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Interoperability of CBDCs: Optimising Cross-Border Settlements through the lens of national and international regulation

Vladyslav Kamyshanskyi*

Doctor of Philosophy

State Organisation “V. Mamutov Institute of Economic and Legal Research of the National Academy of Sciences of Ukraine”

01032, 60 Taras Shevchenko Blvd., Kyiv, Ukraine

<https://orcid.org/0000-0003-4220-8339>

■ **Abstract.** The study was dedicated to analysing various cross-border payment system models in the era of Central Bank Digital Currencies, including the IMF’s XC Model, BIS’s Universal Ledger, and SWIFT interoperability, with a focus on legislative regulation. The research was based on the comparative approach and analytical method used to study the legal framework in the field of digital currencies. It was concluded that, IMF’s XC Model appears to be the most suitable option for Ukraine. One of the key advantages of this model is the implementation of modern technologies, such as blockchain and smart contracts, which ensure high efficiency and security of financial transactions. Smart contracts reduce the need for intermediaries, accelerating processes and reducing transaction costs. Blockchain, in turn, guarantees transparency of each transaction, significantly increasing trust in the system. A critical issue is the protection of personal data, which is vital for national security amid growing cyber threats. The use of cryptographic technologies within the framework of the IMF’s XC Model ensures high levels of data protection and the anonymity of financial transactions. To implement this model in Ukraine, changes are needed in the legislative sphere. First and foremost, it is necessary to define the legal status of smart contracts, integrating them into the existing legal system as tools for fulfilling obligations in financial and legal relationships. Additionally, clear requirements for security standards should be established, and legal frameworks for using cryptographic technologies in the financial sector should be developed. This will ensure a high level of data protection, including personal data, and prevent breaches of confidentiality. Collectively, these measures will promote the development of digital infrastructure, enhance economic resilience, and strengthen Ukraine’s position in the global economy

■ **Keywords:** payment systems; national security; blockchain; smart contracts; legal regulation; digital currency

■ Introduction

Central Bank Digital Currencies (CBDCs) represent a new category of financial instruments with the potential to significantly transform the international financial system and influence monetary hegemony. They can enhance the efficiency of financial transactions, reduce costs, and improve access to financial services. However, the impact of CBDCs on global

financial markets and relations requires thorough investigation. According to a report by the U.S. Congressional Research Service, global economic and geopolitical shifts may lead to a reassessment of the dollar’s role as a reserve currency and an increased adoption of alternative currencies, including CBDCs. This is particularly relevant in the context of

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■ *Corresponding author

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contemporary financial sanctions, which drive the search for new currency alternatives (Congressional Research Service, 2022).

As of June 1, 2024, 134 countries representing over 98% of global GDP are working towards CBDC implementation. Three countries have already deployed CBDCs in practice, while 36, including Ukraine, are conducting pilot projects (Atlantic Council, n.d.). The motivations behind CBDC development vary: while some countries aim to enhance domestic financial inclusion and payment system efficiency, others view CBDCs as a means to counteract the dominance of the U.S. dollar in international trade and financial settlements. Sanctions imposed on Russia, China, and Iran have been a significant catalyst, pushing these nations to explore alternatives to the dollar, which, in turn, may influence their participation in global financial initiatives. For instance, the cross-border mBridge project, connecting China, Thailand, the UAE, and Hong Kong, is expected to expand to 11 additional countries in 2025. BRICS countries, including China and Russia, are actively exploring CBDCs as a tool to facilitate trade settlements outside the SWIFT network and circumvent Western-imposed restrictions (Prokopenko, 2024). However, while CBDC development is progressing rapidly, the implementation of this technology is accompanied by significant legal and regulatory challenges. A detailed analysis of legal aspects, particularly issues of data privacy and security, is crucial to ensure that new currencies comply with existing legislation. Progress in CBDC adoption may face legal barriers at both domestic and international levels, especially within the EU.

The legal challenges surrounding the circulation of virtual assets, including CBDCs, have intensified in 2020s. Economic and legal research, along with international experience, has contributed to the development of scientifically grounded and innovative solutions. Implementing these solutions at the legislative level could drive positive transformations in the ongoing digitalisation of the payments market. The study of the legal aspects of CBDC implementation is becoming increasingly important, particularly in the context of legal certainty and compliance with existing regulatory standards. In this regard, considerable attention has been paid to the works of authors such as K. Vozniakovska *et al.* (2021), who examined the legal challenges of digital assets, as well as the work of T. Hudima (2020) and E. Avgouleas & W. Blair (2024), which explores the impact of financial innovations on regulatory approaches. The international dimension of CBDC implementation also attracts significant attention. D. Niepelt (2018) studied the cross-border movement of capital in the digital environment, while J. Fernández-Villaverde *et al.* (2020) analysed potential risks of currency substitution and monetary instability. Among more recent

studies, the work of A. Veneris *et al.* (2021) stands out, as it assesses the potential for reducing costs associated with international transactions through CBDCs. At the same time, as noted by E. Eren *et al.* (2022), the introduction of digital currencies may pose additional risks to financial stability due to capital flow volatility.

The purpose of the study was to determine the optimal model of cross-border payments, in particular the IMF's XC model, for implementation in Ukraine, taking into account the specifics of national legislation and challenges related to the use of digital currencies by central banks. The objectives of this Article were:

1) to assess the prospects for qualitative changes related to the implementation of CBDCs in Ukraine, taking into account both national and international legislation (including EU laws), while addressing issues of data privacy, transaction security, and legal compliance;

2) to identify the most suitable model of CBDC interoperability to optimize cross-border settlements. This area remains insufficiently explored in academic literature and presents a significant opportunity for further investigation.

■ Literature Review

It is worth noting that a substantial body of current research is dedicated to examining these aspects. Among the wealth of valuable works, special attention should be given to the dissertation by A.C. Haskell (2024). The author examines how CBDCs can enhance cross-border payments, making them faster, cheaper, and more transparent, provided central banks account for key design aspects such as architecture and interoperability. The research introduces novel theoretical models and tools to assist central banks in the development and implementation of CBDCs. The analysis of fundamental aspects of CBDCs includes questions regarding the feasibility of their implementation. For instance, F. Allen *et al.* (2022), J. Flemming & R. Judson (2024) explore the economic foundations of CBDCs, while T. Keister & D. Sanches (2021) focus on potential consequences for the banking sector and lending mechanisms. Additionally, Z. Li (2024) examines the relationship between CBDCs and the transmission of monetary policy, particularly its impact on liquidity and financial inclusion. The technological aspect of CBDCs remains a crucial area of research as well. For example, A.C. Haskell (2024) examined the interoperability of digital currencies and their compliance with data protection standards. In this context, T. Hudima *et al.* (2023) analyse different CBDC models, while H. Wang & S. Gao (2024) explore technical solutions aimed at ensuring cross-border compatibility of digital currencies. Another area of research focuses on

assessing the macroeconomic impact of CBDCs. In this aspect, O. Sharov (2022) and S. Hrytsai (2022) investigated the transformation of national payment systems due to the introduction of digital currencies. Meanwhile, M. Brunnermeier *et al.* (2019) emphasise potential changes in the international monetary system, which would require coordination of regulatory policies across different countries.

Researchers caution against excessive optimism about the advantages of CBDCs due to design limitations and their inability to simultaneously meet conflicting objectives (privacy, accessibility, improved monetary policy, payment optimisation, etc.) (Ozili, 2023). In this context, the recommendations of M. Hamdy (2023) on how the G20 can support a global wholesale CBDC architecture stand out, emphasising the significant benefits CBDCs could bring to cross-border payments. Equally valuable is the Article by A. Reslow *et al.* (2024), which focuses on the development of retail central bank digital currency systems. The authors identify critical model and policy aspects required to ensure compatibility with cross-border payments. They analyse ongoing pilot projects and research to determine which issues should be addressed when designing retail CBDCs targeted at households and non-financial firms. While the focus is on retail CBDCs, some of the issues discussed are also relevant to wholesale CBDCs and other forms of digital money. Overall, technical interoperability of CBDCs is achievable; however, further work is required on developing standards, interfaces, and legal, regulatory, and governance aspects (Bech *et al.*, 2022; Themistocleous *et al.*, 2023). Additionally, as stated F. Syarifuddin (2023), to realise the benefits of such currencies, challenges related to high investment costs and technological issues – such as the digital divide and power outages – must be addressed.

■ Materials and Methods

This is research based on an analytical method applied to examine the legal framework of Ukraine in the field of digital currency, as well as to compare regulatory approaches and intergovernmental cooperation in the context of central bank digital currencies (CBDCs). The legislation of Ukraine is analysed with a focus on the Law of Ukraine No. 1591-IX “On Payment Services” dated June 30, 2021¹, which enabled the identification of key aspects of the regulatory definition of digital money by the National Bank of Ukraine and its distinction from electronic money. For the research of international experiences

related to CBDC interoperability, a comparative legal approach was employed. International interaction models, including the XC Interoperability Model by the International Monetary Fund (2023), the BIS Unified Ledger of the Bank for International Settlements (BIS, 2023), and the SWIFT project (Swift, 2022) aimed at optimising cross-border payments, were analysed.

Special attention was given to a systemic approach, allowing for a comprehensive examination of the architectural, technological, and legal aspects of each model. Within this approach, elements such as settlement mechanisms, the degree of decentralisation, integration of smart contracts, data protection, and risk management were explored. Furthermore, the role of the National Bank of Ukraine in developing pilot projects (NBU, 2019; 2022) for the digital hryvnia was studied through the analysis of the regulator’s current initiatives and proposals. Reports published by BIS (2022a; 2022b; 2023), SWIFT (2022), and other international organisations were utilised, providing an assessment of their practical significance and applicability to Ukraine.

The research also employed a predictive method to evaluate the potential use of the digital hryvnia in cross-border transactions and its integration into global CBDC platforms. This approach allowed for the identification of promising areas for improving the legal framework and developing strategies to enhance Ukraine’s integration into the international digital economy. The research adheres to the principles of objectivity and consideration of the international context, ensuring a holistic and scientifically grounded examination of the topic under review.

■ Results and Discussion

The general principles governing the issuance and use of digital money by the National Bank of Ukraine (NBU), as well as their distinction from electronic money, were officially established by the Law of Ukraine “On Payment Services”². This law is a result of the implementation of European legislation³. According to Clause 96 of Article 1 of this law, “digital money of the National Bank of Ukraine represents an electronic form of the monetary unit of Ukraine, issued by the National Bank of Ukraine”. This contrasts with units of value stored electronically and issued by electronic money issuers to facilitate payment operations (including prepaid multipurpose payment cards), which are accepted as a means of payment by entities other than their issuers and constitute a monetary obligation of the respective issuer of electronic

¹ Law of Ukraine No. 1591-IX “On Payment Services”. (2021, June). Retrieved from <https://zakon.rada.gov.ua/laws/show/1591-20/ed20210630#Text>.

² Ibidem, 2021.

³ Directive of European Parliament and of the Council No. 2015/2366 “On Payment Services in the Internal Market, Amending Directives 2002/65/EC, 2009/110/EC and 2013/36/EU and Regulation (EU) No. 1093/2010, and Repealing Directive 2007/64/EC”. (2015, December). Retrieved from <https://eur-lex.europa.eu/eli/dir/2015/2366/oj/eng>.

money (Clause 14, Article 1 of the Law of Ukraine “On Payment Services”). At the same time, it is important to note that the Law “On Payment Services”¹ adopts a somewhat declarative approach to regulating the specific features of issuing and using digital currency. Notably, the law states that such currency may be issued by the NBU exclusively in non-cash form and can be utilised by both business entities and ordinary citizens. However, the procedures for issuing and storing digital money, as well as the specifics of conducting payment operations using digital money, are to be determined by regulatory acts of the National Bank of Ukraine (Article 62 of the Law of Ukraine “On Payment Services”). Despite the two years since the adoption and enactment of the Law of Ukraine “On Payment Services”, the regulator (the National Bank of Ukraine) has been progressing rather slowly in implementing the aforementioned provisions. Specifically, the National Bank of Ukraine has postponed the next pilot project for the issuance of the e-hryvnia to 2025 (Epravda, 2024).

NBU is considering and exploring potential use cases for the e-hryvnia, which will influence its design and key features (NBU, 2022). One such use case is the e-hryvnia for enabling cross-border payments. In this context, within the framework of integration into the global digital payment system, interoperability between CBDCs of different countries is a critical aspect that requires consideration and demands international cooperation. As noted V.K. Mamutov (2011), “integration is inherently an international process, capable of development only when, in one way or another, the interests of all objectively interdependent participants are taken into account”.

It is worth noting that the BIS and the G20 have already worked on identifying potential options for CBDC interoperability in cross-border payments, each offering different potential advantages (GOV. UK, 2021). In July 2022, three models were proposed: compatibility (separate CBDC systems adopting common standards), interlinking (establishing a set of contractual agreements, technical connections, standards, and operational components between CBDC systems), and a single system (a unified technical infrastructure hosting multiple CBDCs). These models involve varying levels of operational challenges and costs while considering the differing levels of maturity of CBDC projects (BIS, 2022a). However, a single universal approach has not yet been established.

Instead, growing awareness among central banks and international financial institutions of the risks associated with uneven development of digital currencies (such as further financial system fragmentation,

deepening of the digital divide, and the creation of systemic risks) has led to the development of new models (platforms) for cross-border CBDC operations. The primary focus of such platforms is to safeguard the monetary sovereignty of each jurisdiction (Auer *et al.*, 2021). Among the key examples of such platforms is the IMF’s XC Interoperability Model, an innovative approach to optimising cross-border payments inspired by CBDC projects such as Mbridge (Ledger Insights, 2022a), Project Inthanon-LionRock (Ledger Insights, 2021), and others. This model envisions a global centralised ledger that connects commercial banks, payment systems, and central banks to streamline operations. It features a three-tiered architecture: a settlement layer serving as the primary ledger, a programming layer for executing smart contracts, and an information layer dedicated to protecting personal data, ensuring compliance, and enabling currency controls when necessary.

The primary goal of the XC model is to reduce costs and accelerate settlement processes. Instead of CBDCs, the model proposes the use of conditional deposit certificates (a unified instrument of the platform), which financial institutions can convert into central bank reserves (Adrian & Griffoli, 2023). This structure eliminates typical counterparty risks (credit risk – counterparty insolvency, liquidity risk – lack of funds for settlement, settlement risk – delays or failures in payments, concentration risk – overreliance on specific financial institutions, operational risk – failures in payment systems, legal risk – uncertainty in the enforcement of obligations). Unlike SWIFT, which is purely a messaging system, the XC model integrates messaging with the actual movement of funds, aligning with most digital currency projects.

The model envisions using a blockchain-like foundation to reduce the need for intermediaries by automating most functions through smart contracts. Encryption and credentials will play a key role. XC participants, such as banks and payment service providers, will receive anonymous credentials from credential providers. This will enable participant identities to be verified outside the ledger, while any restrictions on their credentials, such as transaction limits, can be checked on the platform (Ledger Insights, 2022b). Confidentiality also extends to the end client making a payment. Instead of sharing KYC (know your customer) data with foreign counterparties whose reliability is uncertain, the client’s identity can be checked against sanctions lists outside the ledger, and a cryptographic proof can be retained as confirmation of the verification. However, this approach relies on external data and third parties conducting the verification.

¹ Law of Ukraine No. 1591-IX “On Payment Services”. (2021, June). Retrieved from <https://zakon.rada.gov.ua/laws/show/1591-20/ed20210630#Text>.

XC platforms enable the creation of a multi-currency system without mandating a single or new settlement asset. Participants can freely choose which currencies to use on the platform, within the constraints of central bank reserves. Notably, XC platforms do not require countries to adopt CBDCs; however, their design and functionality are influenced by concepts and technologies developed around certain CBDCs. Several central banks, including those in Brazil, France, Italy, Singapore, and the United Kingdom, have already begun experimenting in this area. This concept has also received support from Agustin Carstens, General Manager of the Bank for International Settlements (Carstens, 2023).

However, for the model to function effectively, it will require a compatible legal and regulatory framework to manage risks efficiently and ensure compliance across various jurisdictions (Atlantic Council, 2023). Firstly, the harmonisation of international legal standards is critically important. Countries participating in the XC platform must adopt unified norms for cross-border payment systems. This includes recognising escrow certificates as legally enforceable instruments and ensuring the enforceability of smart contracts in compliance with relevant national laws. Secondly, clear regulatory oversight of credential providers, which play a pivotal role in identity verification, is essential. These providers must be licensed and adhere to strict data protection laws to prevent misuse or leakage of sensitive information. Furthermore, countries should adapt their legal frameworks to recognize cryptographic proofs generated by XC platforms as valid evidence in disputes or compliance investigations. This step will eliminate uncertainty for participants relying on automated processes within the platform. Moreover, a compliance framework for sanction enforcement should be established, requiring collaboration with international bodies such as the Financial Action Task Force (FATF). Aligning XC platform operations with global standards on anti-money laundering (AML) and combating the financing of terrorism (CFT) is vital (FATF, n.d.). Additionally, consumer protection measures should be introduced to ensure transparency regarding fees, processing times, and dispute resolution mechanisms, thereby fostering trust among users.

For Ukraine, the adoption and integration of the XC model present unique opportunities and challenges. Aligning with European standards under the EU Association Agreement¹, Ukraine should consider

incorporating XC platform mechanisms into its digital payments legislation. Legal recognition of escrow certificates and ensuring interoperability with EU systems are critical steps in this process. In addition, the Law of Ukraine “On Payment Services”² requires updates to accommodate XC platform operations. This includes provisions for regulating credential providers and ensuring the admissibility of cryptographic proofs in Ukrainian courts. Given the reliance on external data verification, Ukraine must ensure compliance with its Law of Ukraine “On Personal Data Protection”³ while aligning with the EU’s General Data Protection Regulation (GDPR)⁴. For example, Article 29 of the Law of Ukraine “On Personal Data Protection”⁵ should be expanded to clarify the conditions for cross-border data transfers, including introducing requirements for the use of Standard Contractual Clauses (European Commission, 2021) in accordance with Article 46 of the GDPR, and ensuring compliance with encryption and pseudonymisation requirements as outlined in Article 32 of the GDPR, as well as the general conditions set forth in Article 44 of the GDPR. These measures are crucial for maintaining trust in the platform and safeguarding data privacy.

The National Bank of Ukraine (NBU) could also launch pilot projects to test XC-like functionalities, such as multi-currency settlement layers or smart contract-based automation. Examples of such operational systems include: Jasper-Ubin (Canada – Singapore) (MAS, 2019) and mBridge (BIS, 2022b). Furthermore, Ukraine should actively participate in international discussions on cross-border payment innovations, leveraging insights from initiatives led by the IMF, BIS, and regional organisations.

The BIS Unified Ledger Interoperability Model proposes the concept of a global unified ledger that supports the issuance and operation of both CBDCs and tokenised assets (BIS, 2023). The primary goal of this model is to eliminate financial system fragmentation by enabling safer transactions and atomic settlements within a transparent framework. However, the BIS Unified Ledger approach significantly differs from the XC model as it relies on the use of centralised APIs (Application Programming Interfaces) rather than blockchain-based solutions. The centralised nature of the BIS Unified Ledger implies that transaction processing and verification are carried out by authorised entities, such as central banks or designated financial institutions. At the same time,

¹ Association Agreement Between Ukraine, of the One Part, and the European Union, the European Atomic Energy Community and their Member States, of the Other Part. (2014, March). Retrieved from https://zakon.rada.gov.ua/laws/show/984_011#Text.

² Law of Ukraine No. 1591-IX “On Payment Services”. (2021, June). Retrieved from <https://zakon.rada.gov.ua/laws/show/1591-20/ed20210630#Text>.

³ Law of Ukraine No. 2297-VI “On Personal Data Protection”. (2010, June). Retrieved from <https://zakon.rada.gov.ua/laws/show/2297-17>.

⁴ General Data Protection Regulation (GDPR). (2018, May). Retrieved from <https://gdpr-info.eu/>.

⁵ Law of Ukraine No. 2297-VI “On Personal Data Protection”. (2010, June). Retrieved from <https://zakon.rada.gov.ua/laws/show/2297-17>.

the model allows central bank money to circulate on a platform that is neither owned nor operated by the central bank itself, which introduces certain risks. This raises legal concerns related to the control and security of funds, especially if the platform fails to meet strict regulatory standards. For example, in the European Union (Article 128 of Treaty on the Functioning of the European Union¹) and the United States², central banks are the sole authorities for currency issuance, and involving private entities in such activities might violate these laws, potentially leading to constitutional or statutory challenges. Additionally, jurisdictional issues may arise in cases of fraud or disputes, especially if the platform operates across multiple jurisdictions, complicating the determination of which legal system holds authority. This could undermine accountability, as private platforms may not be subject to the same rigorous regulatory scrutiny as traditional financial institutions, increasing the risk of money laundering or financial crimes.

The BIS Unified Ledger model is already in the pilot testing phase for wholesale CBDCs, particularly in South Korea (BIS, 2023). From a legal perspective, the BIS Unified Ledger model necessitates the precise allocation of responsibilities among participants, including data control, transaction verification, and operational security. The requirement for centralised transaction verification also raises concerns about the risks of power concentration and potential misuse of authority. To ensure the platform's functionality, new regulatory frameworks will be needed, including mechanisms to oversee interactions with private platform operators. Similar regulatory mechanisms can be drawn from the EU Digital Operational Resilience Act³, which sets requirements for ICT risk management in financial entities, and the Markets in Crypto-Assets Regulation⁴, which establishes oversight mechanisms for crypto-asset service providers. These frameworks provide a foundation for ensuring security, accountability, and compliance in digital financial infrastructures.

Furthermore, unlike the XC model, which offers a flexible architecture tailored to the interests of participants and employs a decentralised approach, the BIS Unified Ledger model is less adaptable to multi-layered integration within international and national financial systems. For Ukraine, which is in the process

of aligning with European legislation, the XC model presents a more suitable option. Its decentralised structure better aligns with EU requirements, including compliance with GDPR⁵ provisions – particularly data minimisation (Article 5(1)(c)) and the right to data portability (Article 20). By limiting centralised control over personal data and enhancing interoperability across jurisdictions, the XC model ensures greater user autonomy and facilitates compliance with cross-border data transfer regulations within the EU. While the BIS Unified Ledger model offers advantages in terms of transparency and faster settlements, it is less suitable for Ukraine compared to the XC model. The centralised approach of BIS may conflict with objectives related to data protection, digital asset management, and integration with European standards.

Another interoperability model is SWIFT's cross-border project. Leveraging its central role in global financial messaging, SWIFT's innovation center has introduced a model aimed at enhancing the existing cross-border payment infrastructure, making it faster, more transparent, and cost-efficient. This model is currently undergoing testing. It enables the seamless connection of separate domestic CBDC networks, allowing them to interact and transact while leveraging SWIFT's existing infrastructure and security protocols. As the project progresses beyond the innovation center, significant operational changes will be needed to scale it across the entire SWIFT ecosystem (Swift, 2022).

In September 2023, SWIFT announced that three central banks, including Hong Kong Monetary Authority, the National Bank of Kazakhstan, and one unnamed institution, would join the next beta phase of its CBDC interoperability project. Initially launched in March 2023 with over 18 participants, including MAS and the Bank of France, the initiative has since grown to encompass more than 30 organizations and has processed over 5,000 transactions within a twelve-week period. This solution capitalizes on SWIFT's global reach and existing network effects among financial institutions, allowing countries to maintain their domestic CBDC infrastructure while ensuring seamless global connectivity (Swift, 2023).

The choice of the "best" digital currency model depends on the specific needs and priorities of a country or region. Each of the models presented –

¹ Consolidated version of the Treaty on the Functioning of the European Union. (2012, October). Retrieved from <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A12012E%2FTXT>.

² The Federal Reserve Act. (1913, December). Retrieved from <https://www.federalreserve.gov/aboutthefed/fract.htm>.

³ Regulation of the European Parliament and of the Council No. 2022/2554 "On Digital Operational Resilience for the Financial Sector and Amending Regulations (EC) No. 1060/2009, (EU) No. 648/2012, (EU) No. 600/2014, (EU) No. 909/2014 and (EU) 2016/1011". (2022, December). Retrieved from <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32022R2554&qid=1738308404310>.

⁴ Regulation of the European Parliament and of the Council No. 2023/1114 "On Markets in Crypto-Assets, and Amending Regulations (EU) No. 1093/2010 and (EU) No. 1095/2010 and Directives 2013/36/EU and (EU) 2019/1937". (2023, May). Retrieved from <https://eur-lex.europa.eu/eli/reg/2023/1114/oj/eng>.

⁵ General Data Protection Regulation (GDPR). (2018, May). Retrieved from <https://gdpr-info.eu/>.

IMF's XC Model, BIS's Universal Ledger, and SWIFT's new cross-border project – has its own strengths and weaknesses (Kumar & Chhangani, 2024). SWIFT model is best viewed as a linking chain between various central banks, with SWIFT positioned at its core (Swift, 2022). For Ukraine, the use of the SWIFT model appears to be an appealing solution, given the need to ensure global compatibility and accelerate cross-border payments. However, in the context of European integration and the necessity to adapt the national financial system to EU standards, the XC model might be more preferable, as it allows central banks to retain greater control over internal processes while also ensuring interoperability at the international level. Thus, the choice of model for Ukraine depends on the priorities: if the focus is on the speed of implementation and minimal changes to the existing infrastructure, the SWIFT model may be useful. At the same time, for a long-term strategy focused on innovation and compliance with European standards, the XC model or a hybrid approach could be a more suitable option.

As W. Bossu *et al.* (2020) point out, most current central bank laws do not provide clear mandates for the issuance of digital currencies, which could lead to significant legal and financial risks. However, analysis of these claims leads to the conclusion that such limitations are not universal across all jurisdictions. In certain cases, particularly within the European Union, there is active consideration of adapting legal frameworks to incorporate digital currencies into existing financial systems. Nevertheless, as emphasised in the study by A.S. Haskell (2024), this creates challenges in managing new digital assets and ensuring their compliance with traditional regulations. Therefore, the issue of legally defining the role of central banks in the creation of CBDCs requires further research, which is necessary to minimize the legal risks associated with their issuance.

Regarding the research presented in the Bank for International Settlements (Carstens & Nilekani, 2024) Working Paper, the authors highlight the importance of creating unified registries for digital currencies. They emphasise the need to develop new mechanisms that would allow central banks to manage tokenised forms of money in accordance with unified standards. However, the analysis presented above demonstrates a different picture, as existing legislative and regulatory systems, particularly in developing countries, have much less capacity for the rapid adaptation of such standards. This is also confirmed by the findings of researchers, including K. Vozniakovska *et al.* (2021), who underline that legal challenges arise due to the lack of relevant legislative acts regulating digital assets within states.

The reason for different interpretations may lie in the fact that researchers base their conclusions

on different assumptions about the pace of financial technology development and the degree of readiness of states for innovation. For example, research by F. Allen *et al.* (2022) indicates a positive economic effect of digital currencies; however, it must be noted that such changes may have an ambiguous impact on the banking sector, as pointed out by T. Keister & D. Sanches (2021). They warn about the risk of destabilizing the financial system due to the displacement of traditional deposits and the growing dependence on digital assets.

The conclusions drawn by the researchers are entirely appropriate, as they reflect the complexity and multifaceted nature of the process of implementing CBDCs in various regions. Different approaches to this process can be complementary, but it is essential that a global consensus is reached on the fundamental principles of regulation and ensuring interoperability of digital currencies. Overall, the results of research confirm that despite the obvious benefits of using CBDCs, there are numerous legal, economic, and technical challenges that require thorough study and resolution. This includes, in particular, issues related to legal status, interoperability, and economic impact on national economies, which necessitate further developments in this area.

■ Conclusions

The conducted analysis allows to conclude that the IMF's XC Model offers a practical and promising approach to enhancing cross-border payments by reducing transaction costs and settlement times. Its compatibility with existing systems, requiring minimal technological adjustments, positions it as an optimal choice for countries with substantial international trade volumes. Moreover, the model enables central banks to focus on domestic use cases before transitioning to broader cross-border integration. However, its reliance on a harmonised legal and regulatory framework across jurisdictions remains a notable challenge, and its largely theoretical nature underscores the need for comprehensive practical testing.

The BIS Universal Ledger model, while innovative in supporting tokenised assets and demonstrating viability through pilot projects, faces inherent challenges due to its centralised nature. Concerns regarding the security and control of central bank funds arise, particularly when central bank money circulates on platforms not managed by the central bank itself. This situation risks losing monetary policy control, increasing the potential for misuse of funds or financial fraud. Therefore, such platforms require robust regulatory oversight and protection to mitigate these risks effectively. Similarly, SWIFT's cross-border payment project leverages its extensive global infrastructure, reducing implementation costs and fostering global trust. However, its reliance on

centralised infrastructure creates dependency on SWIFT, which may undermine the autonomy of central banks in participating countries.

All analysed models share a common goal of reducing costs, enhancing efficiency, and improving the security of cross-border transactions. However, governance remains a critical issue across these models. Establishing consensus on a global system operator is a challenging task, given geopolitical differences. Many countries exploring CBDCs hesitate to entrust existing global institutions with leadership roles or specific technological models. Conversely, fragmented development of digital currencies risks further financial system disintegration, deepening the digital divide, and introducing systemic risks. This fragmentation undermines the core objective of digital currencies, which is to enhance the efficiency of the existing financial system.

For Ukraine, the IMF's XC Model appears to be the most suitable option due to several key advantages. One of its primary benefits is the significant financial autonomy it provides. Unlike models that rely on a single settlement asset, the XC Model allows for flexibility in currency selection, which is crucial for a country seeking to minimize currency risks and avoid dependence on a single currency. This flexibility is particularly important given the instability of Ukraine's financial markets. Another essential advantage lies in the technological efficiency and security offered by the XC Model. The use of blockchain and smart contracts streamlines transactions by reducing the role of intermediaries, thereby accelerating processes and lowering operational costs. At the same time, blockchain ensures full transparency of each

transaction, which fosters trust in the system. Additionally, the model addresses growing concerns over data protection and cyber threats. By incorporating cryptographic technologies, it ensures a high level of security and anonymity in financial operations. This is especially critical for Ukraine, where reliable mechanisms for protecting sensitive financial data are needed to prevent breaches and fraud. However, to fully implement the XC Model, Ukraine will need to undertake comprehensive legislative changes. This includes recognising the legal status of smart contracts and integrating them into the legal framework as enforceable tools in financial and legal transactions. The promising directions for further research include a detailed analysis of the legal aspects of implementing the IMF's XC Model in Ukraine, particularly regarding the legal status of smart contracts and their integration into the national legal system, as well as the study of mechanisms for ensuring security and regulatory control in the context of cross-border use of CBDCs.

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■ Conflict of Interest

The author of this research declares no conflict of interest.

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Інтероперабельність CBDC: оптимізація транскордонних розрахунків крізь призму національного та міжнародного регулювання

Владислав Камишанський

Доктор філософії в галузі права

Державна установа «Інститут економіко-правових досліджень
імені В.К. Макутова НАН України»

01032, б-р Тараса Шевченка, 60, м. Київ, Україна

<https://orcid.org/0000-0003-4220-8339>

■ **Анотація.** Дослідження було присвячено аналізу різних моделей транскордонних платіжних систем в епоху цифрових валют центральних банків, зокрема моделей ХС Міжнародного валютного фонду, Universal Ledger BIS та інтероперабельності SWIFT, із фокусом на нормативно-правовому регулюванні. Вивчення теми ґрунтувалося на використанні порівняльного підходу й аналітичного методу, який було використано для вивчення правової бази у сфері цифрових валют. Сформульовано висновок, що модель ХС Міжнародного валютного фонду є найприйнятнішим варіантом для України. Однією з ключових переваг цієї моделі є впровадження сучасних технологій, таких як блокчейн і смартконтракти, що забезпечують високу ефективність та безпеку фінансових операцій. Смартконтракти знижують потребу в посередниках, що пришвидшує процеси та скорочує витрати на обробку фінансових операцій. Блокчейн, зі свого боку, гарантує прозорість кожної транзакції, що значно підвищує довіру до системи. Однією з ключових проблем є захист персональних даних, що є критично важливим для національної безпеки в умовах посилення кіберзагроз. Використання криптографічних технологій у межах моделі ХС Міжнародного валютного фонду забезпечує високий рівень захисту даних й анонімність фінансових операцій. Для впровадження цієї моделі в Україні необхідні суттєві зміни в законодавчій сфері. Передусім слід визначити юридичний статус смартконтрактів, інтегруючи їх у чинну правову систему як інструмент виконання зобов'язань у фінансових і правових відносинах. Поза тим, необхідно встановити чіткі вимоги до стандартів безпеки, а також розробити правові межі для використання криптографічних технологій у фінансовому секторі. Це забезпечить високий рівень захисту даних, зокрема персональні дані, і запобігатиме порушенню конфіденційності. У сукупності ці заходи забезпечать розвиток цифрової інфраструктури, підвищать економічну стійкість та зміцнять позиції України в глобальній економіці

■ **Ключові слова:** платіжні системи; національна безпека; блокчейн; смартконтракти; правове регулювання; цифрова валюта