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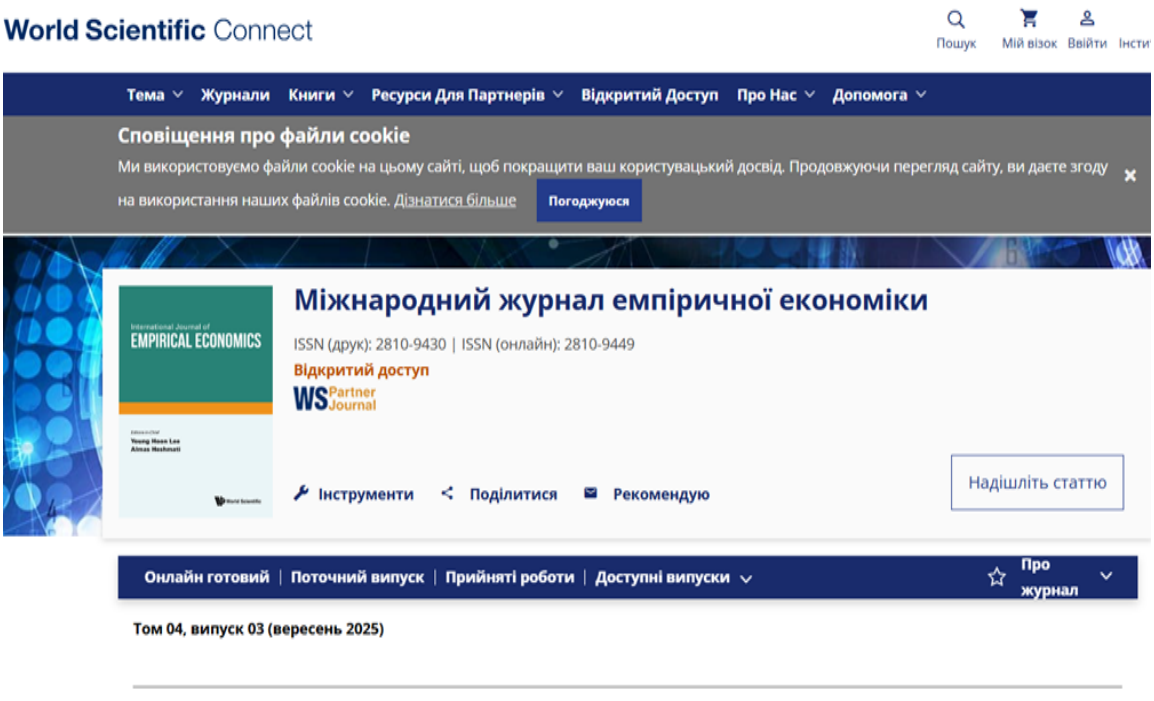
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Implication of Digital Metaspace Technologies on Financial Market Infrastructure

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This paper examines how digital metaspace technologies impact the financial market infrastructure. This paper develops a methodological platform for integrating the financial technology (FinTech) ecosystem models in the financial market infrastructure. The findings show that the benefits of financial market development in the digital metaspace technologies are simplified and continuous interbank payments, increased reliability of the debt securities settlement system, and guaranteed settlements through payment systems. This paper offers a conceptual approach to the development of the integrated financial market infrastructure, subject to the introduction of digital metaspace technologies. The study determined which methods should be used to assess the level of integration of the FinTech ecosystem into the segments of the financial market. The business models of FinTech services within the banking sector of the financial market were grouped using clustering methods. The volume of investments in the FinTech ecosystem and the level of

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its integration in the world financial markets were analysed. The functionality of Ukraine's payment segment within the financial market was assessed. A model was developed to analyse how the Digital Acceleration Index of Ukraine's financial market changes the country's GDP. The scientific novelty consists in the designed model for the ratio between Ukraine's GDP and the volume of digital transactions, which was based on the level of financing provided to economic agents.

Keywords: Banking sector; digital technologies; economic agents; FinTech ecosystem; metaspace.

JEL Classifications: G21, O33, E44

Introduction

The financial market is undergoing transformations due to recurrent crises and the need for macro-financial stability; its geopolitical landscape and financial structures are reshaping, while attempts are being made to balance state regulation and market mechanisms (Mykhalchynets, 2018; National Bank of Ukraine, 2022b). The digitalisation of the financial ecosystem has shifted societal expectations and necessitated new paradigms in financial science, which have become possible thanks to digital metaspace technologies (World Bank, 2022). Metaspace represents the convergence of immersive digital environments with real financial operations. It encompasses blockchain, artificial intelligence (AI), and decentralised finance technologies to ensure secure, transparent, and efficient financial transactions. According to a study by Del Sarto *et al.* (2024a), financial innovations within the metaspace reduce risk and accelerate technological changes in regulatory mechanisms. Del Sarto *et al.* (2024b) substantiate that social networks play a key role in shaping digital banking trends, which re-emphasises the need for seamless integration between metaspace and financial services. These metaspace innovations improved resource allocation and liquidity redistribution, particularly within financial institutions.

As in many economic processes, the introduction of financial innovations in the metaspace reflects a dual nature: on the one hand, they are designed to reduce uncertainty and mitigate risks for financial actors; on the other, their implementation drives rapid technological change and transforms core regulatory mechanisms and institutions — particularly amid growing global economic instability. Many research works were devoted to a thorough examination of banking digitalisation, the impact of blockchain on financial intermediaries, and the role of digital banking in addressing specific industry challenges (Sutikno *et al.*, 2022; Del Sarto *et al.*, 2024a,b). However, there is still a gap in the existing literature concerning the integration of metaspace technologies into the broader financial ecosystem context. The need for adaptable regulatory frameworks has become

more urgent as digital banking faces operational challenges (Mbama and Ezepue, 2018; Wewege *et al.*, 2020).

Therefore, this study aims to develop a methodological platform for integrating FinTech models in the financial market infrastructure, focusing on the impact of digital technologies on financial relationships and institutions. It addresses the gaps in the scholarly literature by examining the integration of metaspace technologies into financial systems and their role in improving transaction security and financial risk management. The research also emphasises the need for regulatory policies that adapt to new digital realities and protect national interests amid hybrid threats. The scientific novelty consists in the designed model for the ratio between Ukraine's GDP and the volume of digital transactions, which was based on the level of financing provided to economic agents. Unlike previous scholarly works, which focused predominantly on digital banking and blockchain as separate phenomena, this study considers them in their relationship with FinTech ecosystems. Particular attention is paid to the impact of metaspace technologies on the security of financial transactions, the efficiency of market mechanisms, and the adaptation of regulatory policy to new digital challenges.

Literature Review

An analysis of the impact of digital technologies on financial markets shows that innovations in financial technology (FinTech) represented by blockchain, digital banking, and algorithmic trading create new opportunities for the development of financial infrastructure. Studies by Gomber *et al.* (2018) highlight the significant influence of digital technologies on financial services, identifying them as key drivers of innovation within financial markets. In particular, the development of blockchain technology, as argued by Del Sarto *et al.* (2024a), is fundamentally transforming the role of financial intermediaries by reducing transaction costs and enhancing operational transparency.

Digital technologies, if adopted in the financial market infrastructure, significantly enhance its efficiency and resilience. The implementation of big data analytics and AI for market trend forecasting, as noted by Brusseau (2021) and Hidayat-ur-Rehman and Hossain (2024), contributes to more effective risk management and the identification of investment opportunities. However, Del Sarto *et al.* (2024b) note that social media platforms have revolutionised digital banking and reshaped interactions between financial institutions and customers. This shift concerns the provision of personalised services and strengthens customer loyalty. Metaspace, with its digital technologies, has become an emerging component of this transformation in financial infrastructure. Gomber *et al.* (2018) and

Tucci (2023) believe that the metaspace introduces novel opportunities for the digital economy, including financial markets. Metaspace technologies may fundamentally alter how users interact with financial systems by integrating virtual economies and traditional financial instruments.

Digital technologies also influence the resilience of the financial system. Martinez-Jaramillo *et al.* (2016) emphasise that financial stability is ensured when the risks of financial crises are minimised, which can be achieved by integrating blockchain and smart contracts technologies in financial market infrastructures. These technologies also increase public trust in financial institutions and their operations.

The regulation and governance of financial technologies represent other critical aspects of this integration. Schinasi (2005) argues that ensuring financial market stability requires developing effective regulatory mechanisms to address challenges posed by digital innovation. In particular, instruments like PSD2, if introduced, can reshape approaches to security and transparency in payment systems. This shift will enable banks and other financial institutions to better adapt to the demands of the digital economy (Sydorenko and Maksimenko, 2019). The challenges and opportunities presented by digital technologies indicate that there is great potential to create more efficient and inclusive financial systems, but considerable risks remain. These include cybersecurity threats, data protection issues, and the regulation of novel financial instruments. Hagedorna and Pinkwartb (2013) highlight the urgent need for clear legal frameworks governing crowdfunding platforms and new forms of financing. This calls on governments and international organisations to rapidly adapt their legislation to evolving conditions.

The authors of this paper have already examined the social dimensions of metaspace and suggested a hypothesis on its integration into a digital ecosystem that reflects real financial and economic interactions among market participants. The study focused on metaspace technologies that enable collaboration between individuals and decentralised financial instruments through software tools (Melnyk and Trusova, 2023). Unlike this research, it did not examine the development of business models specifically for FinTech services within the banking sector. Another research by (Melnyk, 2024) is devoted to the essence of metaspace and its profound influence on the trajectory of social progress. The author highlights that metaspace contributes to the use of the country's financial potential for economic development, such as liquid surplus redistribution over time. Like many economic innovations, the integration of financial technologies within metaspace is characterised by dualism. On the one hand, these innovations are designed to reduce uncertainty and mitigate risks within the financial environments of economic agents. On the other hand, they drive rapid technological transformation and reshape the core regulatory mechanisms of financial markets and institutions. In

the context of the authors' previous studies, the research "Features of the implications of digital metaspace technologies in the financial market infrastructure" should be noted. This paper focuses on the digital capabilities of metaspace in the Internet network of financial market segments, emphasising its ability to maintain equilibrium despite various factors that disrupt financial flows. These flows shape financial capital amid divergent price trends and influence the allocation of financial assets for investment across financial institutions (Trusova and Melnyk, 2024).

This study, in turn, is devoted to the development of a model of the relationship between a country's real savings and the volume of digital transactions, which is based on the level of financing provided to economic agents. Unlike previous scientific works, which mainly considered digital banking and blockchain as separate phenomena, this study considers them in their relationship with FinTech ecosystems. Particular attention is paid to the impact of metaspace technologies on the security of financial transactions, the efficiency of market mechanisms, and the adaptation of regulatory policy to new digital challenges. Therefore, this study contributes to the academic discourse by developing a methodological framework that incorporates emerging technologies and their impact on financial markets. It also offers theoretical and practical recommendations for regulatory bodies seeking to adapt to rapid changes in the financial ecosystem. Thus, the hypotheses of this study are based on theoretical, empirical, and contextual developments. The first hypothesis sets forth that the integration of the metaspace into financial market infrastructure will lead to lower transaction costs and increased transparency of financial transactions.

(i) The use of virtual economies for financial transactions allows to reduce the need for physical intermediaries, which can reduce transaction costs.
(ii) The integration of digital technologies into financial markets helps to increase the level of transparency.
(iii) Metaspace provides for the flexible integration of digital assets, which potentially reduces the costs of administering transactions.

The second hypothesis puts forward that blockchain technology, if incorporated in financial systems, reduces risk and enhances the stability of financial markets.

(i) Blockchain ensures transparency and security in financial operations through distributed ledger technology.
(ii) Multiple studies confirm that blockchain lowers the likelihood of financial fraud and operational errors.
(iii) Analysis of financial market infrastructure shows that blockchain-based security technologies contribute to market stability by reducing risks for all participants.

(iv) The integration of blockchain technology into financial infrastructure mitigates transactional risks and enhances systemic stability.

Thus, our paper seeks to fill gaps in the literature that relate to a deeper understanding of the impact of digital technologies on financial infrastructure.

Materials and Methods

The study employs independent and dependent variables to examine the impact of metaspace technologies on financial infrastructure and markets. The independent variables include blockchain technologies (which influence the security and transparency of financial transactions), AI (which facilitates the automation of financial processes and the provision of advisory services), and DeFi, which eliminates traditional intermediaries in financial operations. These variables directly transform the financial environment under digitalisation and metaspace integration. The dependent variables comprise the efficiency of financial infrastructure, which is reflected in its productivity and adaptability to emerging technologies. They also include the level of integration of financial institutions into FinTech services (i.e. the implementation of new technologies within financial processes) and the security and resilience of financial transactions in a digital context. Changes in these variables make it possible to assess the influence of metaspace technologies on the stability and development of financial infrastructure. In order to operate these variables, the study employs statistical methods and analyses data from financial reports and performance metrics issued by European central banks. This approach ensures the credibility and reliability of the research findings.

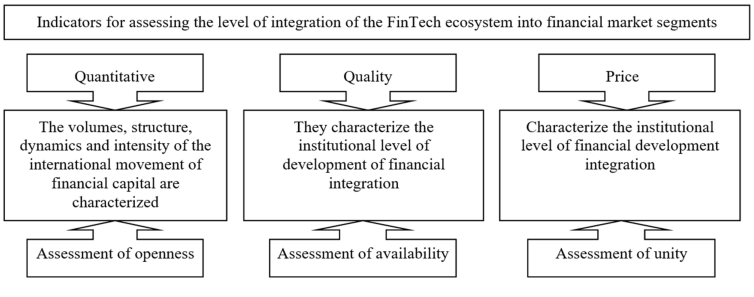
Three key indicator groups are employed to assess FinTech integration: quantitative (capital flows, investment volumes), qualitative (regulatory liberalisation, institutional frameworks), and price-related (price convergence of financial instruments). Binary choice models (logit, probit) are often used to evaluate financial openness, though standard regression approaches may be limited. Thus, distribution-specific models and σ-convergence methods are recommended for more accurate analysis (Gomber *et al.*, 2018; Hidayat-ur-Rehman and Hossain, 2024). Financial infrastructure comprises institutions that ensure efficient contract execution by facilitating transactions through intermediaries, including payment systems, depositories, registrars, and traders (Martinez-Jaramillo *et al.*, 2016; Dudynets, 2018). The financial market infrastructure involves subjects of payment systems, depositories, registrars, and securities traders (Mykhalchynets, 2018). Given the public interest, infrastructure reforms should be implemented at the micro-level (e.g. transaction cost management) and macro-level (e.g. systemic risk mitigation) through FinTech integration (Krupka, 2014; Trusova *et al.*, 2021).

The financial services market functions as the "front office" of the broader financial market. Although both rely on intermediaries, their objects differ (services versus instruments). Service provision enables intermediaries to reallocate resources, shaping financial assets and liabilities (Ball *et al.*, 2011; Ijaz *et al.*, 2020). Market stability encourages capital flow, while instability often drives innovation, like crowdfunding. Metaspace-related FinTech technologies foster new intermediaries and collaborative financial models, transforming operational infrastructure (Patlasov and Grakhov, 2016; Grebe *et al.*, 2017; Degrik, 2020). These changes also necessitate revisions in regulatory frameworks. Collaborative finance models, including crowdfunding and P2P lending, bypass traditional intermediaries and function through digital platforms (Sydorenko and Maksimenko, 2019; Trusova *et al.*, 2021; Tucci, 2023). This convergence of FinTech players seeks to reimagine banking in open, interactive metaspace environments (Dudynets, 2018; Ivasiv and Garbar, 2018).

To measure the depth of FinTech ecosystem integration into the financial market infrastructure, a methodological framework is suggested. It includes three groups of indicators: quantitative, qualitative, and price-based. Quantitative indicators measure openness through capital flow data, and qualitative indicators capture institutional developments, such as deregulation, legal harmonisation, and formation of coordination bodies. Price-based indicators analyse price equalisation across homogeneous financial instruments (Fig. 1).

These metrics provide a comprehensive framework to evaluate financial capital flows and the FinTech ecosystem's role in global integration and economic growth (Mankiw and Summers, 2009). The elasticity of demand for financial capital also plays a role in this analysis. It is measured as

$$E_{m_p} = \frac{\Delta Qm(\%)}{\Delta Pm(\%)}, \tag{1}$$



Source: Constructed by the authors based on International Monetary Fund (2023a).

Fig. 1. Methods for assessing the FinTech ecosystem integration level into financial market segments.

where ΔQm is a percentage change in the volume of capital imports, %;

ΔPm represents percentage change in the price of capital, %.

If $E_{m_p} \geq 1$, a 1% decrease in capital price leads to more than a 1% increase in demand, indicating elastic demand. In the case of a decrease in the national interest rate, the volume of imports decreases, and vice versa. Lower interest rates generally improve foreign capital inflows (Ismail and Rahman, 2009; Mankiw and Summers, 2009).

From an economic point of view, quantitative indicators of the FinTech ecosystem in financial from an economic perspective, the FinTech ecosystem quantitative indicators reflect integration levels, while qualitative indicators offer a regulatory viewpoint. These are drawn from the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER) (International Monetary Fund, 2023b). Binary models, including probit, logit, and gompit, are used to evaluate FinTech integration; they involve econometric models of the dependence of a binary variable, which takes only two values (0 and 1) on a set of factors. However, standard linear regression is inappropriate for binary outcomes due to non-normal distribution assumptions (Izquierdo and Izquierdo, 2018). The IMF's FinTech liberalisation index (FLI) employs such binary methods to assess openness but does not reflect integration depth. Thus, alternative indices, such as Finreform, Kaopen, Kashi, Foru, and Lane, should be used to capture regulatory gradients and financial mobility intensity (Lin *et al.*, 2009). All indices of financial liberalisation have a high level of correlation among themselves. Quantitative and price indicators of the FinTech ecosystem integration are considered by the segments of the financial market (credit and bond market, stock market, etc.), and qualitative indicators are examined by subjects, including households, financial companies, and the state (Fig. 2).

The following equation is used to assess the overall level of financial market infrastructure integration based on metaspace digital technologies, as well as to calculate the rate of financial integration over time within the FinTech ecosystem (Mankiw and Summers, 2009):

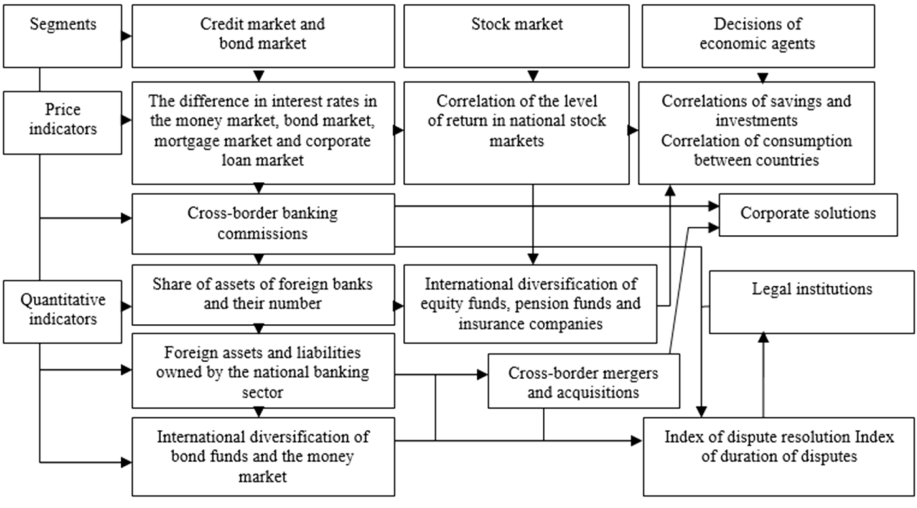
$$\Delta i_{ct_{\text{FinTech}}} = a_c + \beta i_{ct_{\text{FinTech}}-1} + \sum_{l=1}^{L} \gamma_l \Delta i_{ct_{\text{FinTech}}-1} + \varepsilon_{ct_{\text{FinTech}}} s, \tag{2}$$

where c and t_{FinTech} are country indices and the time of integration of the FinTech ecosystem into the financial market;

Δi represents interest rate change;

a_c is a conventional country.

The deviation indicator on the right side of the equation represents exogenous shocks that lead to differences in interest rates among the countries under study. If



Source: Built by the authors from the data (Izquierdo and Izquierdo, 2018; European Central Bank, 2018; International Monetary Fund, 2023a).

Fig. 2. Indicators for measuring the time interval of the FinTech ecosystem.

β has a negatively value, it indicates the presence of convergence (if β is equal to zero, there is no convergence). The value β is defined as the speed of convergence. The suggested methodology extends the traditional concept of β-convergence to scenarios where interest rates may be non-stationary; this methodology also incorporates sectoral and time-series data.

To evaluate the level of the FinTech ecosystem integration within financial market segments over time, σ-convergence is employed. Economic growth of σ-convergence occurs if the intersectoral distribution of the variable (income per person) decreases over time. Thus, the interval of integration is considered to increase when the cross-sectional standard deviation of interest rates across financial sectors decreases. If the distribution of interest rates across sectors converges to a single point and the standard deviation approaches zero, it suggests that full integration of the FinTech ecosystem has been achieved within those segments of the financial market (Kyrylych, 2013; Ivasiv and Garbar, 2018). It is important to note that β-convergence and σ-convergence convey different types of information. The presence of β-convergence does not necessarily imply σ-convergence, as the former is based on the mean regression of cross-sectional variance over time.

Therefore, convergence analysis based on interest rate dynamics should be applied to assess the FinTech ecosystem integration interval across various segments of the financial market, including the credit, bond, government securities,

mortgage, and short-term corporate loan markets (Mankiw and Summers, 2009):

$$\Delta i_{ct_{\text{FinTech}}} = a_c + \beta_{\text{pre-emu}} D_{\text{pre-emu}} i_{ct_{\text{FinTech}}-1} + \beta_{\text{post-emu}} D_{\text{post-emu}} i_{ct_{\text{FinTech}}-1} + \\ + \gamma_1 \Delta i_{ct_{\text{FinTech}}-1} + \gamma_2 \Delta i_{ct_{\text{FinTech}}-1} + \varepsilon_{ct_{\text{FinTech}}}, \quad (3)$$

where c and t_{FinTech} are country indices and the time of the FinTech ecosystem integration into the financial market;

a_c is conventional country;

$D_{\text{pre-emu}}$ and $D_{\text{post-emu}}$ stand for conditional variables;

Δi represents the deviation that occurs in response to a corresponding change in the interest rate, relative to the prevailing rates within the country. The interest rate lag coefficient measures the rate of convergence before ($\beta_{\text{pre-emu}}$) and after ($\beta_{\text{post-emu}}$) the establishment of institutions, such as the European Monetary Union (EMU).

If the β coefficient is negative in all regressions, this indicates the presence of convergence. The β coefficient's magnitude directly reflects the convergence speed within each country. β-convergence provides for a comparative analysis of the FinTech ecosystem integration intervals across different segments of the financial market and over different time periods. Integration levels can vary; the highest degree of integration is typically observed in the interbank interest rate. Mortgage rates exhibit moderate integration, while the lowest levels are found in corporate loan rates. On average, the introduction of the euro led to a 5% acceleration in convergence across all segments of the financial market (Mankiw and Summers, 2009).

A fundamental assumption in regression analysis is the stationarity of variables. Stationarity ensures that statistical properties such as the mean, variance, and autocorrelation remain constant over time. When this assumption is violated, it can result in biased parameter estimates and unreliable forecasts in financial modelling (Fulcher *et al.*, 2013). Non-stationary variables pose risks of biased parameter estimates and inaccurate evaluations of variable effects. Therefore, verifying the stationarity of variables is a critical preliminary step before conducting regression-based analyses to ensure reliable and sound results (Chukhrova and Johannssen, 2019). Another indicator of the FinTech ecosystem integration interval is σ-convergence, which analyses the level of integration in financial market segments at a specific point in time. This method contrasts with β-convergence, as it measures the cross-dispersion of interest rates (Mankiw and Summers, 2009).

$$sd(i)_{t_{\text{FinTech}}} = (a_{\text{pre-emu}} + \sigma_{\text{pre-emu}} t) D_{\text{post-emu}} \\ + (a_{\text{post-emu}} + \sigma_{\text{post-emu}} t) D_{\text{post-emu}} + \varepsilon_{t_{\text{FinTech}}}, \quad (4)$$

where $sd(i)$ is the cross-sectional standard mean squared deviation of each of the four interest rates in the period t.

σ-convergence may be stronger in the interbank and government bond markets, whereas it appears weaker in the mortgage and corporate loan markets. Separate regressions for countries that introduced the euro allow the analysis of σ-convergence levels before and after the euro's introduction. σ-convergence is considered complete when the slope and cross-coefficients equal zero (Mankiw and Summers, 2009).

Thus, having considered all these aspects, this study will suggest a more innovative and adaptable methodological foundation for financial technologies that meets the current industry's requirements and challenges.

Results

The development of financial relations is characterised by a complex and chaotic dynamic, shaped by economic, political, behavioural, and social processes. Rational and irrational decisions made by individual economic agents, local communities, and regional authorities play a crucial role in shaping financial market dynamics. The financial market stability is affected by the decisions taken at the national, supranational, and global levels. The unstable state of global financial markets periodically entails crises of various scales. These include manifestations of debt, currency, banking, and stock market crises.

Jordana *et al.* (2018) established that the multidimensional nature of asset pricing is directly related to the distribution of financial flows that form financial capital. Quantitative data confirm these conclusions: the integration of FinTech services into financial systems grew from 16% in 2019 to 87% in 2022, indicating a rapid digitalisation of financial operations. At the same time, global investments in the FinTech ecosystem reached USD 111.8 billion in 2021 but decreased by 33.7% in 2022. This decrease demonstrated a high level of volatility in financial flows.

The International Monetary Fund has developed a matrix of financial market stability characteristics (Fig. 3), which appears as a list of indicators grouped into four categories. On the one hand, they characterise the state of financial institutions (banks and non-banking institutions). On the other hand, they reflect the situation in financial markets.

The FinTech ecosystem has become the foundation for all online transactions in the financial market. In today's era of metaspace technologies, it operates through digital innovations embedded in financial products, services, and the business processes of both banking and non-banking institutions. FinTech services based on innovative metaspace technologies rely on high-quality business models that foster interconnection among economic agents in the financial market. In the banking

	Financial institutions	Financial markets
Depth	the ratio of private sector credits to GDP; ratio of assets of financial institutions and GDP; ratio of monetary aggregate M2 and GDP; the ratio of deposits to GDP; the ratio of the gross added value of the financial sector to GDP.	the ratio of capitalization of the stock market, issued domestic debt securities and GDP; ratio of private debt securities and GDP; ratio of government debt securities and GDP; ratio of international debt securities and GDP; the ratio of capitalization of the stock market and GDP; ratio of share trading volume and GDP.
Accessibility	the number of accounts in commercial banks per 1,000 people; the number of commercial bank branches per 100 thousands people; % of people who have a bank account; % of large firms with open credit; % of small firms with open credit.	% of market capitalization excluding the 10 largest companies; % of the volume of securities trading, excluding the 10 largest traders; yield of government bonds (3 months and 10 years); the ratio of internal and total volumes of debt securities; ratio of private and total volumes of domestic debt securities; the ratio of new issues of corporate bonds to GDP.
Efficiency	net interest margin; credit-deposit spread; non-interest income to total income; overhead costs (% of total assets); profitability (return on assets, return on equity); welfare indicator (or Herfindahl index or H-statistic).	turnover ratio (turnover / capitalization) of the stock market; synchronicity of prices (joint movement); trade in private information; impact of prices; liquidity / transaction costs; quoted bid-ask spread for government bonds; turnover of bonds (private, state) on the stock exchange; efficiency of calculations.
Stability	Q-score capital adequacy ratios (or approach to default); asset quality ratios; liquidity ratios; other (net currency position to capital, etc.).	volatility (standard deviation / average) of the stock price index, sovereign bond index; index asymmetry (share price, sovereign bond); vulnerability to profit manipulation; price/earnings ratio; duration; the ratio of short-term bonds to total (domestic, international); correlation with primary bond yields.

Source: Built by the authors from the data (Jordana *et al.*, 2018; World Bank, 2022; International Monetary Fund, 2023b).

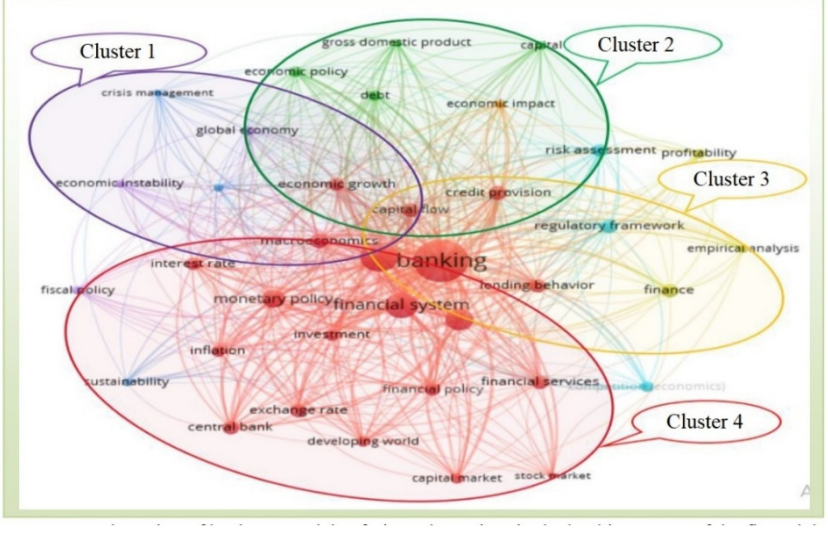
Fig. 3. Financial market stability matrix.

sector, these models operate in the P2P, P2B, and B2B segments. Every year, innovative models of metaspace technologies continue to expand, along with the increasing depth of financial services. These models include personal finance management, investment platforms, crowdfunding and crowdsourcing, Big Data analysis services, cryptocurrencies and blockchain technologies, payment and settlement systems, digital security, neo-banks (branchless banks), AI-powered business platforms, InsureTech (automation of insurance products), international transfer systems, RegTech (digital automation of business adaptation to changes in legislation and market conditions), and others (Hagedorna and Pinkwartb, 2013; Patlasov and Grakhov, 2016; Synyuk, 2018; Wright, 2019).

Cluster relationships of business models of FinTech services in the banking sector of the financial market were built as follows: Cluster 1 focuses on globalisation and impulses of the banking sector in the financial market; Cluster 2 addresses macroeconomic impulses; Cluster 3 involves regulatory impulses,

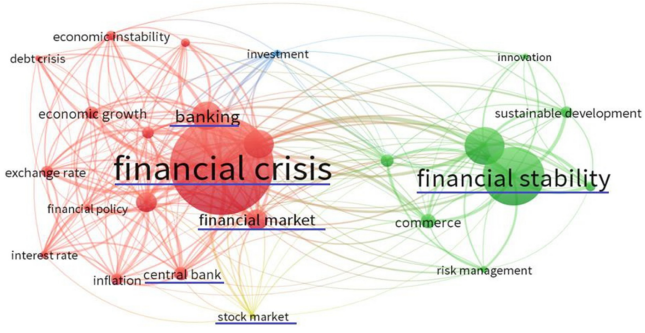
forecasts, and analytics; and Cluster 4 deals with impulses of the banking system as an element of the financial ecosystem. Within Cluster 4, all coherent components are concentrated, which are determinants for the modification of the financial market segment system into a FinTech ecosystem. This ecosystem expands the boundaries of monetary and financial policy, ensures the safety of financial services, coordinates and digitises financial operations on the capital and stock markets, and controls inflationary processes, interest rates, investment flows, exchange rates, and market stability (Fig. 4).

Figure 4 illustrates the clustering of business models of FinTech services in the banking sector of the financial market into four distinct groups. Cluster 1 reflects globalisation trends and external impulses affecting the banking sector. Cluster 2 encompasses macroeconomic drivers, such as GDP dynamics, employment rates, and inflation trends. Cluster 3 is oriented toward regulatory impulses, forecasts, and analytical tools that guide strategic decision-making. Most notably, Cluster 4 consolidates the core components that serve as determinants for transforming traditional financial market segments into a FinTech ecosystem. This cluster captures the expanded role of FinTech in reshaping monetary and financial policy frameworks, improving the safety and efficiency of financial services, and enabling the digital coordination of operations in capital and stock markets. It also reflects mechanisms for managing



Source: Built by the authors from the data (Klaas and Daryakinm, 2016; Synyuk, 2018; Wright, 2019).

Fig. 4. Clustering of business models of FinTech services in the banking sector of the financial market.



Source: Built by the authors from the data (Schinasi, 2005; Klaas and Daryakinm, 2016; Patlasov and Grakhov, 2016; Wright, 2019).

Fig. 5. The close relationship between the financial crisis and the financial stabilisation in banking sector.

inflation, interest rates, investment flows, and exchange rate dynamics to foster market stability.

The close relationship of the components of Cluster 4 demonstrates the need to modify the structure of the banking sector in the system of financial market segments under the conditions of the financial crisis (Fig. 5). This requires a clear coherence of banking sector functioning in the digitised innovative metaspace and its integration into the FinTech ecosystem to stabilise financial development.

Figure 5 highlights the strong interconnection between the elements of Cluster 4 and their role in responding to financial crises through structural transformation. The figure demonstrates how, under crisis conditions, the coherence of Cluster 4 components necessitates the reconfiguration of the banking sector's structure within the financial market. This is achieved through digitalisation and the integration of banking operations into the FinTech ecosystem, thereby promoting financial stabilisation. The innovative metaspace environment enables synchronised adaptation of the banking system to market shocks, enhancing resilience and functional continuity. The transformation supports the stabilisation of financial architecture by aligning infrastructure components with contemporary technological imperatives and collaborative finance principles (Schinasi, 2005; Klaas and Daryakinm, 2016; Patlasov and Grakhov, 2016; Wright, 2019).

The main trends in the FinTech ecosystem integration into the financial market include invisible finance (payments and settlements), QR codes, cryptocurrency, hybrid financial products, lending and insurance, and hyper-personalisation through AI, big data, and cybersecurity. The markets of Central Asia and Eastern Europe have a combined population of over 300 million, making them particularly attractive to FinTech companies. This is especially true since only half of the

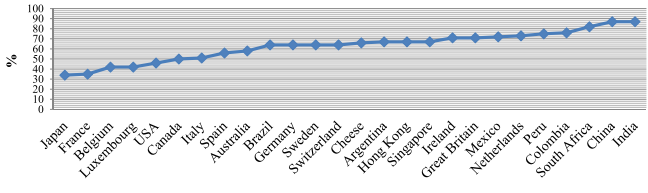
population actively uses financial products (Platon Payment Service Provider, 2019; World Bank, 2022). A strong argument for the FinTech ecosystem integration into Ukraine's financial market is the rapid adaptation of financial service consumers to new technological innovations (Ukrainian Association of Fintech and Innovation Companies, 2019b).

The FinTech ecosystem is transforming the world by establishing a new order of total digitalisation of financial relations. The expansion of new financial technologies in the metaspace has become unstoppable, with efforts focused on maximising their beneficial effects and minimising negative aspects in the financial market (Fig. 6). FinTech opens up new opportunities for consumers to access services remotely in areas such as money transfers, budgeting, financial planning, savings, investments, lending, and insurance. In Ukraine, over a hundred companies are involved in the FinTech sector, although most lack long-term practical experience (National Bank of Ukraine, 2020; Ukrainian Association of Fintech and Innovation Companies, 2019b).

The level of investments in the FinTech ecosystem increased significantly in many countries during the period from 2019 to 2022. There was an increase of 45% in Australia, 42% increase was observed in Canada; and this increase amounted to 38% in Hong Kong. As for Singapore, Great Britain, and the USA, the FinTech ecosystem increased by 52%, 57% and 29%, respectively.

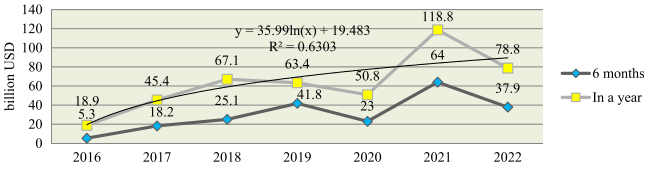
The analysis of global investments made in the FinTech ecosystem in the period from 2016 to 2022 shows some unevenness. In 2016, they amounted to USD 18.9 billion; a significant growth was observed in 2017, reaching USD 45.4 billion. Even though it rose to USD 67.1 billion in 2018, there was a decline to USD 63.4 billion in 2019, and it further dropped to USD 50.8 billion in 2020. In 2021, it became a record year, with global investment growing 2.3 times compared to 2020, reaching USD 111.8 billion. However, investments in the FinTech ecosystem decreased by 33.7% in 2022, compared to 2021 (Fig. 7).

According to estimates, 2021 was a landmark year not only in terms of capital inflows into the FinTech ecosystem but also in terms of the expansion of its



Source: Built by the authors from the data (World Bank, 2022; International Monetary Fund, 2023b).

Fig. 6. The average level of the FinTech ecosystem integration in the countries' financial markets for 2019–2022,%.



Source: Built by the authors from the data (Platon Payment Service Provider, 2019; World Bank, 2022; International Monetary Fund, 2023a).

Fig. 7. Global investments in the FinTech ecosystem for 2016–2022, billion USD.

boundaries within the financial market. This included significant increases in venture capital and corporate venture capital and activity in mergers and acquisitions. Tree agreements exceeding USD 10 billion were concluded, alongside additional agreements totalling USD 14 billion (Platon Payment Service Provider, 2019). Venture investments grew to USD 25.3 billion in 2021. The volume of investments by financial companies for private financial capital management was not significant, which indicated insufficient investment capacity of the leaders of this financial market segment. The same year, investments in the segment of blockchain and cryptocurrency amounted to USD 5 billion, and the number of investments in InsurTech reached USD 7.6 billion (Platon Payment Service Provider, 2019).

In 2022, there were changes in global investment in the FinTech ecosystem, which had been actively implemented in the financial markets of world countries until then. The trade war with the U.S. caused China to suspend a number of major deals, leading to a sharp drop in investment in the first half of the year, which totalled USD 37.9 billion. This trend could be considered temporary, as the latter half of 2022 witnessed the execution of several major mergers and acquisitions involving companies such as Worldpay, First Data, and Total System Services. Worldpay was expected to be acquired by Fidelity in a deal valued at approximately USD 43 billion. First Data was also set to be acquired, with the transaction estimated at USD 22 billion. Furthermore, a merger between Total System Services and Global Payments was projected, with a deal value of USD 21.5 billion (World Bank, 2022; International Monetary Fund, 2023a).

The amount of venture investments by financial corporations in the FinTech ecosystem for integration into the financial market was USD 4.75 billion, while global private capital investments amounted to USD 1.9 billion. In the blockchain and cryptocurrency segment, 171 deals provided USD 1 billion in investments, and the volume of investments in InsurTech reached USD 1.1 billion. Even though there was the slowdown in global financing, many countries experienced an increase in this indicator. In the USA, the value of deals grew by 60%, reaching USD

12.7 billion; investments doubled in Germany and Great Britain, totalling USD 829 million and USD 2.6 billion, respectively. In Sweden, the value of transactions increased more than four times and reached USD 573 million; growth was also noticed in such countries as Singapore (USD 453 million) and Australia (USD 401 million) (International Monetary Fund, 2023a; World Bank, 2022).

The second EU directive on payment services in the internal market (PSD2) (Sydorenko and Maksimenko, 2019) became a favourable factor for the creation of a more transparent and open payment market in the European space and the expansion of financial services of the FinTech ecosystem. An important area of focus for Ukraine is the assessment of the FinTech industry in the Central and Eastern Europe region, which is currently valued at EUR 2.2 billion. This industry employs about 600 companies, which operate in sectors such as mobile payments, investments and asset management, insurance, personal finance management, and cryptocurrencies (World Bank, 2022).

The implementation of PSD2 (Sydorenko and Maksimenko, 2019) in the integrated FinTech ecosystem infrastructure of Ukraine allows FinTech companies to form financial relationships with banking institutions and economic agents. In Ukraine, the FinTech ecosystem in the financial market is estimated at USD 650 million, but it cannot compete with the European market or the US market. In Ukraine, out of the total number of FinTech companies, only 48% are at the stage of business scaling, 24% are at the stage of starting sales, 7% offer a minimum viable product, and 1% have only a plan to realise the idea. The number of mature FinTech companies operating in the financial market is 19% (Table 1).

The majority of FinTech companies operate in the Payments/Money Transfer (38 companies) and the Technology and Infrastructure (36 companies) segments. There are 26 companies focused on Consulting/Analytical Systems, 22 companies working on Mobile wallets, and 16 companies involved in Blockchain/Crypto. The presence of FinTech companies in other segments is much lower: 11 companies in Cybersecurity/Anti-fraud, 10 in Personal and Consumer Lending, 8 in Digital/Neobanks, and 6 each in Insurtech and Personal Finance/Wealth Management. Business lending and Regtech each have 5 companies, Legaltech has 4, and Digital Comparison Tool has 3.

The USAID Financial Sector Transformation Project has 41.5% of companies operating in Ukraine's financial market. More than half of Ukrainian FinTech companies operate in the EU, over 40% operate in the financial markets of Kazakhstan, Turkmenistan, and Georgia. About 25% operate in the U.S., Canada, and Asia, and almost 15% are present in African markets. About 10% of Ukrainian FinTech companies operate in South and Latin America, and 7% operate in Australia and Oceania (Garasym and Tanchak, 2013; Ukrainian Association of Fintech and Innovation Companies, 2019a; National Bank of Ukraine, 2020).

Table 1. Functioning of FinTech companies in segments of the financial market of Ukraine.

Company	Activity segment	Financial market	Economic agents
GlobalMoney	Payments/Money transfer	Ukraine	Small, medium and large business
Nexstep Solutions LLC	Insurtech		
Interkassa	Payments/Money transfer	Europe	
Financial Service Bureau	Consulting/Analytical systems Payments/Money transfer Regtech	Ukraine, Georgia, Israel, Eastern Europe	
Unity-Bars	Technology and Infrastructure	Ukraine, Europe	
Renome-Smart	Technology and Infrastructure Payments/Money transfer Consulting/Analytical systems Cybersecurity/Anti-fraud	Ukraine, Africa	
TAS Link	Technology and Infrastructure Payments/Money transfer Mobile wallets	Ukraine	
Portmone	Payments/Money transfer	Ukraine	Individuals, small, medium and large businesses
Post Finance	Payments/Money transfer Mobile wallets Business lending		
Uapay	Payments/Money transfer	Ukraine, Europe	
Bradley Holding	Personal and consumer lending	Ukraine, Poland, Moldova, Romania	
Wallet Factory	Mobile wallets Payments/Money transfer Blockchain/Crypto Technology and Infrastructure Consulting/Analytical systems	International market	Big business
ProFIX	Technology and Infrastructure Payments/Money transfer Consulting/Analytical systems	Europe, Southeast Asia, Central Asia	
Ukr.Pay	Technology and Infrastructure Consulting/Analytical systems	Ukraine	
Lime Systems	Technology and Infrastructure		
Fintech Band	Technology and Infrastructure Payments/Money transfer Mobile wallets Digital/Neobanks	Ukraine	Individuals
Moneyyeo	Personal and consumer lending		

Source: Built by the authors based on (Ukrainian Association of Fintech and Innovation Companies, 2019a; World Bank, 2022; National Bank of Ukraine, 2022a; International Monetary Fund, 2023a).

One of the key problems hindering the full integration of the FinTech ecosystem into Ukraine's financial market is the insufficient amount of financing. 61% of FinTech companies work with their own funds, with this figure reaching 70% for companies that entered the market in 2018, while 39% attract foreign investments (Garasym and Tanchak, 2013; Ukrainian Association of Fintech and Innovation Companies, 2019a; National Bank of Ukraine, 2020). At the same time, the increase in demand for FinTech products in the infrastructure of Ukraine's financial market is driven by the rise in Internet penetration. The number of Internet users (economic agents) in 2021 was 22.96 million (7% more than in 2020). The activation of innovative processes in metaspace is associated with an increase in the number of smartphone owners — 22% of users (economic agents) access the Internet only from smartphones (Garasym and Tanchak, 2013; Ukrainian Association of Fintech and Innovation Companies, 2019a; National Bank of Ukraine, 2020, 2022a).

It remains urgent to create favourable conditions for the establishment and further integration of the FinTech ecosystem into the segments of the financial market. There is a need to increase the level of financial inclusion, ensuring free access for the population to financial products and services based on adequate tariffs and legal protection. The priority is to solve the problem of attracting capital from external sources of financing, which is possible under the condition of reducing the riskiness of investing resources to stabilise the financial market and overcome crisis phenomena in the banking sector.

Discussion

Today, metaspace dynamically integrates the FinTech ecosystem into the financial market segments; it combines advanced financial and technological achievements to develop a potentially promising FinTech market. The transformation of Ukraine's FinTech market into a key innovation hub within the metaspace financial infrastructure has enabled several critical advancements. These include the measurement of the FinTech ecosystem's integration momentum and financial services expansion via payment systems under conditions of remote identification of users (economic agents) (Trusova *et al.*, 2021). Payment systems differ in terms of the number of users they serve and are classified based on their significance: important, socially important, and systemically important. In Ukraine, five payment systems are categorised as important. Three of them are international systems with founders in the USA (RIA and MoneyGram) and Georgia (Intelexpress), which serve a substantial number of users, primarily financial institutions such as banks (see Table 2).

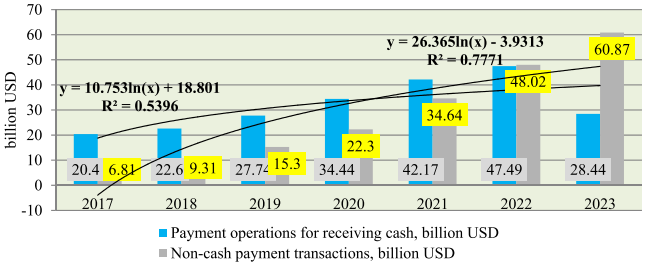
Table 2. Functionality of the payment segment of the financial market of Ukraine.

Payment system	Sign	Characteristics of the payment system	Country of origin	% of the total amount of money transfer transactions
MasterCard	SIPS	IPS	USA	67% of the total amount of transactions using electronic means of payment carried out on the territory of Ukraine (USD 105 billion)
Visa	SIPS	IPS	USA	32% of the total amount of transactions using electronic means of payment carried out in retail payment systems on the territory of Ukraine (USD 51.7 billion)
Western Union	SIPS	IPS	USA	18% of domestic and cross-border transfers (USD 8.1 billion); 56% of cross-border money transfers (USD 2.6 billion)
FORPOST	SIPS	ISPS	Ukraine	11% of the total amount of domestic and cross-border remittances created by residents and non-residents (USD 8.1 billion); 16% of the total amount of intrastate transfers of funds made by residents and non-residents (USD 5.5 billion)
InterPayService	SIPS	ISPS	Ukraine	9% of domestic and cross-border remittances (USD 8.1 billion); 14% of intra-state transfers made by systems (USD 2.5 billion)
MoneyGram	IPS	IPS	USA	7% of the total amount of domestic and cross-border remittances made by residents and non-residents (USD 8.1 billion); 20% of the total amount of cross-border money transfers made by residents and non-residents (USD 2.6 billion)
City24	IPS	IPS	Ukraine	7% of the total amount of domestic remittances created by residents and non-residents (USD 5.5 billion)
RIA	IPS	IPS	USA	6% of the total amount of cross-border remittances created by residents and non-residents (USD 2.6 billion)
Financial world	IPS	IPS	Ukraine	6% of the total amount of domestic and cross-border remittances of funds created by residents and non-residents (USD 8.1 billion); 8% of the total amount of domestic remittances created by residents and non-residents (USD 5.5 billion)
Intelexpress	IPS	IPS	Georgia	6% of the total amount of cross-border remittances created by residents and non-residents (USD 2.6 billion)

Notes: IPS is an important payment system; SIPS is a socially important payment system; IPS is international payment system; ISPS is an intrastate payment system.
Source: Built by the authors based on (National Bank of Ukraine, 2023a,b).

The findings indicate the FinTech ecosystem is being actively integrated into Ukraine's financial market infrastructure, particularly within the payment segment. There is a high concentration of financial services within several key payment systems of both national and international origin. According to Table 2, the largest share of total transaction volume is held by international payment systems, namely MasterCard (67%) and Visa (32%). These international payment systems account for nearly the entire market of electronic payments in Ukraine. This reflects the Ukrainian FinTech infrastructure's heavy reliance on foreign providers. On the one hand, this reliance ensures a high quality of service; on the other, it increases the system's vulnerability to external economic risks and geopolitical instability. Western Union and MoneyGram, which are also international payment systems, play a significant role in the remittance sector for domestic and cross-border transfers. Specifically, Western Union accounts for 56% of all cross-border remittances, underscoring its importance in maintaining financial connections between the Ukrainian diaspora and residents of Ukraine. At the same time, several local payment systems operate within the Ukrainian market, including FORPOST, InterPayService, City24, and Financial World. Although their market share is smaller, they play a meaningful role in facilitating domestic transfers, primarily serving transactions between residents. The distribution of the volume of monetary transactions in the segment of payment systems of Ukraine's financial market is shown in Fig. 8.

Between 2017 and 2021, Ukraine's financial market exhibited a notable trend in its payment systems: the volume of cash withdrawal transactions consistently exceeded that of non-cash transactions by a factor of 1.7. However, a gradual shift occurred in favour of non-cash transactions during 2022–2023. By 2023, the gap had narrowed significantly, with non-cash transactions surpassing cash by USD 32.96 billion, or approximately 1.4 times. Specifically, the average volume of non-cash transactions processed through payment systems in 2023 reached USD 60.87



Source: Calculated by the authors based on the data (National Bank of Ukraine, 2023a,b).

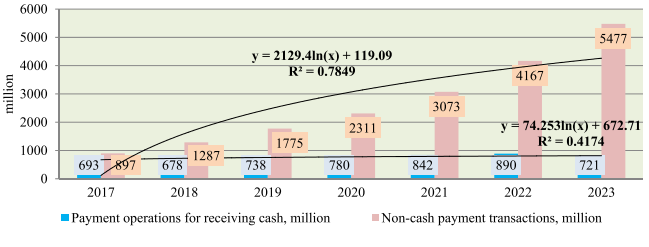
Fig. 8. Monetary transactions in the payment systems segment for 2017–2023, billion USD.

billion compared to just USD 28.44 billion in cash transactions. In contrast, the figures for 2017 were USD 6.81 billion for non-cash and USD 20.4 billion for cash transactions. This evolution reflects a stable and growing increase in consumer (economic agent) trust in both domestic and international payment systems for executing non-cash transactions.

The dynamics of transaction count reveal an even more pronounced shift (Fig. 9). The number of cash transactions has remained significantly lower than non-cash transactions, with the gap expanding substantially over time. While the difference stood at 29.4% in 2017, it had increased by more than 7.6 times by 2023.

In payment systems, the redistribution of transaction volume shares is characterised by the dominance of several key providers. "MasterCard" accounts for the largest share at approximately 25%, followed by "Visa" with around 20%, and "MoneyGram" with over 15%. These figures align with consumer (economic agent) transfer activity, where JSC "Privatbank" and JSC "Oschadbank" are the leading institutions.

When evaluating the stability of the financial market within the innovative metaspace environment, it is essential to consider the dynamics of FinTech ecosystem integration. According to the World Bank methodology, such integration facilitates timely insight into the mechanisms of price formation and its fluctuations in financial assets. The primary metric used to assess financial market stability is the turnover ratio, defined as the volume of FinTech service transactions relative to the capitalisation of assets within the FinTech ecosystem. The relationship between financial market stability and the asset market theory is supported by the principle that higher turnover indicates greater market liquidity (World Bank, 2022). Moreover, indicators of price formation synchronicity and responsiveness to changes in financial asset volatility are critical in evaluating the market's resilience. Based on these factors, the study calculated predictive indicators of effective financial market development for the period 2018–2025 across

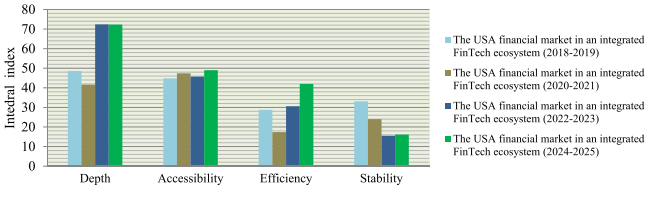


Source: Calculated by the authors based on the data (National Bank of Ukraine, 2023a,b).

Fig. 9. Transactions carried out in Ukraine's financial market for 2017–2023, million.

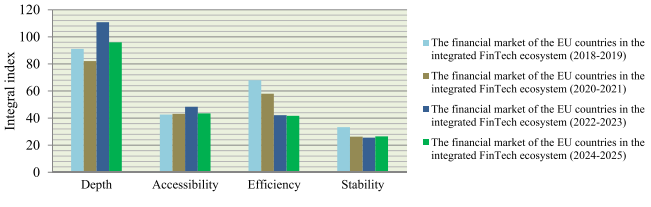
the European Union, Asia, the United States, and Ukraine (Figs. 10–13). These projections account for the FinTech ecosystem's capacity to maintain market stability and respond promptly to volatility shocks and turbulence dynamics.

Ukraine's "digital maturity" was determined by calculating the Digital Acceleration Index (DAI) in the context of its integration into the metaspace innovative environment (Horobet and Lupu, 2009). More than a quarter of the FinTech companies operating in Ukraine's financial market provided virtual FinTech services in 2021–2022. These services are continuously evolving as digital



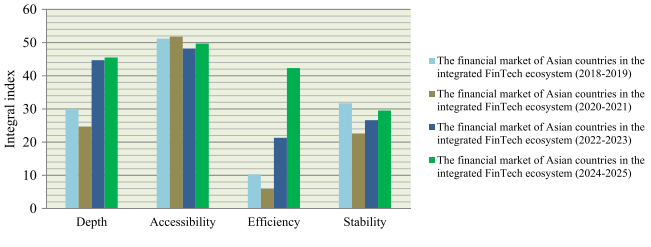
Source: Built by the authors from the data (Platon Payment Service Provider, 2019; World Bank, 2022; International Monetary Fund, 2023a).

Fig. 10. The US financial market stability in the integrated FinTech ecosystem for 2018–2025.



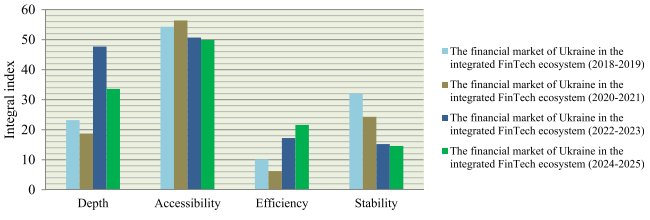
Source: Built by the authors from the data (Platon Payment Service Provider, 2019; World Bank, 2022; International Monetary Fund, 2023a).

Fig. 11. The EU financial market stability in the integrated FinTech ecosystem for 2018–2025.



Source: Built by the authors from the data (Platon Payment Service Provider, 2019; World Bank, 2022; International Monetary Fund, 2023a).

Fig. 12. The Asian financial market stability in the integrated FinTech ecosystem for 2018–2025.



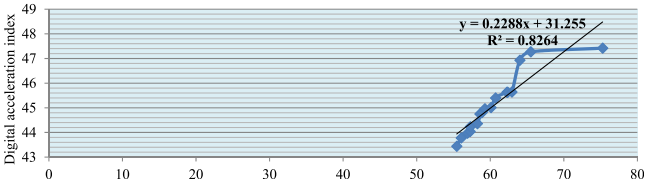
Source: Built by the authors from the data (Platon Payment Service Provider, 2019; World Bank, 2022; International Monetary Fund, 2023a; National Bank of Ukraine, 2023a,b).

Fig. 13. The Ukraine's financial market stability in the integrated FinTech ecosystem for 2018–2025.

technologies within the metaspace develop. Many market leaders operate in Asian countries, and virtual financial intermediaries are widespread here. However, the data privacy standards in these countries are considerably weaker than those in the European Union and the United States (Platon Payment Service Provider, 2019; World Bank, 2022; International Monetary Fund, 2023b).

Figure 14 presents the multi-component index of digital acceleration related to metaspace development in Ukraine. The index reached 65.51% in 2021 and 75.28% in 2022. During the same period, the level of FinTech ecosystem integration into the national financial market ranged between 47.27% and 47.42%, indicating a steadily increasing trend.

Digital technologies development within the metaspace and the dynamic technological changes in the payment systems segment of the financial market reflect the growing acceleration of FinTech services. This acceleration influences internal state lending, foreign direct investment, and monetary transactions involving foreign financial organisations. If the DAI is not included in the metaspace, several key indicators turn out to be statistically insignificant. These included domestic lending by banks to economic agents, domestic lending by other financial institutions, and net claims of foreign financial corporations on public financial organisations in Ukraine. Therefore, these indicators were aggregated into one generalised indicator, namely the digitalised level of domestic



Source: Constructed by the authors.

Fig. 14. The average FinTech ecosystem integration for 2023–2025,%.

lending by the banking sector of economic agents. The aggregation was used to construct a model that analyses the influence of the metaspace DAI in each element of the aggregated indicator.

To build an adequate model evaluating the DAI influence on macroeconomic indicators, several variables were considered. These included changes in the GDP of Ukraine, foreign direct investment (FDI), domestic lending by the banking sector to economic agents (ILBS), foreign portfolio investments in financial assets of economic agents (FIFA), and monetary transfers from foreign financial organisations to the country (MTFO). The results of the regression modelling are presented in Table 3.

Table 3 shows that the adjusted coefficient of determination and the Fisher test is high, while the p-test values of all independent variables are low. The value of the Durbin-Watsen test is 1.49, which indicates the absence of autocorrelation of residuals for this model (according to model parameters $N = 23$, $k = 4$ and significance level $\alpha = 0.01$). All this generally confirms the adequacy of the constructed model. In analytical form, the regression model of the influence of financial factors on changes in the GDP of Ukraine is as follows:

$$\text{GDP} = 846929112 + 0.721 \times \text{ILSB} + 4.414 \times \text{FDI} + 3.417 \times \text{MTFO} + 2.479 \times \text{FIFA}, \quad (5)$$

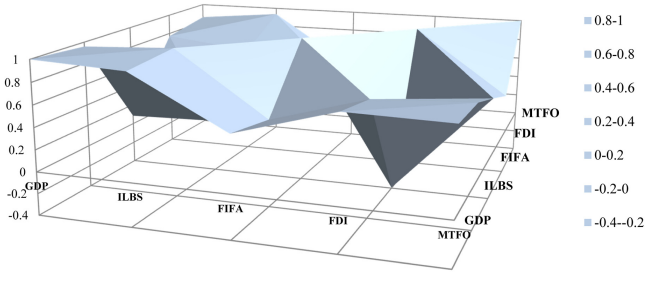
According to the equation, the acceleration of digitisation in domestic lending transactions by one USD leads to a GDP increase of 0.72 USD. In comparison, the digitisation of foreign direct investment (FDI) transactions results in a GDP increase of 4.14 USD. Similarly, the digitisation of monetary transactions conducted by foreign financial organisations contributes to GDP growth by 3.42 USD. Moreover, the digitisation of foreign portfolio investment transactions in Ukrainian financial assets boosts GDP by 2.48 USD. These findings indicate that the digitalisation of external financing flows exerts a significant influence on Ukraine's economic growth. Based on the model calibration results, an approximate surface representing the dependence of Ukraine's GDP on the volume of digitised financial transactions by economic agents was developed. This relationship is illustrated in Fig. 15.

Ukraine is not the only country that relies on digitalised monetary transactions as a key source of foreign currency income. These transactions help minimise risks, hybrid threats, and financial instability. Digital transactions, alongside traditional cash flows, serve as non-debt channels for foreign currency inflows and play a significant role in the balance of payments. This is especially important in contexts of persistent budget deficits and capital outflows. Remittances help finance the budget deficit, reduce dependence on international financial

Table 3. Multivariate regression analysis of the impact of accelerated digital transactions by the amount of financing of economic agents on the GDP of Ukraine.

	Dependent variable: GDP, USD R = 0.98945477; R^2 = 0.9744489 Adjusted R^2 = 0.97211483; F(4.42) = 185.54; p < 0.00000					
$N = 23,\ k = 4$	b*	Std.Err.	b	Std.Err.	t(18)	p-value
A free indicator of the acceleration of digitisation of transactions			3.17787E+10	3.1942225E+09	11.00694	0.00000
Foreign direct investment (net inflows)	0.242827	0.062478	3.643018E+00	8.316878E−01	4.57807	0.00033
Domestic lending by the banking sector	0.623368	0.076619	6.298141E−01	6.744887E−02	9.30402	0.00000
Foreign portfolio investments in Ukrainian financial assets	0.112445	0.042433	2.014945E+00	7.684474E−01	2.67707	0.02394
Money transfers from foreign financial organisations	0.218167	0.057479	2.427384E+00	6.237721E−01	3.73287	0.00236

Source: Calculated by authors based on data (Nagy, 2010; Zlenko, 2018).



Source: Constructed by the authors.

Fig. 15. Dependence of Ukraine's GDP on digitalised transactions by the amount of financing of economic agents.

organisations, and strengthen the national currency, which is crucial for economic reforms (Krupka, 2013). Digitised cash flow transactions from international financial organisations are stable, resilient to crises, and have an anti-cyclical impact on the economy (Krupka, 2014). The World Bank research highlights that digital FinTech ecosystems ensure reliable monetary transactions in times of crisis and act as a powerful cyber protection tool (Kim *et al.*, 2006).

The penetration of FinTech services into the financial system has accelerated significantly. It rose from 16% in 2019 to 87% in 2022, reflecting the rapid adoption of innovative technologies. This growth has expanded access to financial services but has also increased exposure to market volatility and cybersecurity risks. Global investments in the FinTech ecosystem have experienced notable fluctuations. Investment peaked at $111.8 billion in 2021 but declined by 33.7% in 2022 (World Bank, 2022). In Ukraine, the FinTech ecosystem is valued at approximately $650 million. Currently, 48% of Ukrainian FinTech companies are in the scaling stage, and 61% operate using their own capital. This points to limited opportunities for expansion (World Bank, 2022). Thus, the FinTech ecosystem integration can be a powerful tool for sustainable economic development and financial stability. However, realising this potential requires close collaboration among government agencies, financial institutions, and technology companies. Such cooperation is essential to harness the benefits of digital technologies while effectively managing associated risks.

Conclusions

Thus, in the process of financial integration, the openness of national financial markets has changed radically. As a result of globalisation, the scale of international financial transactions and the volume of cross-border capital movement have significantly increased. National economies have become more dependent on foreign sources of financing. This trend is especially noticeable in Ukraine, as the country is largely forced to adapt to the standards of digital innovation in the meta-space. This leads to a fundamental transformation of the business landscape of the FinTech ecosystem. It changes the infrastructure and composition of the financial market, integrating the rules of activity across its sectors, which dynamically influence business processes and financial flows and shape a new vision of modern consumer (economic agent) needs in financial services. These changes also generate innovative approaches to the production and provision of digital products using advanced technologies, expand the circle of market participants, and form new areas of activity within a unified space of financial innovation. Meanwhile, financial innovations optimise the interaction of economic agents with banking institutions, which dominate global trends in digitalised processes and financial asset management. This, in turn, accelerates the integration of the FinTech ecosystem into the credit and investment market segment, which operates in a constantly evolving transformational environment. All these processes should be ensured by the formation of technological network platforms of a spatial nature, namely, the meta-space. The effectiveness of the FinTech ecosystem is based on

improving the means and channels of information exchange, increasing the speed of such exchange, ensuring a higher level of data protection and reducing the risks associated with the protection of personal data.

The acceleration of operations to counter hybrid threats in real time, along with the modernisation of financial instruments to increase capital within the FinTech ecosystem, represents a unique phenomenon that reflects the virtualisation of currency support for financial segments. This allows the system's stability to be maintained even during periods of "financial bubbles" formation, which accumulate risks, particularly in the context of resolving military conflicts that negatively affect the balance of economic agents.

The analysis shows that such a transformation is accompanied by an increase in external debt and the current account deficit, an outflow of resources from real economic activity, disruptions of the normal functioning of financial markets, a decrease in asset prices, bankruptcies among market participants, and a deterioration in both the liquidity and quality of financial instruments. In the global context, the level of FinTech services penetration into financial systems increased from 16% in 2019 to 87% in 2022. Global investments in the FinTech ecosystem reached a record 111.8 billion USD in 2021, confirming the effectiveness of modernisation, but also indicating growing market volatility.

Therefore, the need to implement the FinTech ecosystem as an integral component of the modern financial system is evident. This requires the development of a new concept for the financial market's development, where the structural transformation of mobilised financial resources will be oriented toward meeting state needs. This approach will effectively influence the dynamics of financial flows between countries and help stabilise economic processes through the introduction of advanced meta-spatial innovations on a global scale.

Despite the depth of the conducted analysis, this study has certain limitations. In particular, it does not sufficiently account for the social and ethical dimensions of FinTech implementation, especially the risks of digital exclusion among vulnerable population groups who lack access to modern technologies. Another limitation lies in the absence of scenario modelling for the potential development of the FinTech ecosystem under conditions of economic instability and prolonged military conflict (conditions that are currently characteristic of Ukraine).

Furthermore, the study does not include an analysis of the impact of regulatory changes, such as the implementation of new directives by the National Bank of Ukraine and the adaptation of domestic legislation to European financial law standards. This opens a pathway for future research, particularly in the areas of comparative regulatory effectiveness of the FinTech sector across different countries, state-led innovation support models in the financial domain, and the long-term socio-economic implications of financial services digitalisation.

Conducting applied empirical research based on surveys of financial service consumers and FinTech business representatives appears to be a promising direction. Such studies would provide deeper insights into the barriers and drivers of FinTech development within the national context.

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