

Oleksandr Manoylenko,
Svitlana Kuznetsova

IDENTIFICATION AND THEORETICAL JUSTIFICATION OF THE CORE PRECONDITIONS FOR THE DEVELOPMENT OF DIGITAL FINANCIAL ECOSYSTEMS

The object of research is the process of forming digital financial ecosystems in the context of the transformation of the global financial architecture. The problem is the gaps in the forming digital financial ecosystems during the transformation of the global financial architecture under the influence of technological innovations. This is due to the introduction of blockchain technologies, smart contracts, intelligent agents (based on the introduction of artificial intelligence systems), multi-protocol financial technologies, the lack of unified standards and regulatory norms. A systems approach, structural-functional, comparative and institutional analysis, as well as trend analysis methods serve as the methodological basis of this research, implemented on the basis of statistical data from the Statista database and McKinsey & Company reports. Based on the generalization of quantitative and comparative assessments, the main trends in the transformation of the global financial architecture have been identified and analyzed. Institutional changes in the financial market based on the introduction of decentralized financial technologies (DeFi) and the implementation of the ISO 20022 regulatory standard are systematized. Key barriers to the transformation of modern financial architecture are identified, and directions for overcoming them are highlighted based on the development of hybrid financial solutions, international unification of standards and regulatory norms. The concept of forming a hybrid financial architecture (CeDeFi) and digital financial ecosystems is substantiated, which combines the advantages of decentralization and innovation with the reliability of the traditional financial system. The practical significance of research lies in the possibility of using its results to form effective strategies for the development of digital financial ecosystems, improve regulatory policy and make management decisions by financial institutions and fintech companies.

Keywords: digital financial ecosystems, financial architecture, financial technologies, hybrid financial architecture.

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1. Introduction

In recent years, the global financial system has been undergoing a radical transformation, driven by the introduction of digital technologies, in particular blockchain technologies and decentralized finance. This transformation concerns fundamental aspects of the functioning of the global financial system and actualizes the identification and justification of the advantages of integrating innovation and decentralization and the reliability of traditional financial architecture. Determining the key prerequisites for the formation of digital financial ecosystems allows to ensure the predictability of their development, which reduces risks for all subjects of financial relations. It should be noted that a significant number of scientific works are devoted to the introduction of blockchain technologies and the issuance of central bank digital currencies (CBDC). With the growing interest in digital currencies, the role of blockchain in shaping the future of finance has become crucial. The paper [1] considers the application of blockchain technology in central bank digital currencies (CBDC), exploring its potential to improve financial systems by increasing security, transparency and efficiency. A blockchain-based architecture for the deployment of CBDC is proposed. It is also argued that CBDCs can address key

financial infrastructure challenges such as reducing transaction costs, increasing security, and promoting financial inclusion.

In [2], a central bank digital currency (CBDC) is defined as a virtual currency based on a network of nodes and a digital encryption algorithm issued by a country that has legal protection for its creditworthiness. CBDCs are supported by distributed ledger technologies (DLT) and can become a universal means of payment for the digital age. Their research shows that implementing a blockchain-based CBDC can simultaneously improve payment efficiency and preserve central bank control over monetary policy.

In [3], it is noted that a well-functioning CBDC will require a highly resilient, secure, and performant new infrastructure with the ability to integrate, authenticate, and support users at scale. This will require an architecture that is simple enough to support modular design and thorough security analysis, but flexible enough to accommodate current and future functional requirements and use cases. The implementation of CBDCs also requires resolving the inherent conflict between privacy and transparency. On the one hand, protecting user data from abuse is required, and on the other, selective data mining by end users, regulators, and law enforcement agencies is required.

But in these works, the emphasis is mainly on the features of the implementation of CBDC solutions and their positive properties. The issues of CBDC integration with traditional financial architecture and interaction with the decentralized finance sector (DeFi) are not considered, which requires more thorough scientific research and determination of the features of the formation of a hybrid financial architecture (CeDeFi).

Another direction of research in the analysis of the transformation of the financial system is the consideration of issues related to the tokenization of real assets. In [4], the architecture of a universal tokenization platform is proposed, which allows for universal tokenization, transfer and exchange of assets as a global medium of exchange, called the Alphabill platform. Key conceptual and technical aspects of the platform architecture and their interaction are revealed, including the data structures of KSI Cash and Alphabill Money, the Alphabill Money dust collection solution and the Alphabill platform atomic exchange solution. This research establishes technical standards for a CBDC infrastructure that can support the implementation of digital currency on a national scale.

Asset tokenization is becoming an important mechanism for democratizing access to financial markets and increasing asset liquidity. In [5, 6], the authors analyze how blockchain-based tokenization transforms traditional ownership structures, as well as creating new opportunities for fractional ownership and global participation in investments. Their study identifies tokenization as a key factor in financial inclusion and poses regulatory challenges for investor protection and market integrity.

The rapid development of blockchain technology and its diverse applications has made it important to understand the principles of its implementation, as noted in [7]. This study serves as a guide for institutions to make more systematic decisions on blockchain implementation.

The development of financial infrastructure is key to supporting the economy and increasing social sustainability. In [8, 9], SolarCoin, WePower Token, and ZiyenCoin are analyzed to demonstrate how blockchain-based asset tokenization can be applied to infrastructure development. Tokenization has been shown to promote inclusiveness and sustainable development by empowering shareholders, monetizing incentives, and streamlining finance.

Given the specialized nature of financial technology platforms, the lack of a single universal regulatory framework, and the lack of industry standards for tokenizing real assets, a set of issues that need to be addressed and are not addressed in this research are highlighted. Among the main ones are the barriers that limit the introduction of tokenization of real assets and the need to create systems for interacting financial platforms built on different technological architectures (technological platforms of blockchain solutions).

The transformation of the financial architecture currently requires the appropriate development of a regulatory framework. DeFi regulation can and should focus on this refocused part of the value chain to ensure effective oversight and risk control, argues [10]. Instead of eliminating the need for regulation, DeFi actually needs regulation to achieve its main goal of decentralization. Furthermore, DeFi potentially offers the opportunity for the development of an entirely new way of designing regulation: the idea of “built-in regulation”. Regulatory approaches can be built into the design of DeFi, thus potentially decentralizing both finance and its regulation, which is the ultimate expression of RegTech.

In [11] examines the implementation of CBDCs and their implications for the traditional division of supervisory powers between central banks and financial regulators. Their research argues for the need for new governance structures that can combine centralized monetary control and decentralized financial innovation.

Digitization is transforming economic activity, reducing the role of cash and stimulating the emergence of new digital forms of money.

Central banks are considering whether and how to adapt. One possibility is a central bank digital currency (CBDC), a widely available digital form of fiat money that could be legal tender. This discussion paper [12] proposes a conceptual framework for assessing the case for CBDCs from the perspective of users and central banks. It focuses on the implications for monetary policy, financial stability, and integrity.

In [13] provides an analytical framework for categorizing the legal structures of tokenized assets. A taxonomy based on the legal relationships between tokens and their underlying assets is introduced. The research reveals the need for a regulatory framework that takes into account innovation and balanced stability.

The reviewed scientific works do not address the issues of determining the directions of unification and standardization of regulatory solutions, especially when implementing cross-border transactions, which slows down the development of digital financial architecture.

A lot of research is devoted to the formation of a new innovative financial architecture. In [14], a thorough analysis of the centralized use of decentralized technology (blockchain) in monetary and financial systems at the national level is presented. Based on the analyzed different contexts, the authors expand the “Technology Adoption Model”, emphasizing the role of perceived benefits, perceived risks and shared leadership in building trust and promoting the implementation of tokenization.

In [15], the impact of cryptocurrencies on financial markets and traditional banking systems is studied; how blockchain technology can be used in the financial sector; assessing policy and regulatory considerations; and forecasting and planning for the future. This research delves into how cryptocurrencies have revolutionized the banking and financial sectors.

There is a wealth of academic research based on the technical architectural integration of DeFi. In [16–18], a fundamental analysis of tokenization is being conducted, which has a transformative impact on various asset classes, establishing new opportunities for digital exchange and value transfer. The authors analyze the combination of decentralized mechanisms with centralized infrastructure using the technological foundations of hybrid financial systems.

Blockchain technology in the financial sector, especially in asset management, has become a transformative force. In [19], a comprehensive review of the positive and negative factors associated with the implementation of blockchain in asset management practices is provided. Increased transparency and security of asset tracking and transfer are provided by the decentralized and immutable nature of blockchain. A key feature of blockchain is smart contracts, which automate and optimize various processes, reducing operational costs and minimizing the risk of errors.

However, it should be noted that these works pay little attention to the formation of a hybrid financial system (CeDeFi), as one of the directions that allows combining the advantages of traditional financial institutions and innovative financial technologies. In addition, the issues of the formation of digital financial ecosystems are not considered, the formation of which becomes the basis for the development of a new global financial system built on an innovative digital financial architecture (the basis is the implementation of DeFi technologies).

As a result, the literature review creates a comprehensive theoretical basis for understanding the main prerequisites for the transformation of the financial architecture. Scientific developments emphasize the importance of prioritizing infrastructure, joint evolution of regulation and coordinated international approaches in developing effective transformation strategies. The issue shows that the successful transformation of the financial architecture requires careful coordination of technological, regulatory and institutional changes, rather than a complete replacement of existing systems. Also, there are gaps in identifying the main aspects of the formation of a digital financial ecosystem when implementing decentralized financial technologies. Thus, taking into account the literature review, the issue of the comprehensive formation of digital financial ecosystems and the identification of their patterns is relevant for research.

The object of research is the process of forming digital financial ecosystems in the context of the transformation of the global financial architecture.

The aim of research is to determine the main prerequisites for the formation of digital financial ecosystems in the symbiosis of decentralized financial technologies and traditional financial architecture and to change the paradigm of interaction of key actors in the implementation of technological innovations.

To achieve the aim, the following objectives were solved:

1. To identify and analyze the main trends in the transformation of the global financial architecture and to systematize institutional changes in the financial market with the allocation of the development of payment and investment infrastructure based on the introduction of decentralized financial technologies (DeFi) and the regulatory standard ISO 20022.

2. To identify key barriers to the transformation of modern financial architecture. This involves the symbiosis of centralized and decentralized payment systems; tokenization of real assets with regulatory aspects; introduction of smart contracts and integration of artificial intelligence into financial services; presence of multi-protocol and lack of unified standards. To highlight the directions of overcoming them based on the development of hybrid solutions, creation of cross-chain bridges, international unification of standards and regulatory norms.

3. To substantiate the concept of forming digital financial ecosystems in the context of the formation and evolution of a hybrid financial architecture (CeDeFi), which combines the advantages of decentralization and technological innovations with the reliability of the traditional financial system.

2. Materials and Methods

The methodological basis of research is a systemic approach, which allows considering financial architecture as a holistic multi-level ecosystem. The work uses systemic, structural-functional, comparative and institutional analysis, as well as trend analysis methods to study the development of the fintech industry, non-cash payments, asset tokenization, digital banks and the stablecoin market.

The research uses the integration of quantitative and qualitative analysis, synthesis of information from academic publications, reports and regulatory documents: the International Monetary Fund, the Bank for International Settlements, the European Commission, the Statista

and McKinsey & Company databases, Standard Chartered and Synpulse. The data covers the period 2008–2025 with regional detailing and analysis of the EU MiCA regulatory initiatives, Basel Committee requirements, ISO 20022.

3. Results and Discussion

3.1. Main trends in the transformation of the global financial architecture

In recent years, the global financial landscape has undergone significant changes. A new financial architecture is being formed, based on digital technologies and, accordingly, the modernization of payment and investment infrastructure, regulatory initiatives to introduce DeFi solutions, this is becoming the basis for the formation of a new financial ecosystem. The key elements of the transformation of the financial architecture include digital financial technologies, which are associated with the acceleration of payment services, more complete and faster access of the end consumer of financial services to payment instruments, financial institutions and institutions. Taken together, all this ensures the functioning of the financial ecosystem, the interconnection of actors and regulatory acts that ensure unification and standardization, stability and minimization of risks.

First of all, it is necessary to consider the main trends that are changing the financial landscape and are becoming the basis for the formation of a new financial architecture.

The rapid growth of fintech start-up investments, venture capital and growth capital, clear regimes for non-bank financial services providers and cross-border data flows. At the same time, the cooling of new company formation after the peak highlights the need for increased efficiency of invested capital, harmonized cyber resilience baselines and “built-in” standards for interaction with payment systems and data repositories. Creating the conditions for scaling is becoming a priority: harmonization of regulations, expanded access to payment systems, introduction of distributed data centers and introduction of industry standards. These conclusions are confirmed by the dynamics of changes in the number of fintech companies, which is presented in Fig. 1.

The diagram demonstrates a “stormy” growth in the number of fintech companies during 2008–2020 with a slowdown in 2021–2024, which indicates the saturation and maturity of the market at the current stage of development. Moreover, starting from 2018, the growth in the market is mainly due to companies from the APR region.

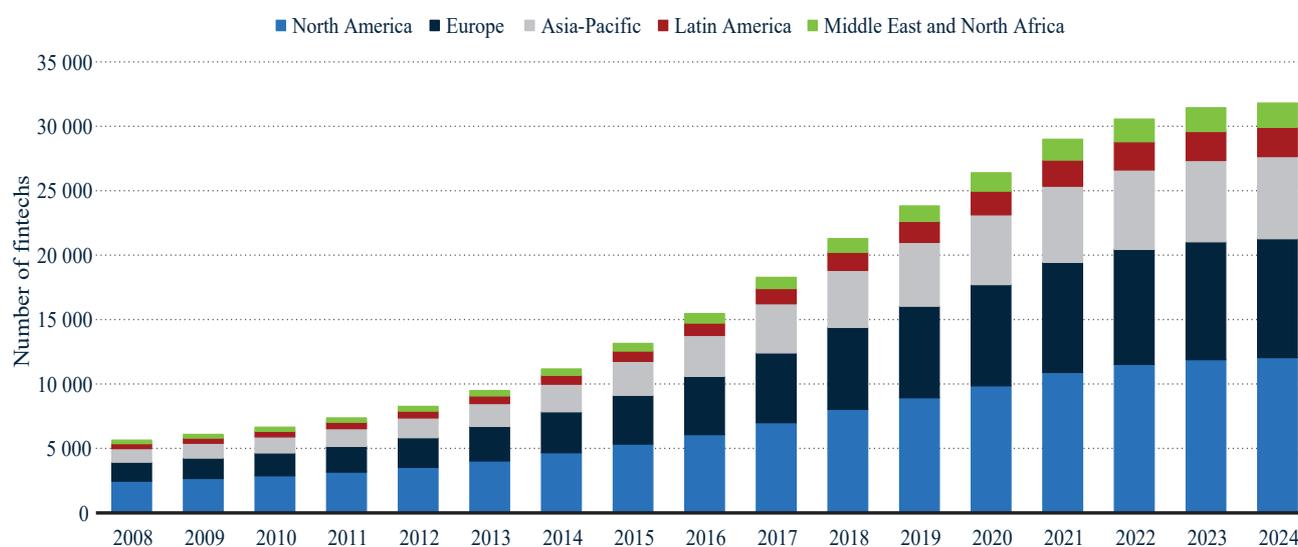


Fig. 1. Number of fintechs worldwide from 2008 to 2024, by region [20]

Integration of digital banking institutions into the traditional financial sphere, as evidenced by the growth in the number of digital banks that have received regular banking licenses. This process requires the formation of new regulatory approaches to ensure banking supervision (Fig. 2).

These trends are confirmed by the cumulative curve of the number of licensed digital banks (approximately 5-fold growth over the period 2014–2023 with a decreasing trend starting in 2022). This indicates a transition from pilot experiments to institutional structures of digital banking for the provision of financial services (deposits, risk assessment, connectivity to clearing, settlement and payment infrastructure).

The rapid growth of cashless payments worldwide, especially in the Asia-Pacific region (APR). The introduction of the ISO 20022 standard leads to the standardization of payment services, in addition, the use of tools such as mobile payments, NTFT tags, QR codes, instant clearing facilitate payments in the B2B and B2C sectors, which is shown in Fig. 3.

The dynamics of cashless transactions shows a gradual growth with the outstripping development of the countries of the Asia-Pacific region, which is implementing digital payment systems at the fastest pace.

The main driver of the architectural transformation of the financial sector is the introduction of cryptocurrency payment services. Moreover, the integration of blockchain protocols and the use of stablecoins in transactions are taking place not only in the field of fintech companies, but also in the activities of traditional payment institutions (Visa, Mastercard, Swift, commercial banking and other financial and credit institutions). The dynamics of the market capitalization of stablecoins is presented in Fig. 4.

As can be seen from the graph in Fig. 4, since 2020, there has been a rapid growth in the capitalization of stablecoins, and accordingly, their use as payment instruments.

Analysis of scientific and practical literary sources made it possible to formulate five theoretical premises that formed the basis of the analysis:

1. The transformation of financial architecture is based on the creation and subsequent scaling of a secure blockchain infrastructure, which becomes the foundation of transformation processes [3, 4].

2. Synchronization of technology scaling and the introduction of regulatory norms are the basis for the integration of digital and traditional financial architecture, at the theoretical level this is defined as a co-evolutionary development concept that involves standardization and unification [11, 12].

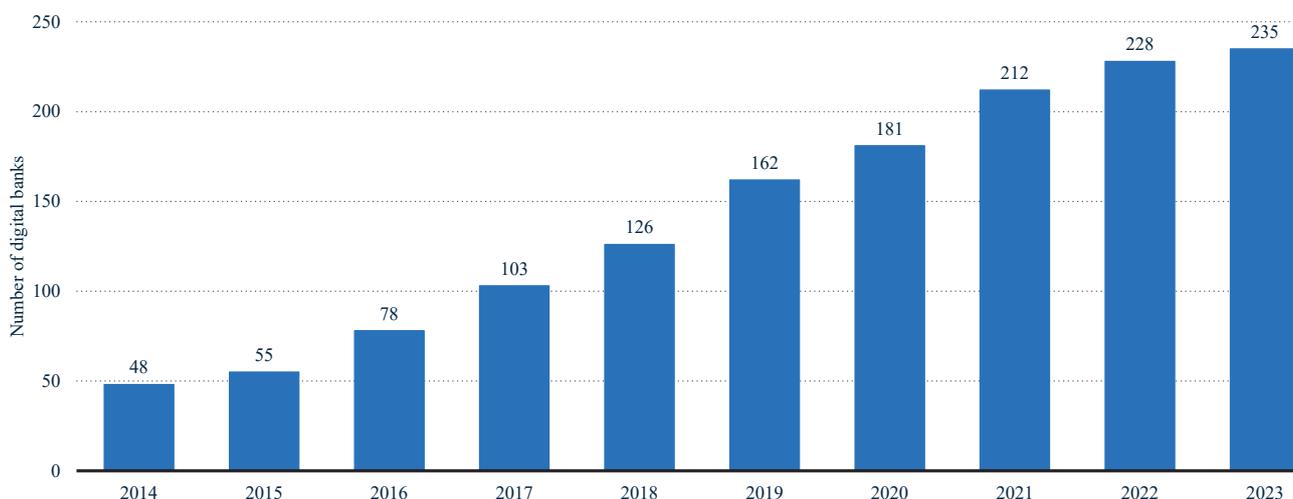


Fig. 2. Cumulative number of licensed digital banks worldwide from 2014 to 2023 [20]

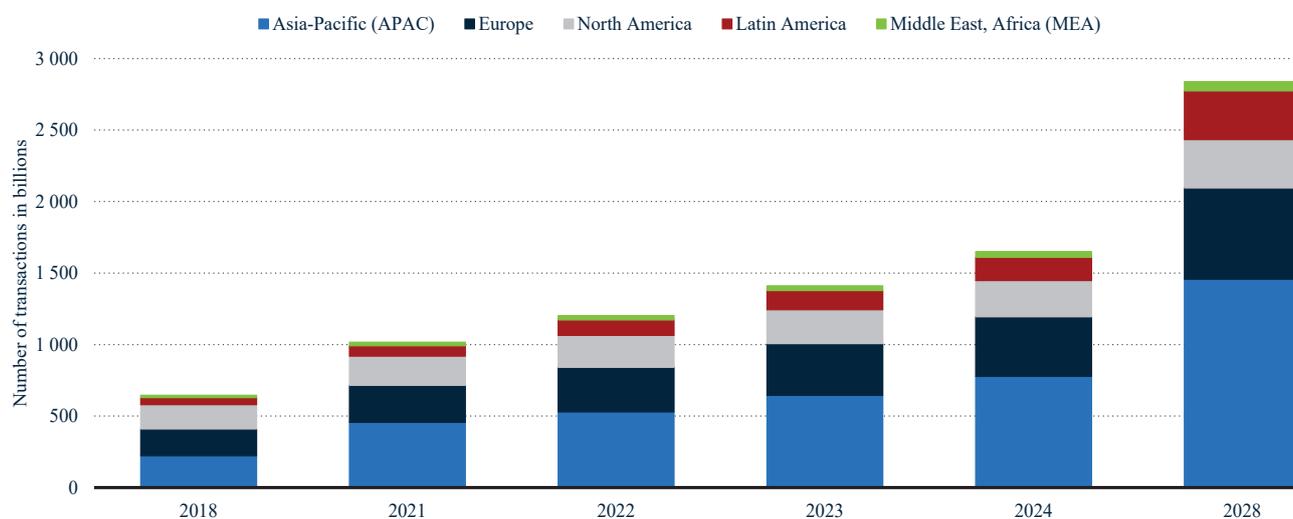


Fig. 3. Total number of cashless transactions worldwide – including B2C and B2B – from 2014 to 2023, with forecasts for 2024 and 2028, by region (in billions) [20]

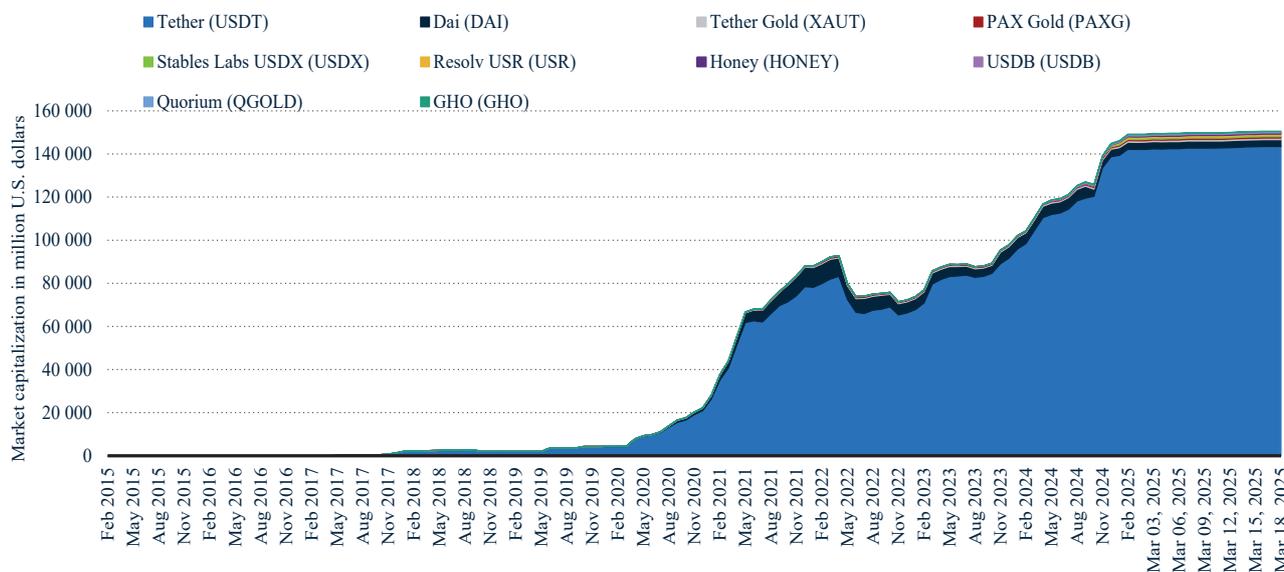


Fig. 4. Estimate of the market capitalization of crypto-collateralized stablecoin from February 2015 to March 18, 2025 (in million U.S. dollars) [20]

3. Formation of a hybrid financial architecture (CeDeFi), which involves the integration of decentralized technologies (DeFi) and centralized elements (for example, payment instruments such as CBDC, stablecoins, fiat currencies, which is determined by the principle of complementarity). This involves the creation of hubs (cross-bridges) for the interaction of multi-protocol decentralized financial systems and traditional financial instruments [8, 9, 13, 14].

4. The introduction of smart contracts and intelligent agents based on AI becomes the basis for accelerating transactions and automatic contract execution, which increases the efficiency of the functioning of traditional financial systems and their tight integration with DeFi [15–17].

5. Tokenization of real assets and development of relevant regulatory acts taking into account the focus on the introduction of a “green” economy and ESG principles (for example, financial inclusion) become the basis for the formation of regenerative financial ecosystems (ReFi) [12, 13].

The research of the identified prerequisites shows that the financial architecture is on the verge of cardinal transformations. A hybrid financial architecture is being formed. That is, a symbiosis of traditional financial architecture and a new digital one is being formed, based on the introduction of decentralized financial instruments. This al-

lows to identify the following key areas of financial architecture transformation:

- development of decentralized finance (DeFi) and modernization of traditional financial institutions using blockchain technologies (CeDeFi);
- introduction of central bank digital currencies (CBDC) and development of stablecoins (as alternative or additional payment instruments);
- development of smart contracts and integration of artificial intelligence into financial services;
- transformation of regulatory policy towards legislative regulation of the implementation of DeFi tools and technologies into the financial architecture of national economies;
- creation of a regenerative financial ecosystem (ReFi).

A summary of theoretical and institutional analysis, practical experience in the implementation of decentralized financial technologies and central bank digital currencies (CBDC), regulatory initiatives of governments in different countries of the world is summarized in Table 1.

The analysis of Table 1 allows to summarize data related in general to the state of the fintech industry and the development of a new digital financial architecture.

Table 1

Analysis of key initiatives aimed at shaping a new digital financial architecture and modernizing the existing one

Initiative/Project	Initiators (countries/organizations)	Sphere of influence	Implementation stage
1	2	3	4
Transformation of payment systems			
Central bank digital currencies (CBDC)			
Launches of national CBDCs (eNaira, Sand Dollar, etc.), various digital registries (national platforms, sometimes based on blockchain)	European Central Bank (ECB), People’s Bank of China (PRC); central banks of over 100 countries (Nigeria, India, Brazil, etc.)	Technologies/institutions, regulatory impact	Pilot projects, prototype, launched into active circulation
Decentralized financial instruments			
Cryptocurrencies (e.g., stablecoins). Implemented on the basis of blockchain protocols of the 1st and 2nd levels (e.g., USDC and USDT)	Open source communities for blockchain protocol development, commercial and private organizations Circle, Tether, Hyperledger, etc. Circulation regulation has been introduced in the US, EU, Singapore and other jurisdictions under the condition of 100% reservation in high-quality institutional assets	The basis for the introduction of a hybrid financial architecture (CeDeFi), actually serve as the basis for payment services in DeFi and a gateway between fiat currencies and tokenized assets. Increase transaction speed, reduce fees, ensure compatibility between networks	Actively used as payment instruments. Integrating into digital financial systems of traditional financial institutions and payment systems. Interoperability is being implemented: connections between networks and “instant” clearing

Continuation of Table 1

1	2	3	4
Transformation of circulation of real assets and investment instruments. Tokenization of real financial assets			
DeFi and DEX (Uniswap, PancakeSwap, etc.), Tokenization Initiative (Project Guardian, etc.), DTCC Project Ion (blockchain settlements for shares), DLT platforms; smart contracts; oracles	DeFi community (globally decentralized), Monetary Authority of Singapore, banking consortia. Traditional financial institutions (banks: JPMorgan, SBI, etc.; exchanges: SIX, Nasdaq; clearing houses: DTCC; corporations) and crypto startups, technology providers	Technological infrastructure, tokenization and DeFi technologies for markets, clearing and settlements, digitization of real assets (stocks, bonds, real estate, etc.) to increase liquidity, accelerate circulation and lower the entry threshold for investors	Market growth, platform convergence and scalability of successful pilot solutions
Formation of hubs of interaction of digital technologies and traditional financial systems. Cross-bridges and modernization of traditional financial infrastructure			
Crypto-fiat bridge infrastructure: custodial solutions for banks, blockchain APIs, corporate blockchain networks, fiat-pegged stablecoins, integration into payment networks (e. g. Visa B2B Connect, SWIFT gpi with blockchain); mCBDC Bridge projects (mBridge, Dunbar, Icebreaker) BIS Innovation Hub, IMF global CBDC platform, BRICS platform for settlements in national currencies (BRICS Bridge)	IMF, central banks (within the G20), central banks of BRICS countries, Hong Kong, Singapore, UAE, etc., SWIFT, more than 30 banks from the USA, EU, Asia (the largest banks: JPMorgan, BNY Mellon, Citi, etc.); exchanges and clearing houses (NASDAQ, CME, SIX, DTCC, etc.); payment systems (Visa, Mastercard, SWIFT); fintech companies (PayPal, Revolut, etc.); Big Tech (Meta plans, Amazon projects, etc.). Visa and Mastercard are testing settlements in stablecoins and issuing cards for access to crypto. Exchange-traded products: crypto ETFs launched in Canada, Europe, USA	Infrastructure/institutions: global and multi-currency payments. Access to crypto assets for traditional finance clients; leveraging blockchain to speed up and reduce the cost of settlements; expanding markets (new products such as BTC-ETF, tokenized securities); increasing the efficiency of interbank transactions	At the launch and pilot operation stage, scaling of effective solutions to the entire financial system
Regulatory policy			
Regulatory technologies: regulations, licensing, monitoring of blockchain transactions	Governments and regulators worldwide: USA (SEC, CFTC, Congress, Treasury), EU (European Commission, ECB, ESMA), China (State Council, NBK), international bodies (FATF, BIS, FSB), etc.	Ensuring the stability of the financial system and investor protection, preventing money laundering and evasion of sanctions, tax control. Creating a framework for the responsible development of new technologies (DeFi)	Active development of legislative initiatives aimed at implementing tokenized financial instruments and payment systems based on blockchain into the traditional financial system

Thus, 114 central banks are testing or launching pilot projects of digital currencies [21]. In general, the global trend is obvious: more than 130 countries around the world are exploring the possibilities or have already issued CBDCs, considering them as the basis of future money. In addition, CBDCs are also issued by various alliances or blocs of countries.

A separate trend is corporate stablecoins, such as PayPal USD (PYUSD) – a stablecoin of the PayPal payment system in cooperation with Paxos. PYUSD is backed by dollar reserves and regulated by NYDFS (New York). It is designed to facilitate payments within the PayPal application and beyond. Thus, large fintech companies are entering the DeFi sphere. At the same time, traditional banks are developing their own solutions for corporate clients – for example, JPM Coin; ING bank is developing its own stablecoin (based on MiCA requirements) [21]. This indicates that global banks and fintech companies have entered the “stablecoin race”, seeking to occupy the niche of fast international payments.

Mastercard launched Multi-Token Network (MTN) – the so-called “private blockchain network” for the secure transfer of tokenized funds and assets between financial institutions. DeFi project Ondo Finance integrated with MTN Mastercard to “contain” the liquidity of real assets.

3.2. Key barriers to the transformation of modern financial architecture and ways to overcome them

The main problem that the development of a new financial architecture faces at the current stage is multi-protocol, the lack of common standards and the lack of unified regulatory principles in different countries. This makes it advisable to form cross-chain bridges that connect different platforms, and in fact, the need to create spatial hubs for interaction and cooperation between different participants in the financial services market. Thus, to ensure the

sustainable functioning of the new financial architecture, the basis of which is payment networks, unification or clear interconnections between different protocols, which are currently largely localized or segmented, are necessary.

One of the first attempts was a pilot project of the SWIFT interbank network, which serves transactions between 11 thousand banks in over 200 countries, to integrate CBDCs and tokens. This makes it possible to overcome the problem of fragmentation of blockchain ecosystems by connecting different blockchains to the SWIFT network for exchange. Due to its coverage, SWIFT expects to become a connecting link between “old” and “new” forms of value and demonstrate this in practice [22]. In other words, the traditional financial infrastructure is evolving – switching to ISO 20022 standards, implementing blockchain protocols in order to continue to remain a central element of the global financial architecture. That is, the integration and symbiosis of traditional and digital financial architecture is taking place.

Projects in this area are being implemented by: the Federal Reserve launched the FedNow instant payment system; in Europe, the TIPS instant payment system is being implemented together with the ISO 20022 standard; China is increasing the international use of its e-CNY and CIPS networks [21].

Settlement and clearing systems are also being modernized. In recent years, systems based on blockchain technologies have appeared that provide almost instant settlement of “delivery versus payment”, that is, these operations are being automated. For example, the DTCC clearing center has introduced the Project Ion platform, a DLT network for settlement of shares. The European Union has launched a DLT project, a regulatory “sandbox”, which allows the use of blockchain for trading and post-trade settlements. The Luxembourg and Swiss stock exchanges have started trading digital bonds with settlements through tokenized currencies in central bank accounts.

All this leads to the development and formation of both international and local platforms – cross-chain bridges, which ensure the transfer of tokenized or other digital assets between different blockchain platforms. Moreover, this process is taking place at a more intensive pace at the regional (interstate) level, which reduces the influence of international organizations such as the IMF, the IBRD, and SWIFT.

Examples of regional integration include:

- Project mBridge (BIS, UAE, Thailand, Hong Kong, China);
- Project Dunbar (BIS, Australia, Malaysia, Singapore, South Africa);
- BRICS Bridge (Brazil, Russia, India, China, South Africa);
- ASEAN is shaping the transition to settlements in national currencies and to a regional digital currency to facilitate trade [23, 24].

In fact, spatial virtual hubs are being formed that combine local and differentiated regional and technological platforms and payment systems, developing global interaction on a decentralized basis.

In parallel, the decentralized finance (DeFi) sector is developing. DeFi protocols provide lending, exchange and investment services based on smart contracts without intermediaries. If to consider the total trading volume on decentralized exchanges (DEX), it reached 410.2 billion USD, which was 25.3% of the volume on centralized exchanges [21]. This indicates a significant paradigm shift or approach to trading in financial and real assets: an increasing part of trading is moving to blockchain platforms, and the role of traditional intermediaries is decreasing. The most difficult problem that needs to be solved is cross-chain interoperability. In addition, such activity is explained by the growth of cross-border transactions that can be executed automatically, in particular through automatic exchange rates. The introduction of DeFi protocols into traditional financial models and institutions makes it possible to make transactions cheaper and faster; in addition, it contributes to the emergence and implementation of instant payment and clearing systems. As a result, there is a need to modernize the existing banking system, its role as an intermediary is decreasing. Traditional exchange activities are also undergoing a transformation: the tokenization of real assets leads to the attraction of an increasing number of participants, the formation of investment communities, which reduces the possibilities of market manipulation by institutional investors. On the other hand, the deeper integration of decentralized finance into the sphere of public finances, paradoxically, leads to the strengthening of this segment of the financial services market. Thus, when issuing stablecoins, as a rule, government bonds and loans become collateral instruments. This, on the one hand, forms another source of financing for public debt, and on the other hand, increases the stability of issuers due to a new source of income – interest payments on public debt.

Another tool for strengthening public finances at the local level is the issuance of municipal borrowings in the form of tokenized financial instruments. This, on the one hand, makes it possible to attract additional funds, and on the other hand, contributes to the development of digital financial infrastructure.

In addition, institutional investors are becoming prominent issuers of digital financial instruments backed by cryptoassets: for example, derivatives issued by BlackRock allow them to attract traditional institutional financial investors, which expands the financial services market.

Tokenization of traditional assets increases manageability through the implementation of smart contracts, and also allows for a flexible approach to pricing, thereby increasing their capitalization. In general, this enables automatic compliance and regulation, i. e. automated compliance with requirements (based on intelligent agents). Thus, the integration of DeFi into traditional banks and the creation of hybrid financial products contribute to their strengthening and increasing the efficiency of operational activities.

The development of artificial intelligence systems leads to the emergence of applied intelligent agents, which automates the system of regular payments, allows to form personalized financial services, the cost of which becomes lower than traditional financial instruments.

On the other hand, the implementation of artificial intelligence systems and models in trading operations increases the efficiency of investment (trading) operations, reduces the costs associated with trading in the financial market.

Revolutionary changes are taking place in the field of international transfers and institutional transactions: the introduction of self-executing smart contracts based on blockchain protocols makes it possible to automatically control their execution.

The trend associated with the tokenization of assets – both financial instruments (stocks, bonds, money) and tangible assets (real estate, goods) – makes it possible to sharply increase the capitalization of financial markets and more accurately determine the value of assets. As noted above, the main problem in this case is the unification of registers – the creation of a single platform where different types of tokens can circulate together. According to forecasts by Standard Chartered and Synpulse, by 2034 the volume of tokenized assets may reach 30 trillion USD [25].

Goldman Sachs, Morgan Stanley, BNY Mellon, Citigroup have all launched either digital asset trading units or custody services for institutional clients. BNY Mellon (the oldest US bank) began storing Bitcoin and Ether for individual clients in 2022, noting the demand for such a service. JP Morgan has been using its internal JPM Coin token for settlements between corporate clients since 2019; in 2021, the bank reported that 300 billion USD in transactions had been made through JPM Coin, meaning the system was working [23, 24]. In 2022, JP Morgan first conducted a DeFi transaction on a public blockchain: a tokenized Forex deal was executed with Singaporean bank DBS via the Aave protocol as part of the Project Guardian experiment (with the approval of MAS). This demonstrated the potential benefits: the transaction was instant, and the settlement of tokenized government bonds and deposits was automatic. Deutsche Börse and Nasdaq offer crypto-asset settlement and custody services [26], which is the first step towards the circulation of tokenized securities. JPMorgan, HSBC and Wells Fargo banks conduct transactions on their own solutions. In general, a trend is forming: traditional assets are starting to move to digital registries.

There is a convergence of traditional and decentralized trading platforms (exchanges). Centralized exchanges (CEX) and decentralized (DEX), traditional and fintech exchanges are implementing strict KYC/AML procedures, separating client assets and reporting, and launching products related to crypto assets. Moreover, this trend is global in nature, which practically allows for complementary implementation of regulatory norms for both traditional assets and fintech instruments and technologies (DeFi instruments). Thus, a hybrid financial market infrastructure is being formed – a single ecosystem that combines state and corporate financial instruments, tokenized instruments and crypto-assets through programmable smart contracts, payment systems and settlement and clearing centers.

These trends involve the development and unification of regulatory and technical and technological standards. This is happening both at the level of individual countries: the European Union approved the MiCA (Markets in Crypto-Assets) regulation [27] – a regulatory framework for the crypto market; in the USA, the SEC and CFTC [28] approved regulatory rules for the circulation of crypto-assets; in some jurisdictions, cryptocurrencies are recognized as legal tender. And at the level of various organizations of the regional and intergovernmental levels: FSB – developed a global regulatory framework for crypto-assets; BCBS – approved requirements for banks regarding cryptocurrencies with the separation of “trusted”.

3.3. The concept of forming digital financial ecosystems

Thus, a hybrid financial system is currently being formed, combining the advantages of decentralization and innovation with the reliability of traditional financial architecture. The main problems that hinder development are related to ensuring compatibility between different forms of payment instruments (fiat, CBDC, stablecoins, crypto), different protocols for tokenization of real assets, different types and types of networks. All this requires the creation of cross-bridges, as well as maintaining control over systemic risks and different regulatory frameworks in different countries and associations.

The emergence of a new (digital) financial architecture is associated with the widespread implementation of technological innovations that form a number of technological platforms that perform various functions, and on this basis the issuance of digital currencies (stablecoins) and tokenization of financial assets takes place (Fig. 5). As a result, the formation and development of a digital ecosystem is taking place, which is based on the integration of AI into decentralized financial protocols, i. e. the full symbiotic interaction of traditional and digital financial systems. This becomes the basis for the formation of a regenerative financial ecosystem (ReFi), which is distinguished by sustainability and inclusiveness (which is manifested in personalized financial consumer products and access for all categories of consumers).

The formation of smart contracts as the basis for the development of decentralized finance involves the introduction of intelligent agents based on artificial intelligence. This allows the formation of personalized offers (financial services) of both end products (and relatively inexpensively) and financial instruments, which makes it possible to attract new investors and consumers in the financial services market (development of financial inclusion). As a result, this causes a trans-

formation of the global financial architecture, the formation of digital financial ecosystems based on a number of technological changes taking place in the financial sector, and, accordingly, a change in the paradigm of interaction of key actors in the financial services market, which includes:

1. Formation of new payment centralized (CBDC) and decentralized payment instruments and systems based on DeFi (stablecoins). According to the Bank for International Settlements, 70% of the world's central banks are conducting research in the field of CBDC [26]. The turnover of settlements with stablecoins has exceeded the turnover of payment systems such as Visa and Mastercard.
2. Tokenization of real financial assets, formation of digital investment financial instruments. Introduction of self-executing smart contracts (based on intelligent agents).
3. Formation of multimodal financial architectures of individual financial institutions (financial services market actors) as the basis of a new financial infrastructure.
4. Formation of blockchain portals, i. e. cross-bridges that combine different blockchain protocols, i. e. multi-chain solutions.
5. Technological convergence through the symbiosis of blockchain technologies, AI agents and traditional financial technologies and tools (DeFAI).
6. Formation of financial instruments and products of an individual consumer profile (based on artificial intelligence systems – intelligent agents – formation of personalized financial services and the spread of financial inclusion).
7. Regulatory evolution: gradual formation of clear “rules of the game”, technological and financial standards and regulations for the implementation of DeFi solutions in the financial architecture.

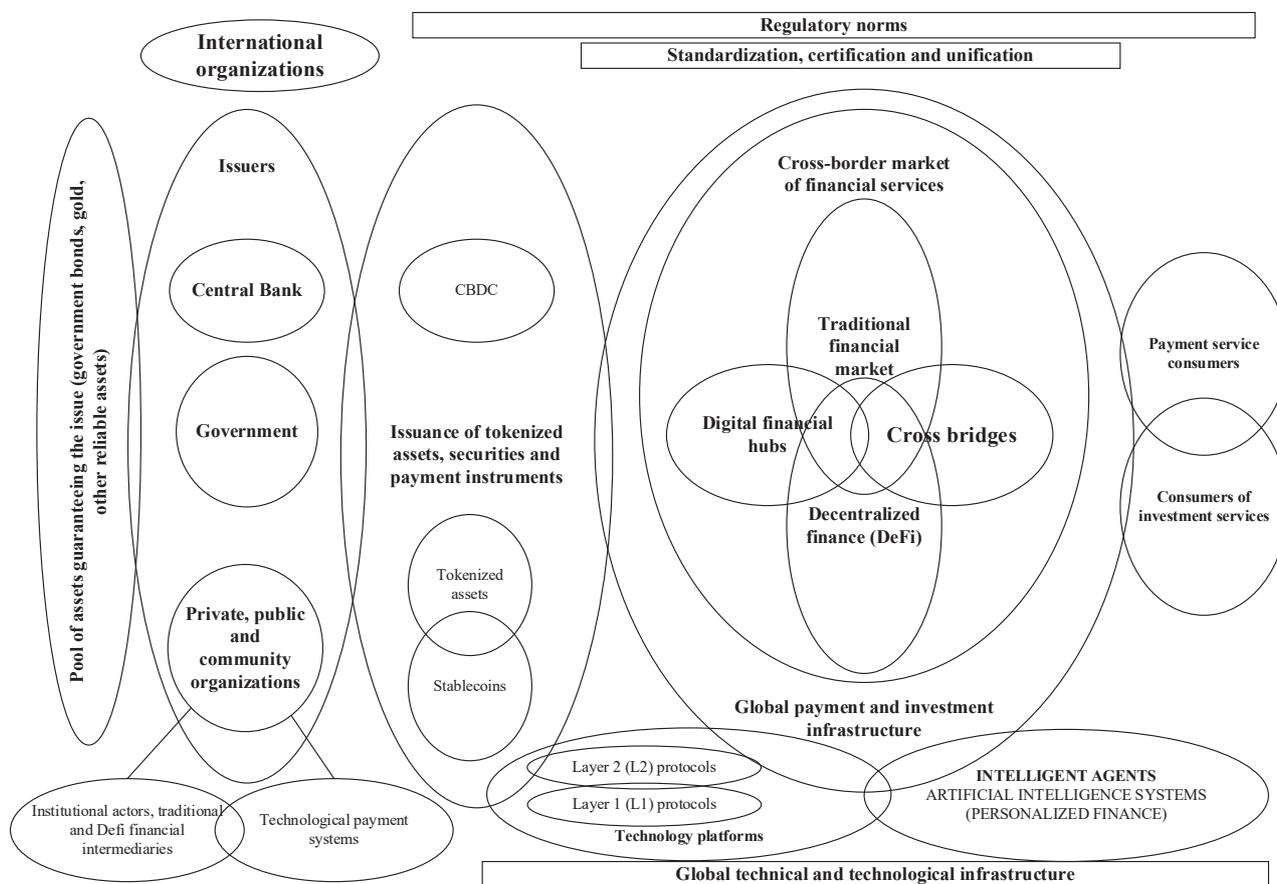


Fig. 5. The main components of the formation of a new digital financial ecosystem

8. Development of hybrid financial solutions CeDeFi – traditional financial institutions use DeFi protocols in their activities.

9. Implementation of the regenerative finance (ReFi) concept. In general, technological changes lead to the transformation and re-thinking of the role and place of traditional financial institutions, which involves their modernization. The above prerequisites for the transformation of financial architecture, institutional environment and technical and technological infrastructure become the basis for the formation of innovative regenerative financial ecosystems.

Comparisons with existing scientific studies indicate their consistency with works that emphasize the growing role of decentralized finance and asset tokenization in the transformation of financial markets [10, 17, 18]. This allows to accelerate transactions, expand financial inclusion, form personalized financial services, and attract more investment, which increases the stability of financial systems. In contrast to approaches that view DeFi as an alternative to centralization, the results reinforce new research that emphasizes the integrative nature of digital finance and the need to combine decentralized technologies with institutional infrastructure and regulatory mechanisms, which, in general, is the basis for the formation of a digital financial architecture [3, 14, 25]. All this forms the theoretical basis for assessing the current state and allows to identify trends in the development of digital financial ecosystems.

Additionally, the results extend the conclusions [23, 24] regarding the economic potential of tokenized assets, justifying that their scaling is possible only within the framework of a hybrid financial architecture with unified standards, interoperability and participation of central banks, and, in an evolutionary aspect, when exceeding 25% (value judgment) of the total global monetary circulation – the gradual replacement of traditional financial institutions – digital financial ecosystems. Thus, the study complements the existing literature with an ecosystem approach that allows to reconcile technological innovations with the requirements of financial stability and regulatory certainty.

The limitations of research are the impossibility of current quantitative assessment of cause-and-effect relationships, which is associated with aggregated data and secondary sources.

The determined theoretical prerequisites for the transformation of the global financial architecture allow to determine the parameters that determine its configuration and predict their change. Thus, a quantitative assessment of the functioning and development of digital financial ecosystems, an analysis of the impact of artificial intelligence on the functioning of the smart contracts market and the formation of regenerative financial ecosystems determine possible directions for the development of research.

4. Conclusions

1. According to the research results, it was found that in 2014–2023 there was a rapid development of key components of the digital financial infrastructure, as evidenced by: an increase in the number of licensed digital banks, more than five times, the total turnover of transactions on decentralized platforms, which exceeded 25% of centralized ones. In addition, more than 130 countries around the world are introducing CBDCs, and key traditional financial institutions are introducing DeFi solutions. This indicates the development of a hybrid financial architecture with the further evolution and development of digital financial ecosystems.

The rapid growth of payment instruments (stablecoins) based on decentralized financial technologies DeFi, in terms of total circulation, already exceeds the volume of payments that go through traditional payment systems (Visa, Mastercard). The pilot implementation of CBDC allows for direct payments without involving intermediary financial structures. This is especially reflected in cross-border payments, which allows for settlements without us-

ing the SWIFT system and correspondent bank accounts. It should be noted that traditional financial institutions are also actively introducing DeFi into their payment systems, which allows for faster efficiency and speed of payment transactions. Tokenization of real assets (RWS) based on DeFi is increasingly being introduced into the activities of financial market entities, which allows attracting new investors and making investment processes international without unnecessary regulatory influence, increasing the liquidity of financial markets. The development and implementation of smart contracts and the introduction of intelligent agents based on AI technologies allow for the introduction of an automatic mode of their execution, which increases the efficiency and reduces the cost of their maintenance and personalizes financial services. In the co-evolutionary aspect, regulatory and legislative acts have recently been stimulating the transfer of DeFi into the licensed sphere of the financial market. In addition, they motivate the symbiotic interaction of fiat and cryptocurrencies, tokenized assets and digital securities based on the ISO 20022 regulatory standard.

2. The key advantages of introducing DeFi determine the key barriers to the transformation of modern financial architecture. At the technological level, this is multi-protocol (requires the creation of digital hubs and cross-bridges). The international nature of DeFi determines the need for standardization and unification of both financial tools and the main regulatory influences in certain national economies. This is solved by creating special regimes or, again, international digital financial hubs of interaction. Here, it is necessary to highlight the problems of crypto-security, which is implemented both at the technological level and on the basis of countering social hacking. There is also a barrier to entry into the market for consumers who do not have special knowledge in the digital financial sphere.

3. The concept of forming digital financial ecosystems in the context of the development and evolution of a hybrid financial architecture (CeDeFi), which combines the advantages of decentralization and innovation with the reliability of the traditional financial system, is substantiated. The basis for the formation of new decentralized payment instruments and systems based on DeFi is the development of smart contracts with the introduction of intelligent agents (based on AI technologies). Their integration into the traditional finance system becomes the basis for the creation of a hybrid financial architecture (CeDeFi). As a result, providing consumers with low-cost personalized financial services (financial inclusion), the possibility of implementing flexible solutions in financing “green” technologies and ESG principles becomes the basis for the formation of digital financial ecosystems. This approach allows to combine real and digital assets.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

Manuscript has no associated data.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies in creating the submitted work.

Authors' contributions

Oleksandr Manoylenko: Methodology, Validation, Investigation, Resources, Data curation, Writing – original draft, Writing – review and editing, Visualization, Supervision, Project administration, Funding acquisition; **Svitlana Kuznetsova:** Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review and editing, Supervision, Project administration, Funding acquisition.

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Oleksandr Manoylenko, Doctor of Economic Science, Professor, Head of Department of Accounting and Finance, National Technical University "Kharkiv Polytechnic Institute", Kharkiv, Ukraine, ORCID: <https://orcid.org/0000-0001-5979-4077>

✉ **Svitlana Kuznetsova**, PhD, Associate Professor, Department of Accounting and Finance, National Technical University "Kharkiv Polytechnic Institute", Kharkiv, Ukraine, e-mail: Svitlana.Kuznetsova@khp.edu.ua, ORCID: <https://orcid.org/0000-0002-1567-4791>

✉ Corresponding author