Original Research

Blockchain and fintech technologies in the digital space of financial and industrial companies

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Abstract

The relevance of the article lies in examining the functional relationship between blockchain and fintech technologies in the innovative digital space of financial and industrial companies. The research aims to investigate the directions for the development of large integrated systems of financial and industrial capital, based on the principles of intensive production. The research methodology included the following methods: analytical (literature review, quantitative analysis), methods of comparison, generalization, and systematization. In particular, quantitative analysis was applied to calculate the index of digital cyber protection, which serves as an indicator and summarizes the safe properties of information resources in the digital space of banking institutions and their ability to prevent cyber-attacks on the financial and industrial capital of subjects in united spheres of economic activity. The results of the research have shown that the optimal criteria for the index of digital cyber protection are financially linked to industrial capital. The article substantiates the macroprudential policy of Ukraine's banking sector based on blockchain regulators and fintech technologies from the EU, which foster the intensive development of technological competitiveness among financial institutions. The article can be useful for financial and industrial executives, banking institutions, consulting firms, and educators seeking insights into the integration of blockchain and fintech technologies.

Keywords: Business processes, Banking sector, Investment flows, Sphere of economic activity, Financial institutions

1. Introduction

Digitalization of the financial and industrial sectors of the economy is evident in the transformation of formal and informal business models, necessitating regulatory tools at the national level to harness new technological opportunities in the modern geopolitical landscape. These profound changes are observable in the organizational and economic mechanisms of financial and industrial companies' development, leading to intersectoral contradictions marked by structural asymmetry in transnationalities, regionalization, and regulatory

institutionalization within public-private partnerships. As a result, the positioning of countries and regions is altered under the influence of financial globalism, informational processes, and social dynamics. To address the diversified multifunctional structure of financial and industrial companies in Ukraine, a digitized space of blockchain and financial technology (fintech) has emerged. These technologies centralize and decentralize the public registry system, employing cryptographic algorithms to pool investment, credit, and financial capital for increased profitability and digitization of international business transactions [1].

Cyber-attacks on the banking system have severe consequences for the economy of financial and industrial companies, heavily reliant on secure information and communication technologies for payment systems' integrity. Even minor security incidents, such as data breaches, can tarnish a banking institution's reputation, leading to significant corporate losses. Consequently, understanding the transformation of corporate business amidst digitalization and finding effective mechanisms to safeguard the interests of financial and industrial companies become crucial research areas, as emphasized by [2]. The influence of blockchain on cognitive management in the production process of industrial companies has been studied by scientists such as [3], [4]. Other researchers like [5], [6], [7] have explored innovative technologies to optimize the use of orbital hydraulic motors and planetary hydraulic machines while managing agricultural machinery and equipment supply chains in technological cycles to ensure product efficiency and competitiveness in the global market. However, these studies do not fully elucidate the functional relationship and financial architecture of financial and industrial companies' development, considering exogenous and endogenous factors influencing business model digitalization in the competitive corporate sector of the world economy. Therefore, the research's priority lies in substantiating the functional connection between blockchain and fintech technologies within the innovative digital space of financial and industrial companies, fostering technological competitiveness for financial institutions and economic subjects in the global market.

The paper by [8] focuses on the theoretical and methodological challenges in defining the concept of fintech and its implications for the legal regulation of the financial market. It delves into the various definitions and interpretations of fintech. The article also discusses the complexities in providing a concise and comprehensive definition of fintech due to its rapid and diverse evolution. The author addresses the importance of interdisciplinary research, as fintech combines elements of finance, technology, law, and other fields. He analyses the existing methodologies and proposes new ways to study the impact of fintech on the legal regulation of the financial market.

The potential role of blockchain technology in shaping the future of sustainable supply chain management within the context of Industry 4.0 is described in the research by [9]. The scientists highlight how blockchain, as a decentralized and immutable ledger, can contribute to enhancing transparency, traceability, and accountability in supply chains. Moreover, the article concludes with policy recommendations and practical guidelines for organizations, policymakers, and stakeholders interested in adopting technology for sustainable supply chain management. A roadmap for effectively implementing blockchain solutions and overcoming potential obstacles is presented. The article by [10] provides information about cybersecurity challenges faced by the banking sector in Ukraine during the period of war in the country: hacking attempts, data breaches, ransomware attacks, distributed denial-of-service (DDoS) attacks, and other malicious activities carried out by cybercriminals or state-sponsored actors. Additionally, the authors analyze how the ongoing war in Ukraine has exacerbated cybersecurity risks for the banking sector. They give recommendations for banks and policymakers to strengthen cybersecurity measures in the banking sector.

2. Research methods

Blockchain is a decentralized (in the classical sense) public registry system, based on cryptographic algorithms and containing data on all previously conducted operations. Schematically, the structure of the blockchain ensures each transaction is encoded with a special set of symbols and forms a hash. The set of hashes is also encoded and forms a new hash. The set of hashed hashes is also encoded and forms a block. The initial block

of the blockchain is zero (Genesis Block). The following transformations occur similarly and form new blocks. Each change of the hash or block will cause a change in previous hashes, which determines the reliability of the system [11]. In Figure 1 the difference between a centralized system and a blockchain is shown.
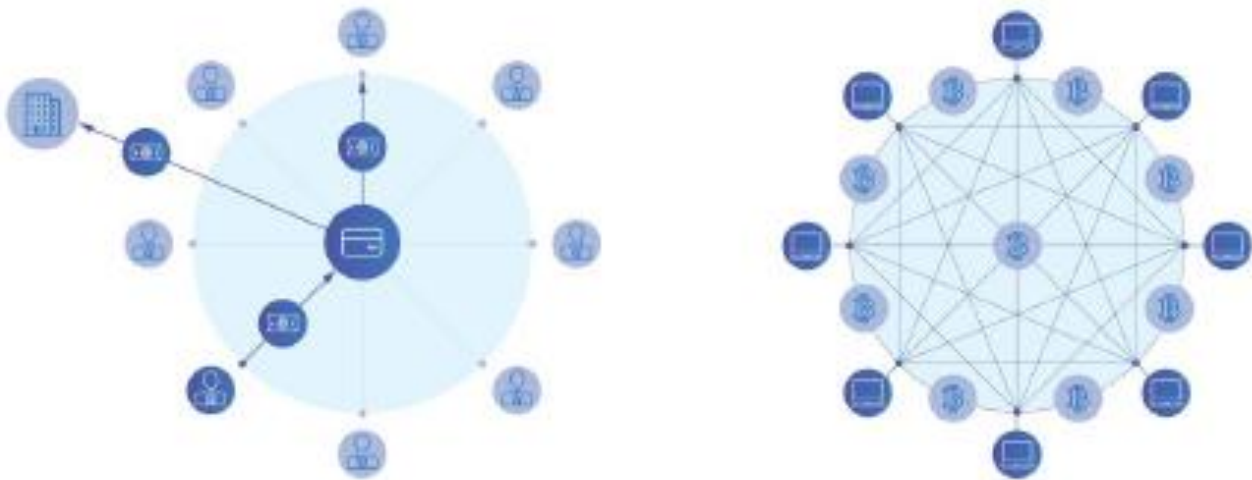

Figure 1. Comparison of centralized and decentralized (blockchain) systems [9]

From the standpoint of behaviorism in the study of fixed income and currencies (FIC) and through the prism of the formation of their architecture, as a separate direction of development of a multifunctional digital model of the economic system, a methodical approach to preventing threats to the functioning of blockchain and fintech technologies in the innovative digital space of the banking sector is proposed [12]. The basis of the methodical approach is a holistic view of the internal parameters of the blockchain and fintech, which digitize financial transactions and prevent cyber-incidents of threats in the spiral of strap-contacts based on the principles of mathematical modeling [8]. The study of the architecture of a banking institution in the FIC involves a wide range of components of integrity (emergency) – (Q_s), which is not a simple sum of the properties of its constituent elements:

$$Q_s \neq \sum Q_i. \tag{1}$$

That is, the integrity of the FIC architecture is manifested through the dependence of its properties on the constituent elements:

$$Q_s = f(q_i). \tag{2}$$

The configuration of the architecture is capable of suppressing certain properties of its components, provided that they acquire new characteristics. The regularity of the integrity of the FIC architecture is characterized by additivity (independence, separation). The additivity of the FIC architecture, when it is divided into independent structural components, is fair under the condition of functional dependence of blockchain and fintech technologies in the formation of an integrated hierarchy:

$$Q_s = \sum Q_i. \tag{3}$$

That is, the hierarchy of blockchain and fintech technologies in the formation of the integrated architecture of the FIC is created according to the levels of factorization of business processes $\{F_i\}$ according to the generalized parameters $\{Q_i\}$, which are the functionality $\{F_i\}$ of their system digitization from the number of variables that depend on the dynamic state of financial transactions of FIC over time. This method of description is called homeostasis, which allows us to determine the functional relationship between the interacting structural components (business processes) of the financial architecture in the digital environment of the FIC. Business processes $\{F_i(1)\}$ are considered as the initial functional parameters of blockchain and fintech in the digital

model of the financial architecture of a banking institution and entities of the combined spheres of economic activity, which are defined as:

- system parameters of the first level – $Q_1(1), Q_2(1),\ldots,Q_j(1),\ldots,Q_m(1)$;
- parameters of active countermeasures against cyber threats of the blockchain and fintech environment, which are directly aimed at a cyberattack on the financial architecture of the banking institution and subjects of the combined spheres of economic activity, and, accordingly, reduce its effectiveness – $b_1.b_2,\ldots,b_k,\ldots,b_K$;
- neutral (random) parameters of blockchain and fintech in the innovative digital field – $c_1, c_2,\ldots,c_l,\ldots,c_L$;
- favorable parameters of the innovative digital field – $d_1,d_2,\ldots,d_p,\ldots,d_P$.

The innovative digital field has direct contact with the subsystems of the financial architecture of the banking institution and subjects of the combined spheres of economic activity, which form a single financial and investment capital of a lower level, influencing through them the subsystems of a higher level of the hierarchy:

$$F_i = F_i \times \big(\{b_k\},\{c_l\},\{d_p\}\big). \tag{4}$$

By constructing a hierarchy (parameters of the β-th level – business processes of the (β -1)-th level – parameters of the (β-1)-th level) it is possible to determine the mutual properties of the innovative digital field of blockchain and fintech, which affect the efficiency of the financial architecture of a banking institution and subjects of united spheres of economic activity, with a single financial and investment capital. Blockchain and fintech parameters in the financial architecture of a banking institution $\{Q_J\}$ can change when the external environment is transformed and are dependent on business processes in the construction of financial and investment capital, which are recorded in the form of state functionals ($Q_{J1}(t)$). The functional digital field of blockchain and fintech in the financial architecture of a banking institution (W) is a space with possible situational options determined by a set of parameters up to the level (b):

$$Q = \{Q(1), Q(2),\ldots,Q(\beta)\}. \tag{5}$$

At the same time, a particular state of digitization of the financial architecture of a banking institution can be kept constant for some interval (T). It can be noted that business processes $\{F_i(2)\}$ are not the initial parameters of the digital model of blockchain and fintech functioning in the financial architecture of a banking institution. These are second-level business processes that depend on the parameters $Q(2)$ of financial and investment capital (second-level parameters). The following hierarchy of description is formed: efficiency (a finite set of functionals) – business processes of the first level (functions) – parameters of the first level (functionals) – business processes of the second level (functions) – parameters of the second level (functionals). At the final level (after the end of financial transactions), the functional properties of blockchain and fintech in the financial architecture of a banking institution are exhausted, and the business process of formalization parameters of blockchain and fintech is interrupted.

3. Results

FIC's activities involve developing integrated systems of financial and industrial capital, driven by intensive production, resource deepening, and the influence of innovative digital technologies on subjects in united economic spheres. The banking institution plays a dominant role within FIC, providing services to specific companies, monitoring fund movements, holding regulatory responsibility, and implementing measures for financial stability. Blockchain and fintech's comprehensive functional relationship in the financial architecture of the banking institution emphasizes understanding the underlying reasons for its emergence. The system-forming and system-preserving factors within the financial architecture encompass structural heterogeneity, contradiction, and aspiration for integration with entities in combined economic spheres. The formalization of interaction patterns is presented in Table 1.

Table 1. Formalized holistic regularity of the structural components of the digital configuration of the financial architecture of financial-industrial companies [13], [14]

Patterns of interaction	The degree of integrity of the digital environment of the financial architecture λ	The coefficient of use of structural components ρ
Integrity (emergency)	1	0
Progressive systematization	$\lambda \geq \rho$	
Progressive factorization	$\lambda \leq \rho$	
Additivity (summability)	0	1

It was assumed that the technological connection of blockchain and fintech in the innovative digital field of FIC architecture (S_{fa}) performs (N) functions ($\psi_1, \psi_2, \ldots, \psi_s, \ldots, \psi_N$), that depend on ($n$) business processes (financial transactions) of a banking institution and affect the efficiency of its functioning ($F_1, F_2, \ldots, F_i, \ldots, F_n$). The performance of the s-th function will have the following form:

$$E_s = E_s(\psi_s) = E(F_1, F_2, \ldots, F_i, \ldots, F_n) = E_s(\{F_i\}), \; i = 1 \ldots n, \; s = 1 \ldots N. \tag{6}$$

The effectiveness of the functional connection of blockchain and fintech in the innovative digital field of FIC architecture depends on the functional vector. This vector is influenced by the number of cyber-incidents and cyber-attacks on the banking system, as well as internal and external factors at the regional, local, and industry levels of subjects in the united economic spheres. The utilization of smart specializations, smart technologies, and smart industry also plays a significant role [15]. The financial and investment capital's multi-level hierarchy is formed, where the higher level's description depends on the generalized and factored variables of the lower level. This structure facilitates financial transactions between subjects in united economic spheres [13]. The functional description of the technological connection of blockchain and fintech in the innovative digital field of FIC architecture is as follows:

$$S_{fa} = \{T, x, C, Q, y, Y, \phi, \eta\}, \tag{7}$$

where, T – is a set of moments in the analysed period; x – is a set of values of incoming blockchain and fintech transactions with the external influence of the digital environment on the state of the financial architecture of the FIC; $C = \{c : T \rightarrow x\}$ – the number of permissible input of structural packages of blockchain and fintech and their impact on the state of the financial architecture of the FIC; Q – the set of states of the FIC architecture over time; y – the set of values of the initial values of the blockchain and fintech transaction; $Y = \{u : T \rightarrow y\}$ – a set of initial values of a blockchain and fintech transaction; $\phi = \{T \times c \rightarrow Q\}$ – is a transient function of the state of the FIC architecture in dynamics; $\eta = T \times c \rightarrow Q$ – the initial transaction of blockchain and fintech, reflecting the state of change of the FIC architecture over time; c – the time interval of incoming blockchain and fintech financial transactions with an external influence on the state of the FIC architecture; u – is the time interval of the initial value (variable) of the blockchain and fintech financial transaction in the state of the FIC architecture. The synergistic effect within the configuration of the financial architecture of the FIC has the form:

$$S_h = S_c + S_i, \tag{8}$$

where, S_h – is the synergy effect within the configuration of the financial architecture of the FIC; S_c – the synergy effect from the centralisation of the functions of structural packages, blockchain and fintech transactions in the financial architecture of FIC; S_i – the synergy effect from the integration of structural packages and transactions of blockchain and fintech in the financial architecture of FIC by hierarchy levels.

The synergy effect from the centralisation of the functions of structural packages, blockchain and fintech transactions in the financial architecture of the FIC is as follows:

$$S_c = \Sigma((\Delta C_i + E_i) \times K_i - C_c), \ i = 1, \dots n,$$ (9)

where, K – is the centralisation coefficient; ΔC – saving transaction costs; E – additional economic effect; C_c – current costs for the implementation of a specific function; n – the number of centralised functions.

Adaptation of the implemented digital model of the financial architecture of the FIC at the national level when the external digital environment changes (cyber threats and cyber incidents) is achieved through formalised planning of the transaction structure of public (private) blockchains and fintech with their purposeful use for the cyber security of financial and investment capital:

$$S_{fa}: X \rightarrow Y.$$ (10)

There is a transformation of the normalised values of the indicators of the statistical base of the study to the dimensionless scale of Harrington's desirability using formula:

$$D_{ij} = exp(-exp(-Q_{ij})),$$ (11)

where, Q_{ij} – is the normalised value of the j-th indicator of the digital cyber protection index of the banking institution in the architecture of the FIC of the i-th country; D_{ij} – is the intermediate value of the j-th indicator of the index of digital cyber protection of a banking institution in the architecture of the FIC of the i-th country, reduced to the Harrington-Mencher dimensionless desirability scale.

On the basis of the results obtained in the second step, it is possible to obtain curves of six types. The curve of the first type is a W-shaped, growing, symmetrical curve defined by formula:

$$D_{ij}^{I} = \exp \times \left(-\exp \times \left(9 \times \left(\frac{Q_{ij} - \min_i Q_{ij}}{\max_i Q_{ij} - \min_i Q_{ij}} \right)^{1.927} - 2 \right) \right),$$ (12)

where, is the intermediate value of the j-th indicator of the digital cyber protection index of the banking institution in the architecture of the FIC of the i-th country, reduced to the Harrington-Mencher dimensionless scale of desirability; $\min_i Q_{ij}$ – the minimum value of the normalised j-th indicator of safe digitization of information resources (blockchain and fintech) of banking institutions in the architecture of the FIC of the i-th country; $\max_i Q_{ij}$ – is the maximum value of the normalised j-th indicator of safe digitalisation of information resources (blockchain and fintech) of banking institutions in the architecture of the FIC of the i-th country.

The curve of the second type is a W-shaped, growing, asymmetric curve with rapid initial growth, which is determined by formulas:

$$D_{ij}^{II} = \exp \times \left(-\exp \times \left(9 \times \left(\frac{Q_{ij} - \min_i Q_{ij}}{\max_i Q_{ij} - \min_i Q_{ij}} \right)^{k_{II}} - 2 \right) \right),$$ (13)

$$k_{II} = \frac{In \times \ln\left(2 - \ln \times \ln \dfrac{1}{D_{ij}^{II}}\right)}{\ln\left(y_{ij}^{II} - \min_i Q_{ij}\right) - \ln\left(\max_i Q_{ij} - \min_i Q_{ij}\right)},$$ (14)

where, D_{ij}^{II}, y_{ij}^{II} – is any comparable pair within one country within one indicator.

The curve of the third type is a W-shaped, growing, asymmetric curve with a slow initial growth, which is determined by formulas:

$$D_{ij}^{III} = 1 - \exp \times \left(-\exp\left(-\left(9 \times \left(\frac{\max Q_{ij} - Q_{ij}}{\max_i Q_{ij} - \min_i Q_{ij}}\right)^{k_{III}} - 2\right)\right)\right),$$ (15)

$$k_{III} = \frac{In \times \left(2 - \ln \times \ln \dfrac{1}{D_{ij}^{III}}\right) - \ln 9}{\ln\left(y_{ij}^{III} - \max_i Q_{ij} -\right) - \ln\left(\max_i Q_{ij} - \min_i Q_{ij}\right)},$$ (16)

where, D_{ij}^{III}, y_{ij}^{III} – is any comparable pair within one country within one indicator.

The curve of the fourth type is a W-shaped, descending, symmetrical curve, defined by formulas:

$$D_{ij}^{IV} = \exp \times \left(-\exp\left(-\left(9 \times \left(\frac{\max Q_{ij} - Q_{ij}}{\max_i Q_{ij} - \min_i Q_{ij}}\right)^{1.927} - 2\right)\right)\right),$$ (17)

$$k_{IV} = \frac{In \times \left(2 - \ln \times \ln \dfrac{1}{D_{ij}^{III}}\right) - \ln 9}{\ln\left(y_{ij}^{IV} - \max_i Q_{ij} -\right) - \ln\left(\max_i Q_{ij} - \min_i Q_{ij}\right)},$$ (18)

where, D_{ij}^{IV}, y_{ij}^{IV} is any comparable pair within one country within one indicator.

The curve of the fifth type is a W-shaped, falling, asymmetric curve with a rapid initial decline, which is determined by formulas:

$$D_{ij}^{V} = 1 - \exp \times \left(-\exp\left(-\left(9 \times \left(\frac{\max Q_{ij} - Q_{ij}}{\max_i Q_{ij} - \min_i Q_{ij}}\right)^{k_V} - 2\right)\right)\right),$$ (19)

$$k_V = \frac{In \times \left(2 - \ln \times \ln \dfrac{1}{1 - D_{ij}^{VI}}\right) - \ln 9}{\ln\left(y_{ij}^V - \min\limits_{i} Q_{ij}\right) - \ln\left(\max\limits_{i} Q_{ij} - \min\limits_{i} Q_{ij}\right)}, \tag{20}$$

where, D_{ij}^V, y_{ij}^V – is any comparable pair within one country within one indicator.

The curve of the sixth type is a W-shaped, falling, asymmetric curve with a slow initial decline, which is determined by formulas:

$$D_{ij}^{VI} = \exp \times \left(-\exp\left(-\left(\left(9 \times \left(\frac{\max Q_{ij} - Q_{ij}}{\max\limits_{i} Q_{ij} - \min\limits_{i} Q_{ij}}\right)^{k_{VI}}\right) - 2\right)\right)\right), \tag{21}$$

$$k_{VI} = \frac{In \times \left(2 - \ln \times \ln \dfrac{1}{1 - D_{ij}^{VI}}\right) - \ln 9}{\ln\left(y_{ij}^{VI} - \min\limits_{i} Q_{ij}\right) - \ln\left(\max\limits_{i} Q_{ij} - \min\limits_{i} Q_{ij}\right)}, \tag{22}$$

where, D_{ij}^{VI}, y_{ij}^{VI} – is any comparable pair within one country within one indicator.

In the fourth step of the calculation, the integral index of the digital cyber protection of the banking institution in the architecture of the FIC, as the geometric mean of the derived values of the group of indicators of technological readiness and safe digitalisation of information resources (blockchain and fintech) of the banks-financial centres of the FIC and the group of indicators of stabilisation of payment systems and threats of fraud (cyberattacks) of banks-financial centres of the FIC:

$$DCSBS_i = \sqrt[n+m]{\prod_{j=1}^{n} (D_{ij}^*)^{\frac{w_j}{100}} \times \prod_{j=n+1}^{m} CB_{ij}^*}, \tag{23}$$

where, $DCSBS_i$ – is the integral index of digital cyber protection of a banking institution in the architecture of the FIC of the i-th country; n – the number of indicators of the group of technological readiness and safe digitization of information resources (blockchain and fintech) of banks-financial centres of the Federal Financial Committee of the country; m – the number of indicators of the stabilisation group of payment systems and threats of fraud (cyberattacks) of banks-financial centres of the FIC of the country; $(D_{ij}^*)^{\frac{w_j}{100}}$ – the degree of variation of the index of technological readiness and safe digitalisation of information resources (blockchain and fintech) of banks-financial centres of the Republic of Kazakhstan under the influence of the j-th input indicator of institutionalisation of the digital capacity of the banking sector of the i-th country (determined at the second stage); CB_{ij}^* – is the intermediate value of the j-th indicator of the group of indicators of stabilisation of payment systems and threats of fraud (cyber-attacks) of banks-financial centres of the FIC of the i-th country, adjusted to the Harrington-Mencher dimensionless scale of desirability.

Visualization of calculations and qualitative interpretation of the integral index of digital cyber protection of the bank-financial centre in the architecture of the FIC of the i-th country is presented in Table 2.

Table 2. Criteria of the integral index of digital cyber protection of the bank-financial center in the architecture of the FIC of the i-th country [10], [16]

Quality interpretation	Quantitative assessment
Stable level	1-0.8 (very good)
Medium-stable level	0.8-0.63 (good)
Medium-critical level	0.63-0.37 (satisfactory)
Moderately critical level	0.37-0.2 (bad)
Critical level	0.2-0 (very bad)

The martial law in Ukraine has had a significant impact on all spheres of the national economy, except for the banking sector. Banking institutions, as dominant forms of business organization, have provided powerful protection for the entire economic system through regional, local, and branch entities in united economic spheres. These forms of business organization are widely prevalent in the USA, Japan, and Germany, forming the backbone of their economies. For instance, in the USA, FIC contributes to creating 55-60% of the GNP, employing about 45% of labor resources, and accounting for nearly 60% of investments. In Ukraine, the concentration of private capital follows the world experience of forming transnational companies, but with domestic specificity linked to economic instability. The formation of FIC is based on systemic business processes and the growth of bank capital amid hyperinflation [13]. FICs in Ukraine act as a driving force for integrating business processes, generating positive synergistic effects to strategically promote the country's economy. They serve as potent sources of investment, stabilizers of the economy, and contribute to crisis recovery through diversification, globalization, and a well-developed network. Some of the largest FICs operating in Ukraine before the war include: "SCM," "DCH," "EastOneGroup," "Group DF," "Universal Investment Group," and "TAS (Table 3).

Table 3. Financial-industrial companies in Ukraine in 2022 [17]

Company	The share of industries in the net income of FIC, %	# of enterprises	Bank
FIC "SCM"	Metallurgy – 7%; Electrical engineering – 3%; Mining and ore – 8%; Agriculture – 7%; Fuel and energy complex – 15%; Coal industry – 4%; Chemical Industry – 7%; Food Industry – 11%; Pharmaceuticals – 5%; Financial sector – 15%; Others – 5%	809	JSC FUIB
FIC "DCH"	Construction – 3%; Transport trade – 4%; Information technologies – 8%; Woodworking – 4%; Non-mineral industry – 6%; Water supply and disposal – 6%; Financial sector – 8%; Others – 7%	351	JSC UkrEximBank
FIC "EastOneGroup" (Interpipe)	Pipe industry – 7%; Agriculture – 10%; Information Technology – 7%; Telecommunications – 4%; Coke industry – 2%; Financial sector – 7%; Others – 3%	242	JSC Bank Credit Dnipro
FIC "Group DF"	Metallurgy – 4%; Construction – 2%; Mining and ore – 6%; Shipbuilding – 3%; Food Industry – 7%; Agriculture – 14%; Financial sector – 10%; Others – 1%	172	JSC Pravex Bank
Universal Investment Group	Metallurgy – 4%; Mechanical engineering – 4%; Mining and ore – 5%; Agriculture – 9%; Fuel and energy complex – 12%; Construction – 4%; Shipbuilding – 3%; Financial sector – 10%; Others – 3%	136	JSC Universal Bank
FIC "TAS"	Metallurgy – 4%; Mechanical engineering – 5%; Mining and ore – 1%; Fuel and energy complex – 4%; Coke industry – 9%; Financial sector – 7%; Others – 3%	70	JSC TASKOMBANK

FICs have diverse activities, but each profiler focuses on a specific type of activity that shapes the companies' formation. Their main concentrations include metallurgy, mechanical engineering, mining, construction, shipbuilding, woodworking, agriculture, food, chemical, and coke industries. These sectors have a high level of concentration within Ukraine, benefiting from a sufficient raw material base to support their development. In 2022, FICs in Ukraine generated nearly 0.16 trillion EUR in income, with a significant portion belonging to the fuel-energy and agrarian-industrial complex branches (Table 4).

Table 4. Income of financial and industrial companies by economic sector of Ukraine in 2022 [17], [18]

Sector of the economy	Net income, billion EUR	Revenue share of TOP-1000 companies, %	Number of companies
Oil and gas sector	33.4	21	146
Electric power industry	27.6	17.3	105
Retail trade	13.3	8.3	53
Agriculture	12.9	8.1	102
Food industry	11.3	7.7	129
Metallurgy	11.1	7	51
Transport and logistics	6.7	4.2	35
Wholesale trade	6.6	4.1	59
Tobacco production	4.9	3.1	14
Pharmaceuticals	4.5	2.8	32
Chemical industry	4.3	2.7	53
Motor vehicle trade	3.7	2.4	47
Coal industry	2.8	1.8	8
Mechanical engineering	2.6	1.6	33
Information technology	2.1	1.3	23
Telecommunications	2	1.2	10
Coke industry	1.8	1.2	4
Construction	1.6	1	24
Woodworking	0.96	0.6	13
Finance	0.87	0.5	10
Non-mineral industry	0.87	0.5	14
Scientific research	0.67	0.4	7
Hotel and restaurant business	0.47	0.3	5
Health care	0.29	0.2	6
Water supply and disposal	0.26	0.2	5
Light industry	0.21	0.1	5
Furniture industry	0.15	0.1	2
Architecture and Engineering	0.13	0.1	3
Media and Film	0.05	-	1
Advertising and Marketing	0.04	-	1

The functioning FIC in Ukraine were created according to the principle of unification around a large banking institution. Thanks to the timely actions of the National Bank and banks participating in the FIC to ensure

smooth operation, the banking sector of Ukraine passed the first months of the war with moderate losses. In 2022, the income of banks participating in the FIC amounted to 8493 million EUR, which lost their positions by only 4.1% compared to 2021, with a significant increase in expenses to 7980.6 million EUR. This almost equalized income and expenses. But the banking sector remains operationally profitable and will continue to generate net profit (Figure 2).
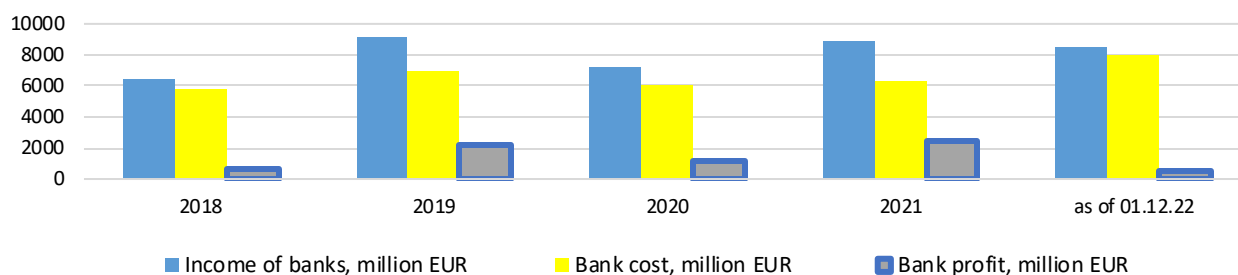

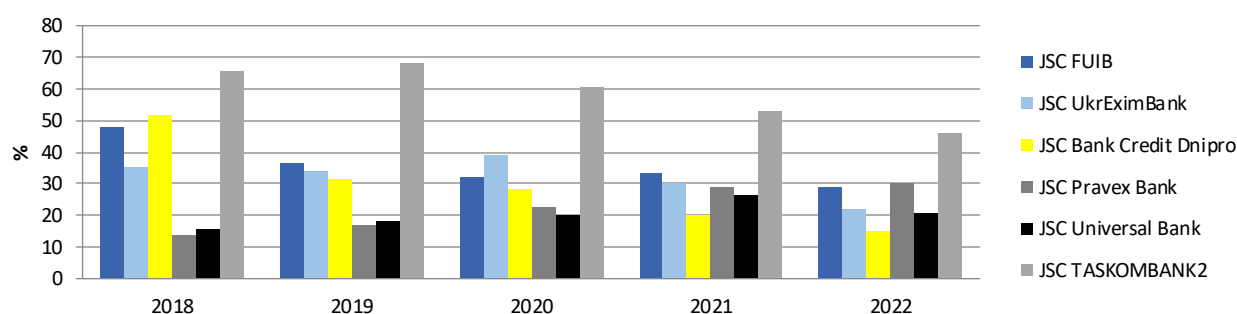Figure 2. The main indicators of the financial result of banks in Ukraine [17], [18]

Figure 3. Dynamics of the share of loans granted to subjects of united spheres of economic activity in the aggregate assets of banks participating in the FIC of Ukraine for 2018-2022 [17], [18]

The distribution of loans granted by JSC FUIB to subjects of united spheres of economic activity by sector of the economy of Ukraine as of 04.01.2023 is presented in Figure 4.
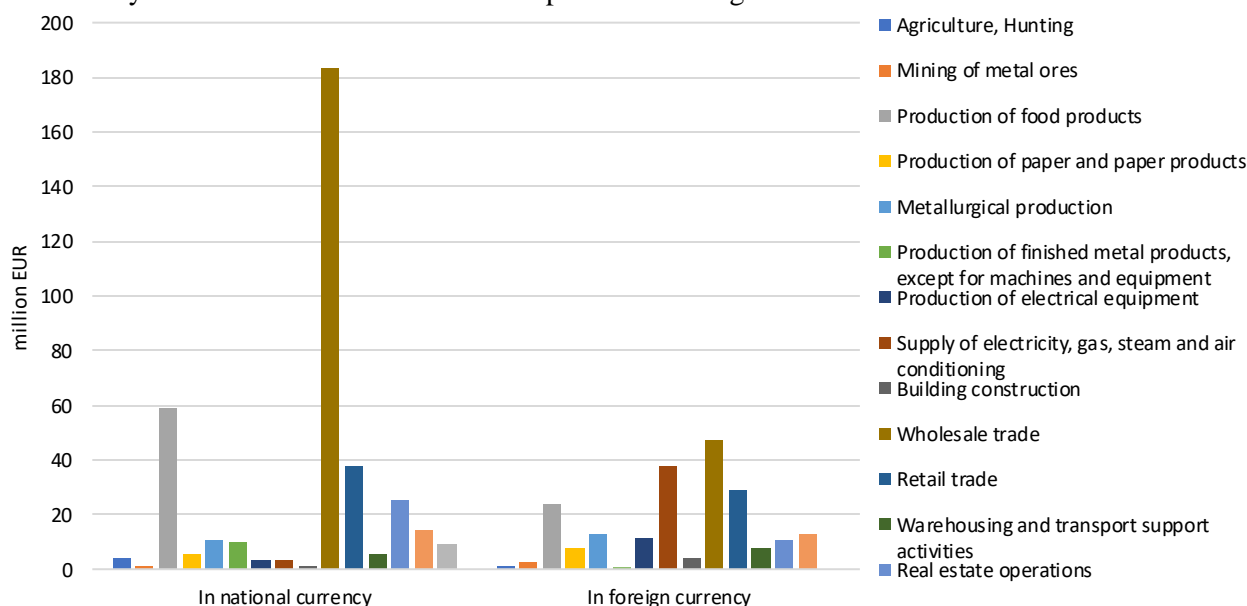

Figure 4. The amount of loans granted by JSC FUIB from FIC "SCM" to subjects of united spheres of economic activity of Ukraine as of 04.01.2023 [18]

Since the majority of payments by participating banks of the Ukrainian Federal Tax Code are made in digital format, the risk of cyber incidents and payment system failures increases. Payment systems are implemented

online based on electronic money that meets the requirements of fraud protection, authorization, and payment confirmation, software, and organizations that perform the calculations themselves (Figure 5).
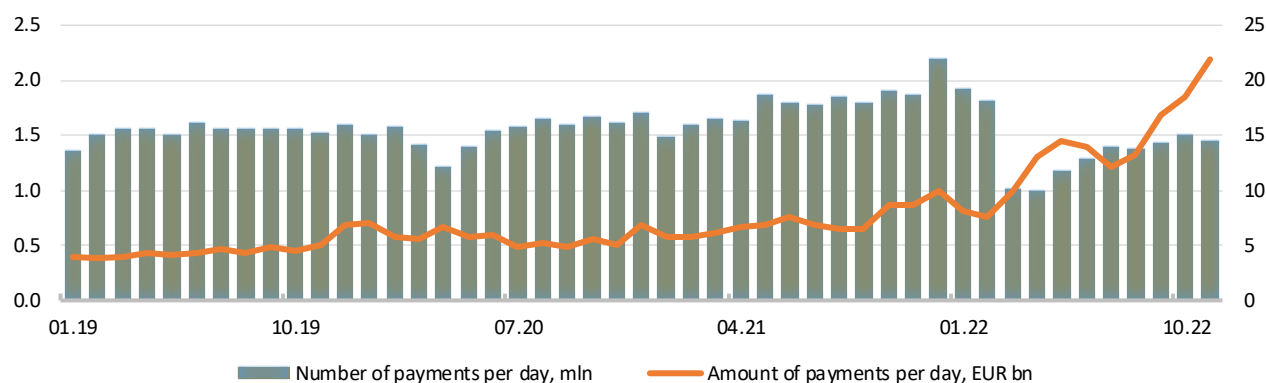

Figure 5. Daily system of electronic payments data [18]

With coordination between payment systems, the National Bank, and international organizations regulating payments at national and global levels, the credit capabilities of banks-financial centers in Ukraine have been affected by the war with an aggressor country. Long-term deposits (over 2 years) decreased significantly, accounting for only 8% of aggregate deposits in 2020, resulting in liquidity gaps for banks. This reduction in financial support by banks-financial centers of the FIC can be attributed to the introduction of legislative norms on financing and the implementation of the maximum credit risk limit for transactions involving individuals and subjects in united economic spheres, segmented by economic sectors (Figure 6).

Figure 6. Norms of the maximum amount of credit risk for bank-related transactions of individuals and subjects of combined economic activities by economic sector in 2015-2021 [17], [18]

In early 2016, the National Bank of Ukraine implemented a norm setting the maximum credit risk for transactions with individuals at 25%. However, this norm was not fully implemented in the banking system over the next two years. In 2022, the Ukrainian banking sector faced numerous DoS attack attempts, phishing emails, and malicious blockers. Banks-financial centers in Russia actively tested operational versions of software for quick responses to cyber-attacks using game theory, considering blockchain and fintech technologies as IT services with multiple crisis scenarios for payment systems of banking institutions [10]. Since February 2022,

cyber-attacks on the Ukrainian banking sector specifically targeted elements of the information infrastructure, including fintech technologies of banks-financial centers within the FIC, responsible for protecting financial and investment capital in united economic spheres [19], [20], [21]. A canonical analysis was conducted to determine the interdependence of indicators for preventing cyber-attacks and the technological readiness of banks-financial centers in the Federal Tax Service of Ukraine for digitizing calculations (Table 5).

Table 5. Canonical analysis of indicators of institutionalization of digital capacity of the banking sector of the economy of Ukraine (calculation fragment)

Name of the indicator	Full redundancy	Canonical R	Chi^2
Assessment of the quality of regulators of the National Bank of Ukraine	56.39	0.751	128.2
Assessment of the efficiency of the financial system of the banking sector	75.61	0.87	218
Assessment of regulatory requirements for digitalisation of banks-financial centres of the FIC	72.17	0.85	197.6
Assessment of technological readiness of banks-financial centres of the FIC for digitalisation of settlements	59.9	0.774	141.2
Assessment of stability of payment systems and threats of fraud (cyber-attacks) of banks-financial centres of the FIC	35.01	0.592	66.6

The change in the normalized values of indicators of institutionalization of digital capacity to the Harrington-Mencher dimensionless scale is presented in Figure 7.
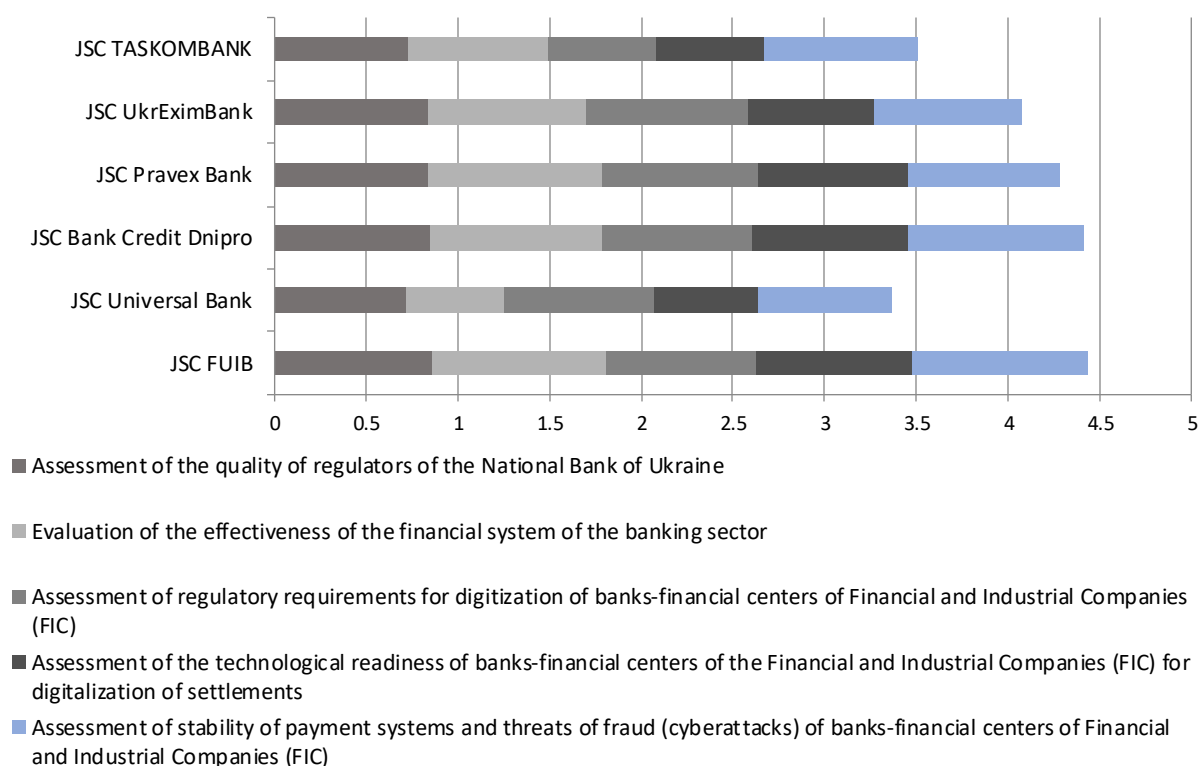

Figure 7. Normalized values of indicators of institutionalization of the digital capacity of the banking sector of the economy of Ukraine, reduced to the Harrington-Mencher dimensionless scale (calculation fragment for banks-financial centers of FIC)

Since the factors of institutionalization of the digital capacity of Ukraine's banking sector have a direct impact on the level of indicators of technological readiness for digitalization of settlements and stabilization of payment systems and threats of fraud (cyber-attacks) of banks-financial centers of the FIC, the obtained values of variability allow to use them as a weighting influence of the indicators in the calculation of the integral index of digital cyber protection of financial and industrial capital of large business from the set of studied banks-financial centers of FIC [22], [23], [24], [25]. Based on the results of the calculation, the distribution of the integral index of digital cyber protection of banks-financial centers (FIC) of Ukraine was carried out according to innovative information resources and blockchain and fintech technologies (Figure 8).
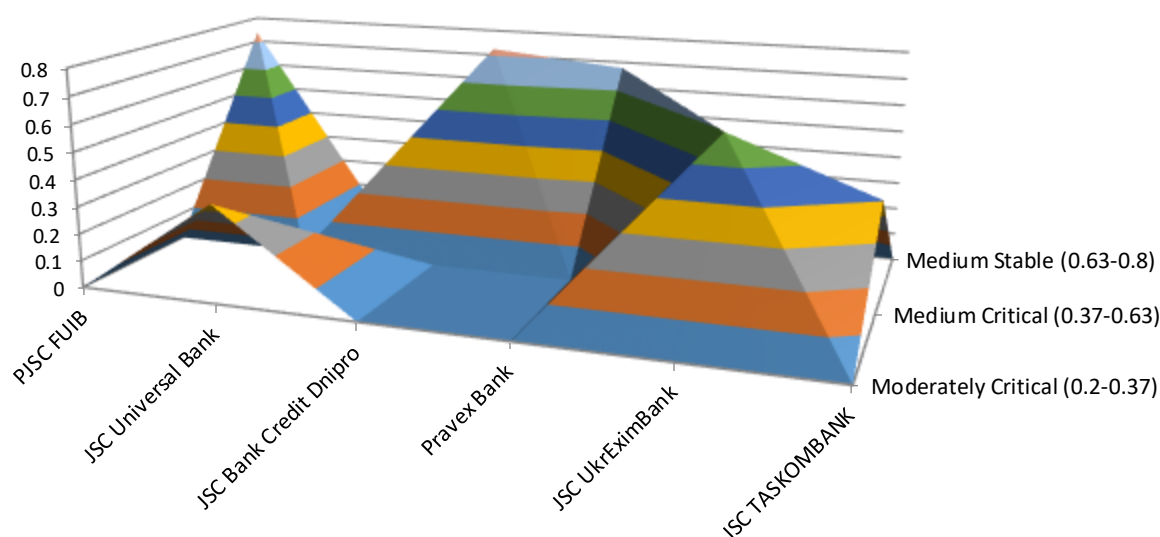

Figure 8. Distribution of the integral index of digital cyber protection of banks-financial centers (FIC) of Ukraine by innovative information resources and technologies of blockchain and fintech

A key priority for the digitalization of cyber protection of a banking institution in the architecture of a financial-industrial company should be an increase of the awareness of participants and users of the digital banking system in the use of innovative properties of blockchain and fintech technologies in order to prevent digital noise in the provision of services, minimize fraud and cyber-attacks on managed banking products for protection financial and industrial capital.

4. Discussion

Many researchers are investigating the applications of blockchain and financial technology within the digital sphere of financial and industrial companies [26], [27], [28]. [19] discusses the principles of payment systems and explore the potential for transformation in light of modern economic trends. Specifically, they analyze the evolving landscape of payment methods, technologies, and regulations, focusing on their impact on payment system efficiency and security. However, the research does not extensively cover regional variations or specific challenges faced by payment systems in different countries.

The article by [29] provides an overview of the current state of research in the field of fintech. It explores the evolution of fintech from its initial stages as a budding industry to its rapid growth and expansion, often referred to as an "explosion" in this context. The scientists also discuss the regulatory challenges and opportunities that have arisen with the rapid growth of fintech, as regulators strive to strike a balance between innovation and consumer protection. They analyze the transformative impact of fintech on traditional financial services and how it has changed the way financial transactions are conducted. In summary, this article provides readers with a comprehensive understanding of fintech research. Although, it does not delve into regional variations and differences in fintech adoption across different countries [30], [31]. In addition, the researchers do not

extensively address the social and ethical implications of fintech, such as data privacy concerns, digital divide issues, or the impact on vulnerable populations.

[16], [32] provide valuable information and insights into Industry 4.0, which integrates advanced technologies like the Internet of Things (IoT), artificial intelligence (AI), big data, and automation in the manufacturing sector. Their research examines how these technologies are reshaping traditional manufacturing practices and driving digitalization. The authors also highlight investment opportunities and challenges related to Industry 4.0 for domestic manufacturers. They emphasize how companies can attract investments to adopt new technologies and enhance their competitiveness in both domestic and international market fields. The research is essential for policymakers, government officials, and industry stakeholders as it offers insights into Industry 4.0's opportunities and challenges, driving economic growth and fostering innovation [33], [34].

[14], [35], [36] explore the role and impact of information platforms in facilitating network institutional transformation. They define information platforms as digital ecosystems enabling information exchange, processing, and sharing among multiple users and entities. Network institutional transformation refers to changes in institutions' structure and dynamics, facilitated by the integration of information platforms [37], [38]. The authors underscore the significant role of information technology, particularly information platforms, in reshaping institutional arrangements and relationships within networked environments. The research provides practical case studies and examples where information platforms have led to network institutional transformation, offering insights for policymakers, researchers, and practitioners seeking effective network collaboration and governance.

[5], [39], [40], [41] focus on the application of mechatronic systems, equipped with orbital hydraulic motors, in agricultural production. Mechatronic systems combine mechanical engineering, electronics, and computer control, leading to increased efficiency and productivity in agriculture. The authors investigate the influence of operating conditions, such as loads, speeds, temperatures, and environmental factors, on the functional characteristics of mechatronic systems with orbital hydraulic motors. Understanding these influences is crucial for optimizing system performance and ensuring reliable operation in real-world agricultural settings [42], [43]. The research's relevance lies in advancing the understanding and application of mechatronic systems with orbital hydraulic motors in modern agricultural production, thereby improving agricultural practices and technology.

The paper by [44], [45], [46] delves into strategies and challenges of attracting foreign investment during cyclic imbalances in the economy. The authors emphasize foreign investment as a driver of economic growth and development, examining different types of foreign investment, such as foreign direct investment (FDI) and portfolio investment. They also explain cyclic imbalances in the economy, referring to cyclical fluctuations in economic indicators like gross domestic product (GDP), inflation, unemployment, and trade balances [47], [48], [49]. The article proposes strategies and policy measures to attract foreign investment during periods of cyclic imbalances. However, the study's specific focus on a particular country or region remains unspecified, and this can significantly influence foreign investment dynamics based on economic conditions and policies [50], [51].

[15], [52], [53], [54] explore innovative strategies and trends in the banking system's development, offering insights into the challenges and opportunities of embracing technological innovations in the banking industry. The research can provide relevant information for understanding how financial and industrial companies are incorporating blockchain and fintech technologies into their business models. Moreover, the article addresses regulatory considerations in adopting innovative technologies, which is valuable for research on the legal and regulatory aspects of using blockchain and fintech in the financial and industrial domains [55], [56]. Overall, the researcher's work enriches the research with real-world examples, challenges, and regulatory insights drawn from the banking industry's experience with technological innovations.

The article by [57] reveals the subject of renewable energy (RE) financing, specifically the role of financial technology (fintech) in the context of a global finance center, which is Hong Kong in this case. The study seeks

to understand expert perceptions regarding the benefits and challenges associated with digital financing of distributed and decentralized renewable energy projects in Hong Kong. The paper delves into how fintech applications are being utilized to facilitate the financing of renewable energy initiatives in a major financial hub like Hong Kong. The author investigates the various ways in which technology, such as digital platforms or blockchain, is shaping the landscape of renewable energy investments and decentralizing their funding sources [58], [59]. In general, the article's findings and insights may contribute to a better understanding of the potential advantages and obstacles related to adopting fintech solutions for financing renewable energy projects [60], particularly in the specific context of Hong Kong as a global financial center.

In turn, the duet of authors [61] focus on the theme of blockchain technology adoption within the Indian banking industry. The primary objective of the study is to investigate whether the implementation and integration of blockchain technology in the Indian banking sector will face challenges. To accomplish this, the authors conducted qualitative research to gather evidence and insights on the potential obstacles and difficulties that may arise during the adoption process. While the article provides valuable insights into the theme, there are some aspects of that it does not highlight. For example, potential benefits and opportunities that blockchain technology could offer to the Indian banking sector or detailed case studies of specific Indian banks that have successfully or unsuccessfully adopted blockchain technology [62], [63]. However, the paper contains a valuable assessment of the legal and regulatory environment in India that could impact the adoption of blockchain technology in banks. This experience can be partly implemented by other countries [64], [65], [66].

5.   Conclusions

Innovative digital space, powered by blockchain and fintech technology, is rapidly expanding and is expected to encompass a broad market of service providers, including banks-financial centers of financial-industrial companies. The development of electronic money is already driving the surge in non-cash payments through payment systems, accelerating the digitalization of the client base through the adoption of cutting-edge solutions. This shift leads to several positive outcomes: reduced cash payments by bank clients, complete transition to electronic document management, heightened security of transactions via virtual and mobile banking, and the expansion of remote bank products and services. As a result, modern digital solutions using blockchain and fintech technologies bring cost savings, enhance customer service quality, and create new opportunities for boosting profits for banks-financial centers of financial-industrial companies.

In Ukraine, the implementation of the mathematical toolkit for digital cyber protection of banks-financial centers takes into account various factors, including the level of information and communication technology development, the degree of digitalization and informatization of payment systems, and the role of state regulators at the National Bank in ensuring effective information security norms and standards. However, the level of digital cyber protection for financial and investment capital of large business entities through financial institutions is currently moderate, posing potential threats to the economy, society, and politics. To address these challenges, the digital space of Ukraine's banking sector requires reforming, focusing on attracting investments for the development of digital cyber protection in banking institutions, thereby enhancing the efficiency and security of the financial system at the national level.

Despite challenges in implementing the investment policy of the Institute of Public-Private Partnership of Ukraine during wartime concerning blockchain technology and fintech in big business, the situation is gradually stabilizing with the assistance of international financial organizations. In the future, a paradigm shift in management and a transition from hierarchical to flat models are foreseen, where decisions are made in a decentralized manner, and the entire process becomes transparent for all participants. This transformation will lead to a re-evaluation of business processes, information management approaches, and protection measures. Blockchain and fintech technologies for the banking sector are rapidly disrupting centralized business services, introducing trust into the network and eliminating intermediaries from this function. The crypto economy is poised to become an economy founded on decentralized trust.

Declaration of competing interest

The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.

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Author contribution

The contribution to the paper is as follows: S. Domashenko, S. Hres-Yevreinova: study conception and design; D. Starostenko: data collection; Y. Zadoia, S. Domashenko: analysis and interpretation of results; S. Salin: draft preparation. All authors approved the final version of the manuscript.

Abbreviations and acronyms

DDoS Attack	Distributed Denial-of-Service Attack
FIC	Fixed Income and Currencies
IoT	Internet of Things
AI	Artificial Intelligence
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
RE	Renewable Energy
FinTech	Financial Technology

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