEs. ... SME managers may meet the liquidity needs of their firms through the use of P2P lending Fintechs" – the findings by K. Abbasi, A. Alam, N. A. Brohi, I. A. Brohi, and S. Nasim (2021). We fully agree with these conclusions and believe that the inclusion of peer-to-peer lending in the financial architecture expands the opportunities for raising capital for small and medium-sized businesses, which are extremely important economic actors for the development of the economy and ensuring employment and reducing unemployment.

"Country's financial system influences the choice of available sources of finance" (Alam et al., 2019, p. 27). Indeed, the more sources, forms, and mechanisms for attracting financial resources the financial system can offer, the more economic entities can receive the necessary capital for business development or other needs, other things being equal. "The financial services industry has been experiencing the recent emergence of new technology innovations" (Gomber et al., 2018, p. 241). Peer-to-peer lending can be classified as such an innovation, and from this point of view, the introduction of peer-to-peer lending expands the financial ecosystem.

Today, the following can be identified as the main trends that initiate the development of peer-to-peer lending: support for innovative activities to create and commercialize intellectual property objects, total, sometimes forced, digitalization of the economy and other spheres of society, creation and implementation of fintech technologies.

Separately, it should be noted that the situation with peer-to-peer lending is exactly the case when the reality is ahead of the formation of the legislative framework for new operating financial institutions in the markets. Peer-to-peer lending has already become part of the architecture of the financial system, contributing to the development of the digital economy, including in Russia. Within the framework of the study, it is said that peer-to-peer lending has points of contact with the banking sector, influencing the sector and fostering its operations. This point of view is supported by M. Siek and A. Sutanto (2019, p. 358) who write the

following: "The fast development of fintech startups on creating payment gateway and peer-to-peer (P2P) lending applications is one of examples for the modern disruptive innovations affecting to traditional financial business".

When studying the financial market ecosystem, it is necessary to note not only the set of economic entities involved in the process of market functioning but also the multifaceted connections between them. The concepts of "financial architecture" and "financial ecosystem" are currently united by the fact that the evolution of these categories is inextricably linked with the development of digital platforms and the digital economy. In this context, a significant role can be assigned to peer-to-peer lending, which gave impetus to the transformational processes of the Russian financial architecture. We support V. Soloviev's perspective, agreeing that so far "fintech initiatives have not yet led to a radical transformation of the financial sector in Russia" (Soloviev, 2018, p. 2). Nevertheless, we suggest that peer-to-peer lending, as one of the innovative financial mechanisms in fintech, is transforming the financial architecture.

The financial market ecosystem should be aimed at the evolutionary development of economic market entities and their relationships, considering the openness of the functioning environment. The development of the financial architecture and the financial ecosystem is determined by many factors of an economic, political, and social nature, considering the need for effective interaction between economic entities and ensuring the availability of financial resources for different entities, which is consistent with the UN sustainable development goals.

During the study, we did not consider the issue that was discussed by other researchers, namely, the influence of such informal factors as linguistic correctness, the presentation quality of the textual material in the application, and the severity of the emotional component of the need to obtain financial resources in the application, in terms the likelihood of obtaining a peer-to-peer loan. An interesting study in this area is the work by S. F. Pengnate and F. J. Riggins (2020) entitled "The role of emotion in P2P microfinance funding: A sentiment analysis approach". The study describes the influence of these factors on the likelihood of obtaining a peer-to-peer loan, and therefore, these factors affect the development of all peer-to-peer lending and, possibly, the features of its interaction with other financial and non-financial institutions within the financial ecosystem. In the future, it is planned to study this issue in detail.

The peer-to-peer lending mechanism can be supplemented with blockchain technology, which will have a positive effect on the functioning of peer-to-peer platforms. The possibility of introducing blockchain technology into peer-to-peer lending is also being considered by other researchers. Thus, L. Gonzalez (2020, p. 821) notes that "the gradual implementation of blockchain technology in peer-to-peer lending platforms facilitates safer, transparent and quick access to funds without having to deal with the more complex and costly processes of banks".

## 6. CONCLUSION

We found that the hypothesis presented in the study is correct. Indeed, peer-to-peer lending can transform the architecture and ecosystem of the financial market, expand both the circle of potential participants in the financial market and the possibilities of each economic entity in obtaining financial resources through a peer-to-peer loan (for borrowers) or in the efficient use of capital through lending operations (for lenders). Moreover, peer-to-peer lending can optimize the existing system of financing the company's operations by expanding the range of sources and mechanisms for obtaining financial resources.

Peer-to-peer lending, first, expands the possibilities of obtaining financial resources by attracting entities previously not involved in the financial market; second, as peer-to-peer lending is a financing mechanism that involves online interaction, all other things being equal, the time lag between the transmission of a request for funds and its approval is reduced. Third, peer-to-peer lending, including through smart contracts and generally more flexible requirements for the provision of formal information, makes the financing procedure less complicated and more adaptive to the needs of borrowers and lenders.


In 2020 and 2021, due to special economic conditions in all national economies, attention was focused on the issues of consumers' "financial health": both during an acute pandemic and subsequent lockdowns and periodic post-COVID space. Traditional financial institutions, primarily banks, tried to smooth out unfavorable economic effects caused by both difficult sanitary and epidemiological conditions and other macroeconomic factors, mainly by refinancing previously issued loans. However, the actions of traditional financial institutions, even in close relationship with the actions of government agencies, are not enough to stabilize the situation in the financial market where many economic entities are in dire need of financial resources. As noted above, an active trend is the expansion of the range of services of financial institutions, including through crowdfunding services, and the simultaneous emergence of hybrid financial products. In this regard, peer-to-peer lending, which operates



online and is a seamless financial product, is a fairly relevant element of the architecture of the financial system and is fully consistent with the digital development trend.

Peer-to-peer lending is part of the lending segment of the financial market architecture and is an almost entirely digital element of its ecosystem.

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