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Central Banks Digital Currencies for Cross-Border Payments: Interoperability Models and Implementation Possibilities

D.A. Kochergin
Institute of Economics of the Russian Academy of Sciences, Moscow, Russia

ABSTRACT

The study is devoted to the use of central bank digital currencies in cross-border settlements. The **purpose** of the paper is to identify the capacity of cross-border settlements using multi-CBDC/mCBCD mechanisms based on different interoperability models. The study identified the main problems of modern cross-border settlements and the possible risks associated with the implementation of mCBDCs. The features of various models of interoperability in mCBDCs arrangements are revealed and prospects of their use are defined. It was concluded that the main problems of traditional cross-border settlements are legacy technology platforms, fragmented data presentation formats; complex processing of compliance checks; long transaction chains and etc. It was identified that the main risks associated with the implementation of mCBDCs are: "digital dollarization", international "spillover effects" of economic and financial shocks, the use of digital currency for tax evasion and supervision of the domestic monetary system and financial market, etc. The obtained results allowed us to conclude that among the three main models of interoperability of mCBDCs, the single system model is the most prospect, since it allows to mitigate of cross-border and cross-currency risks, expand opportunities for infrastructure integration and technical compatibility, reduce the number of intermediaries and improves the security of settlements. In order to successfully implement mCBDC projects, in addition to the chosen operating model, a sufficiently high overall level of technological and infrastructural development of national CBDC systems, as well as economic and geopolitical interest in carrying out cross-border settlements between participating countries.

Keywords: central bank; cross-border payments; central bank digital currency (CBDC); CBDC system; multi-CBDC/mCBDC arrangements; interoperability models of mCBDC; risks of CBDCs for cross-border settlements

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INTRODUCTION

Central banks' interest in implementing national digital currencies (CBDCs) has steadily increased in recent years.[1] Central banks (CBs) and international financial organizations (IFOs)[2] pay particular attention to research and joint implementation of projects aimed at exploring the possibilities of the use of central bank digital currencies of the in cross-border settlements. National central bank digital currency systems (CBDC systems)[3] can be integrated through multiple national CBDCs (multi-CBDCs/mCBDCs),[4] which means payment in the digital currencies of the member countries of such mechanisms is possible [1].[5]

Some economists consider that mCBDC arrangements may be preferable to alternative proposals aimed at increasing the efficiency of cross-border payments either by modifying existing systems[6] [2], or by using cryptocurrencies [3] or global stablecoins in international settlements [4–9]. Thus, instead of creating a new unit of exchange competing with national currencies, the mCBDC arrangements may allow for the unification of the use of the national central bank digital currencies, either by achieving system compatibility, or by interlinked, or through the creation of a single (integrated) system.[7]

The mCBDC arrangements are capable of making international payments and settlements more accessible and transparent, and the introduction of new financial communications standards could significantly change the existing settlement mechanism. However, the implementation of mCBDCs does not in itself guarantee the automatic achievement of the above advantages. Thus, the international use of central bank digital currencies may involve a number of economic risks in the area of monetary and macroeconomic policy for both the issuing country and countries where the digital currency of the central bank of another jurisdiction will be used.

Digital currency systems for cross-border payments may differ in terms of structure, participation rules and membership, governance arrangements, infrastructure and transaction ledger, identification schemes, clearing and settlement mechanisms, etc. The study of the characteristics of the various mCBDC arrangements and the various interoperability models implemented in them is of important scientific importance for the construction of unified systems of international settlements using CBDCs based on new information technologies.

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[1] Central bank digital currency (CBDC) is a new form of central bank money, represented by direct liability of the central bank, denominated in the national unit of account and acting as a means of payment and saving. CBDC can be widely used in retail payments and/or wholesale payments. Digital currencies of central banks for retail payments (retail CBDCs, rCBDCs) are a new form of central bank money that is used for universal settlements between end users (households, enterprises, etc.). Wholesale CBDCs (wCBDCs) is a new form of central bank money that is used for specialized settlements between central banks and financial institutions and is different from traditional bank reserves or funds on settlement accounts.

[2] These IFOs include: International Monetary Fund (IMF); World Bank (WB); Bank for International Settlements (BIS); Group of Seven (G7); Group of Twenty (G20) and others.

[3] Central bank digital currency system (CBDC system) is a digital currency ecosystem that brings together and delegates responsibilities for the issuance, accounting, storage and transfer of CBDCs, as well as the development of standards and infrastructure. The digital currency system is based on a main ledger with supporting infrastructure and operating rules, on the basis of which an operational processing is built, including digital wallets and user services implemented by providers, in accordance with certain technical standards and business rules.

[4] Multi-CBDC/mCBDC arrangements is a set of functional, infrastructural and governance solutions to link the national digital currency systems of central banks, either by ensuring interoperability between systems, or by interlinking such systems or by creating a common system of cross-border multi-currency payments.

[5] Committee on Payments and Market Infrastructures (CPMI). Enhancing Cross-border Payments. Building Blocks of a Global Roadmap. Stage 2 report to the G20. July, 2020. URL: https://www.bis.org/cpmi/publ/d193.pdf (accessed on 08.10.2023).

[6] This could include improving the functionality of correspondent banking systems, modifying traditional real-time gross settlement systems, adapting fast payment systems for cross-border use, etc. [2].

[7] CBDC compatibility criteria may include: 1) the existence of unified rules and governance arrangements; 2) the use of harmonized identification schemes; 3) the application of a common infrastructure; 4) the availability of single ledger or interconnected transaction ledgers, etc.

The paper examines the potential of cross-border payments using mCBDC arrangements implemented on the basis of different interoperability models. The study identifies the main challenges of modern cross-border settlements and identifies possible risks associated with the introduction of mCBDCs. The paper identifies the features of different models of mCBDCs and defines the possibilities of use to solve contemporary problems of cross-border settlements, indicates the prospects of the use of mCBDCs in international payments.

MAIN PROBLEMS OF CROSS-BORDER PAYMENTS AND RISKS OF USING mCBDCs

Cross-border, multi-currency, payments are more complex than domestic payments in national currencies. Settlement in different currencies adds to risks and costs [10]. Currently, most cross-border settlements are based on correspondent bank accounts and real-time gross settlement (RTGS) systems, which use the exchange of financial communications in the Society for Worldwide Interbank Financial Telecommunications (SWIFT) system and the international currency conversion system (Continuous Linked Settlement, CLS). Traditional cross-border banking and SWIFT/CLS settlements involve a large number of financial intermediaries and require the use of payment standards agreed between multiple jurisdictions, including at the level of private banks (PBs) and non-bank financial institutions (NBFIs). These and other infrastructural, technological and functional factors lead to the low speed and high cost of cross-border settlements.[8]

The following challenges of modern cross-border settlements can be identified, which can be addressed by the creation of mCBDCs:

1) fragmented data formats and the absence of single harmonized payment standards (technical and operational);

2) complex and differentiated compliance procedures in different jurisdictions;

3) limited working hours and discrepancies between operating hours of RTGS systems and banks in different jurisdictions and time zones;

4) long chains of transactions and high costs of processing payments;

5) the absence of a standardized payment status notification capability in the common payment messaging network used by banks;

6) outdated payment infrastructure in the networks of CBs and PBs;

7) low competition.

One of the key advantages of central bank digital currency systems over efforts to improve existing payment systems and infrastructures is the ability to start from the "clean slate".[9] Thus, central banks must take into account the need for cross-border use when designing and developing their national digital currency systems. This means that the central bank should work to harmonize

[8] Currently, the average speed of cross-border transfers using the Swift system (the period between sending the payment message and making the settlement) can take up to 3–5 days. This period is determined as follows: (0.5–1 day for the processing of the communication × 2–3 of the intermediary bank) + (1–2 days of delay due to temporary discrepancies in different jurisdictions). Although the costs associated with wholesale payments are difficult to measure (nostro-vista liquidity costs, treasury transactions, currency exchange, compliance procedures, etc.), as they vary greatly depending on the bank, jurisdiction, amount of payment, etc., the average global cost of sending money transfers today is 6.3% of the amount [World Bank (WB). Remittance Prices Worldwide Quarterly: An Analysis of Trends in Cost of Remittance Services. Issue 43. September, 2022. URL: https://remittanceprices.worldbank.org/sites/default/files/rpw_main_report_and_annex_q322_final.pdf (accessed on 10.10.2023)].

[9] For example, the possibility of starting with the "clean slate" has allowed a number of countries to skip through some evolutionary stages in the development of payment systems (the stage of check payments— South Korea, Russia and others, and/or card payments — China, some countries of Africa) and immediately move to the introduction of more technologically advanced payment solutions — mobile payments and/ or fast payments using QR-codes. The possibility of building a system of digital currencies based on new technological standards and infrastructure solutions while reaching international agreements between the central banks implemented in the mCBDC arrangements, including on financial risk management, could in the long-term lead to a qualitative change in the global landscape of cross-border payments. At the same time, the implementation of this possibility involves high initial costs and may take a lot of time and effort to harmonize joint standards and management solutions.

standards and coordinate its national digital currency projects to ensure their functional compatibility [11].[10] Such coordination is not possible without the exchange of information and transparency between the central banks on the projects of their national CBDC systems, which will contribute to a better understanding of which of the new information technologies can be used in the development of the mCBDC arrangements.

The mCBDC arrangements designed to address the infrastructure, technology and functional challenges of modern cross-border payment systems could potentially counteract their major disadvantages. This can be achieved through the use of unified governance methods, mutually recognized identification schemes, a common infrastructure, new accounting technologies, etc. But, at the same time, the use of central bank digital currencies in cross-border payments also involves new risks.

Current research shows that the international use of central bank digital currencies involves monetary and macroeconomic policy risks. One of the main problems with using mCBDCs, especially in emerging markets, is "digital dollarization"[11] [12], or the risk that the use of foreign central bank digital currency could become a widespread phenomenon, supplanting national currency in payments and other financial transactions within the country. At the same time, households facing domestic economic instability or high rates of inflation and depreciation of national currencies may view foreign digital currency or global stablecoins as a convenient means of payment and a reliable means of saving [13].[12] Thus the trend of "digital dollarization" could have destabilizing effects on national economies. Personally, this problem may be relevant for token-based central bank digital currency systems [14]. The negative effects "digital dollarization" could be minimized by introducing new regulatory constraints.[13]

Another important problem is the possibility of using foreign central bank digital currency to evade taxation in national jurisdiction and reduce oversight of the national monetary system and financial markets. This is possible if national monetary regulators have insufficient information about residents' holdings and transactions with international digital currencies. A significant problem is also the possible volatility of exchange rates, which becomes important when funds flow between the national and foreign central bank digital currencies are unmanageable. As a result, the use of mCBDCs could complicate macroeconomic regulation for the central bank issuing the digital currency. Moreover, mCBDCs can enhance the international "spillover effects" of economic and financial shocks, although the flexible configuration of the design elements of the digital currency system can be applied to mitigate the negative effects of such effects [15].

In 2021, BIS invited the world's leading central banks to analyze the significance of the various risks associated with cross-

[10] In the first phase, harmonization of standards is advisable for countries with high levels of mutual export-import transactions that are interested in improving the efficiency of wholesale trade financing settlements. Such countries should be at a level of development comparable to the national CBDCs. In the second phase, countries interested in promoting trade relations with new partners and improving the efficiency of cross-border payments, including in the retail sector, can join the mCBDC projects. To this end, the design of national wCBDC and rCBDC systems can be improved over time for cross-border use. More details see: [11].

[11] For more information on the current role of the US dollar and other currencies in international settlements: [12].

[12] International Monetary Fund (IMF). Digital Money Across Borders: Macro-Financial Implications, IMF Policy Papers, no 2020/050. 2020. URL: https://www.imf.org/-/media/Files/Publications/PP/2020/English/PPEA2020050.ashx (accessed on 01.10.2023).

[13] In the case of cash use, the need for physical transportation of funds across borders allows to limit the influx of foreign currency. Furthermore, the physical wear and tear of banknotes means that foreign cash can be used only a limited number of times in payments before they are replaced. On the contrary, the use of digital money is not limited to the territory. Digital money doesn't wear out. So, for example, the widespread use of US payment services applications in Venezuela illustrates the threat of dollarization in digital payment systems.

border CBDCs adoption. The responses revealed that the central bank has listed facilitating tax evasion and complicating supervision of the national monetary system as important concerns [16]. Other concerns of the central bank highlighted the risks of exchange-rate volatility and bypass of AML/CFT procedures, cyber-risk, as well as the risk of using foreign central bank digital currencies or global stablecoins as the dominant means of payment in the internal market. Some of these risks are closely linked to digital dollarization.[14]

One way to avoid national currency confusion is to supplement the monitoring and development of digital currency cash flow management, but this functionality must be carefully matched to the fundamental characteristics of a virtual currency, which are convenience, flexibility, and confidentiality of use.[15] In principle, at a technical level, digital currencies can be designed to prevent their use outside national jurisdiction [6, 7]. However, in this case, potential of CBDCs to increase the efficiency of international settlements, will be much more difficult to realize.

Central bank responses also showed that there are currently no restrictions in most countries on the use of foreign currencies for domestic transactions. Only 26% of respondents noted such restrictions, while another 8% chose not to respond. It is worth noting that one-third of the central banks surveyed (more than 30%) claimed they would reconsider existing currency restrictions if foreign digital currencies become widely used in their jurisdictions [16].

It should be noted that the various concerns of the central bank are correlated. The greater the concerns about tax evasion and the complexity of supervision of the national monetary system and financial market, the greater is the concern about unwanted exchange rate volatility. Similarly, concerns about supervisory complexity and unwanted exchange-rate volatility are significantly correlated with concerns regarding the use of national CBDCs abroad. Thus, central banks are currently concerned about virtually every risk of cross-border use of central bank digital currencies.[16]

The risks mentioned above are not insurmountable. The customizable design elements of CBDCs enable countries to protect monetary sovereignty,[17] by making cross-border and cross-currency payments easier, eliminating the need to maintain foreign currency balances and assisting the central bank in monitoring transactions. In central banking digital currency systems, CBs will maintain control and oversight of cross-border use of digital currencies on the basis of user-identifying accounts. The full integration of national CBDCs into the single multi-currency mCBDC system could help make national currency replacement less common in both developed and emerging economies through a convenient and simple mechanism for cross-border multi-currency and/or cross-current

[14] For a macroeconomic review of the impact of CBDCs on cross-border payments: [International Monetary Fund (IMF). Digital Money Across Borders: Macro-Financial Implications, IMF Policy Papers, no 2020/050. 2020. URL: https://www.imf.org/-/media/Files/Publications/PP/2020/English/PPEA2020050.ashx (accessed on 01.05.2023); IMF. The Rise of Public and Private Digital Money — A Strategy to Continue Delivering on the IMF.s Mandate. Policy paper, no. 2021/055. July, 2021. URL: https://www.imf.org/-/media/Files/Publications/PP/2021/English/PPEA2021055.ashx (accessed on 04.10.2023)], a for a more detailed study of the international effects of digital dollarization: [14].

[15] The extent of possible replacement of the national currency in the context of the CBDC issue will also be influenced by the various functional and technological solutions embedded in the design of the digital currency — the operational role of the central bank, the infrastructure used, the ways of controlling access to digital currencies, etc.

[16] While most central banks mainly focus on the function of digital currencies as a means of payment, CBDCs are capable of performing all monetary functions. Thus, CBDCs can be stored in the digital wallets of users or in the central bank accounts, and they have no restrictions on destinations and time of use. In some cases, central banks may charge interest on digital currency balances to develop additional monetary policy tools.

[17] For example, access options and limits for the use of digital currency for non-residents or outside national jurisdiction can be set. At present, it is precisely the use of multi-currency or cross currency agreements in the mCBDC arrangements, rather than single currency arrangements.

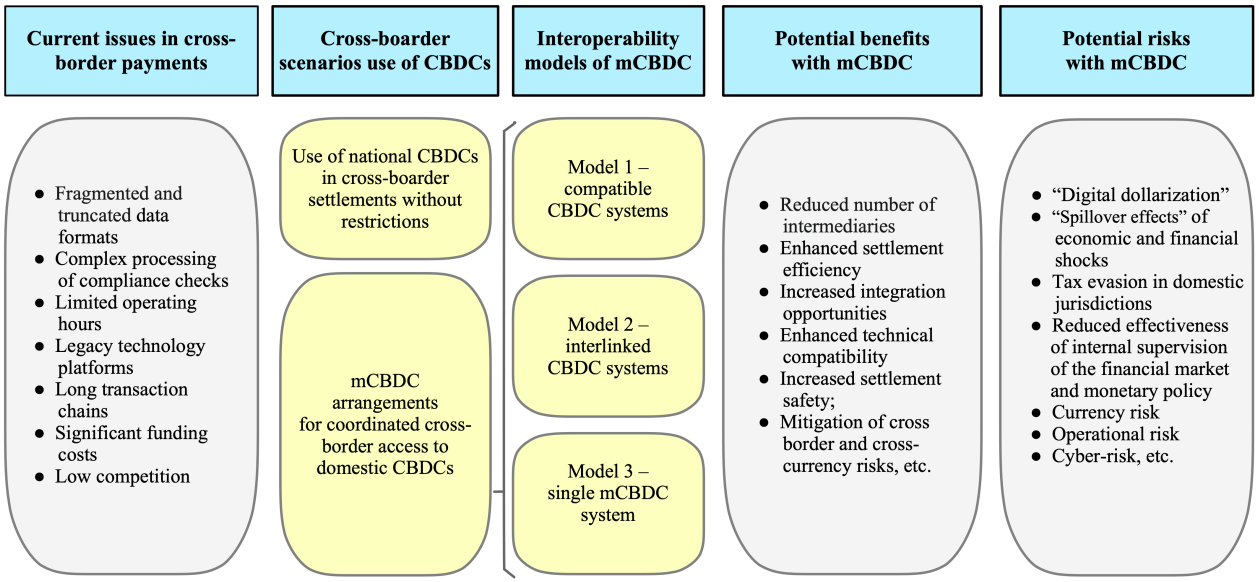

Fig. 1. **The Potential to Enhance Cross-Border Payments with mCBDCs**

Source: Compiled by the author based CPMI, BIS Innovation Hub (BISIH), IMF, World Bank (WB). Central Bank Digital Currencies for Cross-Border Payments. Report to the G20. July, 2021, p. 4. URL: https://www.bis.org/publ/othp38.pdf (accessed on 05.10.2023). CPMI, BISIH, IMF, WB. Options for Access to and Interoperability of CBDCs for Cross-border Payments. Report to the G20. July, 2022, p. 19–23. URL: https://www.bis.org/publ/othp52.pdf (accessed on 08.10.2023).

payments. The continuous operation of the mCBDC arrangements can provide cheap and fast conversion, reducing the need for foreign currency storage [17]. Even if foreign digital currencies were to hold on to economic agents to avoid economic instability or high inflation within a separate jurisdiction, a flexible convertible domestic currency could still provide domestic use of a national unit of exchange for purchasing goods and services. Current research shows that in an optimized model, if banks are allowed to work with foreign CBDCs, the introduction of central banking digital currency may facilitate competition for deposits between foreign CBs and PBs. Foreign digital currency can become an attractive asset, especially if it is issued by trusted foreign central banks and/or interest will be paid on the balances of digital currencies [18].

Fig. 1 summarizes current problems of international payments with cross-border use scenarios of CBDCs, core models of mCBDCs and their potential benefits and risks.

According to *Fig. 1*, all interoperability models of mCBDC have the potential to improve the efficiency of cross-border payments. At the same time, the possible advantages and risks of using CBDCs in cross-border calculations will depend on the choice of a particular interoperability model and the option of interlinking between CBs implemented in the mCBDC arrangements. It is expected that the least effect will be achieved in the compatible CBDC model, the greatest in the single system mCBDC model. This will depend on the different levels of integration of the national CBDC systems, as well as on the scale effect and network effects.

mCBDC ARRANGEMENTS AND INTEROPERABILITY MODELS

In recent years, repeated attempts have been made to explore digital currency system operating models for both retail[18] [19, 20] and wholesale payments, including

[18] BIS. CBDCs: An Opportunity for the Monetary System. BIS Annual Economic Report 2021. June, 2021. P. 65–92. URL: https://www.bis.org/publ/arpdf/ar2021e.pdf (accessed on 10.10.2023).

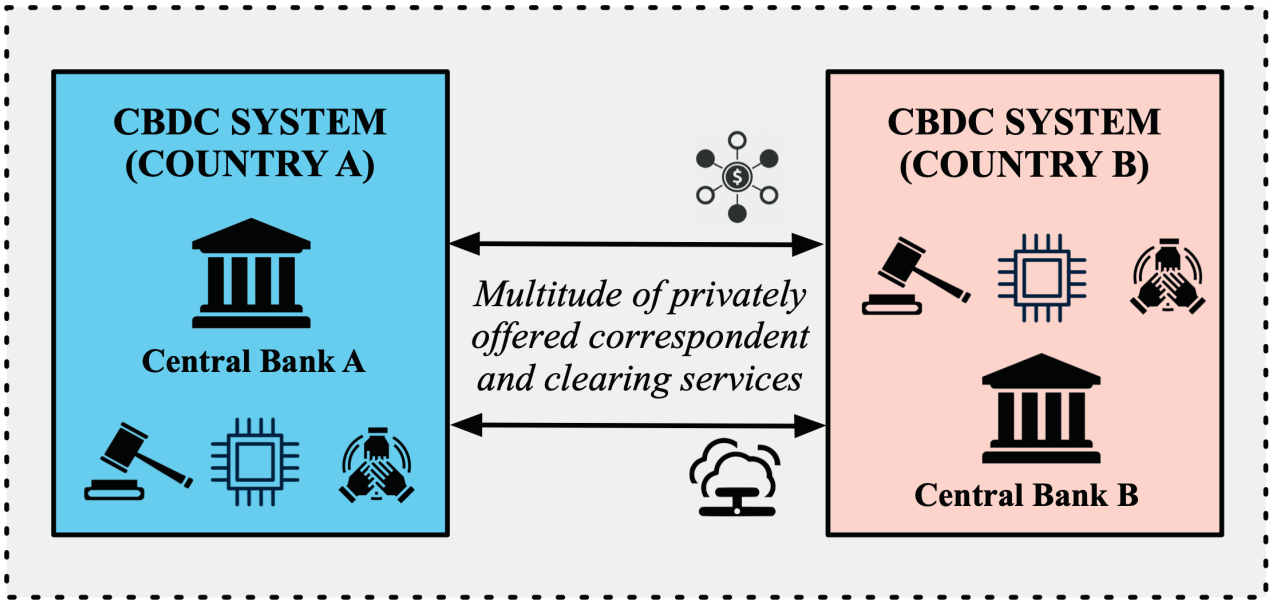

Fig. 2. **mCBDC Model 1**

Источник / Source: Compiled by the author based on [1, p. 4].
Note: 1) compatible technical and regulatory standards are used; 2) coordinated identification schemes are applied. Symbol value: – technical infrastructure; – participation criteria; – rulebook and governance arrangements; – clearing services; – correspondent services; – payment system; – payment arrangement.

their application to cross-border payments [21, 22]. Currently, three main models of interoperability implemented in the mCBDC arrangements can be identified: 1) the model of compatible CBDC systems (model 1); 2) the model of interlinked CBDC systems (model 2); and 3) the model of single mCBDC system (model 3). Conceptual illustrations of these models are presented in *Fig. 2, 3, 7*.

mCBDC Model 1 (model of compatible CBDC systems). This model provides for the interoperability of national CBDC systems through compliance with common international standards and resembles a modified version of traditional cross-border payment schemes based on correspondence relationships (*Fig. 2*).

According to *Fig. 2*, the use of common technical standards (financial communication formats, cryptographic methods, data protection algorithms, user interfaces, etc.) reduces the operational burden on financial institutions in different jurisdictions. At the same time, harmonized legal, regulatory and supervisory standards can simplify AML/CFT procedures processes and transaction monitoring. However, without coordinated policy decisions between countries, achieving a high degree of compatibility between national digital currency systems can take a long time. Current experience shows that it takes many years for international payment and financial market participants to coordinate their actions with regard to the use of common financial communications standards (e.g. ISO 20022) or to harmonize the legal framework for their application. Legal and regulatory compatibility is often seen as the biggest source of friction for cross-border payments by banks and payment service providers.[19]

mCBDC Model 2 (model of interlinked CBDC systems) proposes increased interlinking between national CBDCs, either

[19] BIS. Cross-Border Retail Payments. Committee on Payments and Market Infrastructures, February. 2018. URL: https://www.bis.org/cpmi/publ/d173.pdf (accessed on 01.10.2023). Committee on Payments and Market Infrastructures (CPMI). Enhancing Cross-border Payments. Building Blocks of a Global Roadmap. Stage 2 report to the G20. July, 2020. URL: https://www.bis.org/cpmi/publ/d193.pdf (accessed on 05.10.2023).

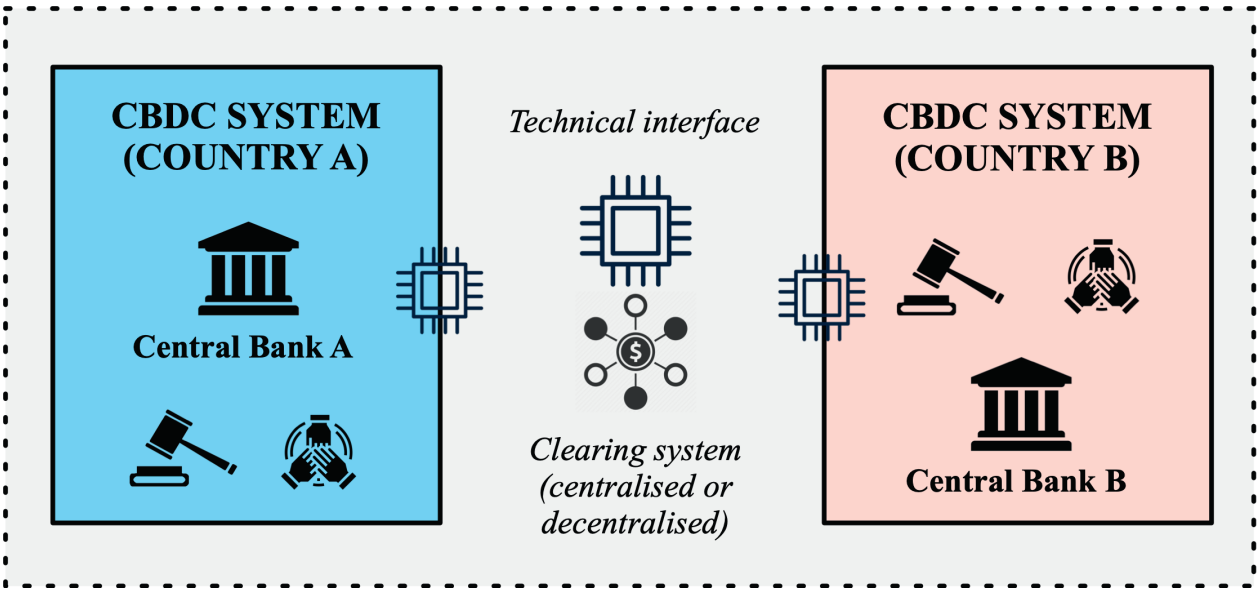

Fig. 3. **mCBDC Model 2**

Source: Compiled by the author based on [1, p. 6].

Note: 1) 1) interlinking between national CBDCs is achieved through shared technical interface or by use of (centralized or decentralized) clearing mechanism; 2) participants join interlinking arrangements; 3) separate rulebook and governance, participation criteria and infrastructure are used. Symbol value: – technical infrastructure; – participation criteria; – rulebook and governance arrangements; – clearing services; – correspondent services; – payment system; – payment arrangement.

through the use of a shared technical interface or the implementation of a single clearing mechanism (*Fig. 3*).

According to *Fig. 3*, the common technical interface, implemented through arrangements between the operators of the national CBDC systems, allows members of one system (both retail and wholesale) to make payments to members of another CBDC system. This approach was tested in the Stella project between the European Central Bank (ECB) and the Bank of Japan.[20]

On the contrary, the common clearing mechanism connects the national CBDC systems either through decentralized mutual accounts or through a centralized joint clearing agent or system. In the first case, central banks have payments accounts with each other.[21] In the second case, the common interlinking system debits and credits national accounts central bank.[22] For mCBDCs, the agreement could provide for a built-in currency exchange mechanism provided by either a central bank or a private payment service provider. National central banks could also allow foreign central banks to keep their digital currencies on their balance sheet and vice versa, acting as correspondents for their national distributors or end-users.[23] With a more centralized approach, a trusted payment intermediary could be used for clearing among the central banks participating in the mCBDC arrangements [1].[24]

There are three main options for implementing connecting in the model of

[20] European Central Bank (ECB), Bank of Japan (BoJ). STELLA — Synchronized Cross-Border Payments. June, 2019. URL: https://www.ecb.europa.eu/paym/intro/publications/pdf/ecb.miptopical190604.en.pdf (accessed on 01.10.2023).

[21] For example, the East African Cross-border Gross Payments System of EAPS.

[22] For example, the European System of International Payments for Transfers of Large Amounts of TARGET.

[23] See details: Bank of Canada (BoC), Bank of England (BoE), Monetary Authority of Singapore (MAS). Cross-border Interbank payments and settlements", November. 2018. URL: https://www.bankofengland.co.uk/-/media/boe/files/report/2018/cross-border-interbank-payments-and-settlements.pdf (accessed on 08.10.2023).

[24] Currently, the central banks provide that the exchange procedure will depend on the interoperability model implemented, as well as on who is the operator of the mCBDC platform, what functions are delegated the central bank to payment service providers (PSPs) etc. In most countries, PSPs are either CBs or NBFIs.

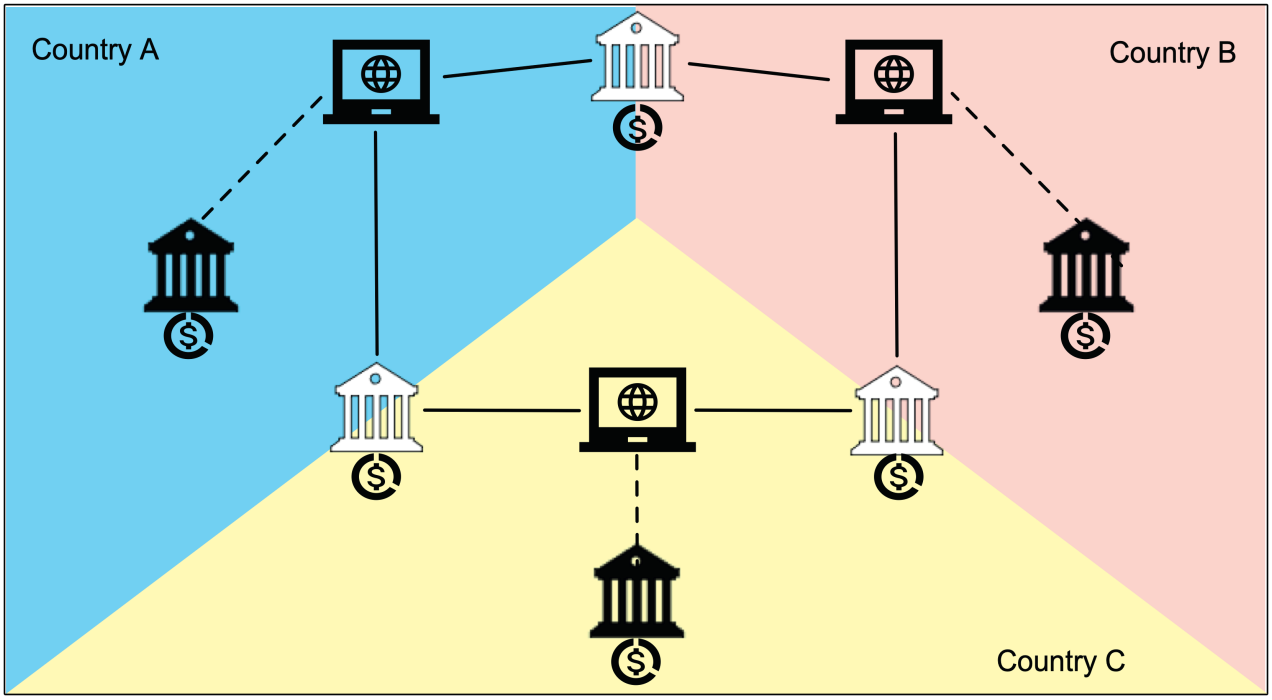

Fig. 4. **mCBDC Model 2 (Single Access Points Option)**
Source: Compiled by the author based on CPMI, BISIH, IMF, WB. Options for Access to and Interoperability of CBDCs for Cross-border Payments. Report to the G20. July, 2022, p. 17. URL: https://www.bis.org/publ/othp52.pdf (accessed on 10.10.2023).
Note: 1) CBDC systems are indirectly linked via a single "gateway"; 2) "gateway" acts as a single access point for all participants of the respective CBDC systems; 3) currency exchange (FX) can take place at "gateway" or PSPs. Symbol value: – country A; – country B; – country C; —— – interlinking arrangement; – – – – payment service provider (PSP) access to CBDC system; – PSP; – "gateway" linking CBDC systems; – CBDC system; – currency conversion.

interlinked national digital currency systems (*Fig. 4–6*). *Fig. 4* presents the first version of the model of interlinked national CBDCs using single access points.

According to *Fig. 4*, when interlinking with individual access points, members of one CBDC system have access to another system through single "gateways" that PSPs can act as. Such provider function as a single bank correspondent for all participants in both CBDC connected systems. This version of the interlinked national digital currency systems model differs from the model of compatible national CBDCs in that such single access points are a formalized part of the agreement to use CBDCs and act as "gateways" for all participants in such a system.

Fig. 5 presents the second version of the model of interlinked national CBDCs through bilateral interlinking.

As shown in *Fig. 5*, in bilateral interlinking, two separate CBDC systems are directly linked to each other, allowing members of one system to directly settle with members of another system [23].[25]

The third variant of the model of interlinked national CBDCs is implemented on the basis of a star-shaped network or the so-called network "hub and spoke" (*Fig. 6*).

As shown in *Fig. 6*, in star-shaped network interlinking, the common hub connects two or more separate CBDC systems from the participating jurisdictions through branched information channels. The hub can be both a stand-alone payment system and simply act as a payment intermediary [23].[26]

Although, as we have shown above, there are different ways to implement interlinking between national CBDCs, none of them are

[25] Interlinking with bilateral connection was implemented in the Jasper-Ubin project.
[26] Interlinking on the basis of "hub and spoke" network was implemented in the modern Icebreaker project.

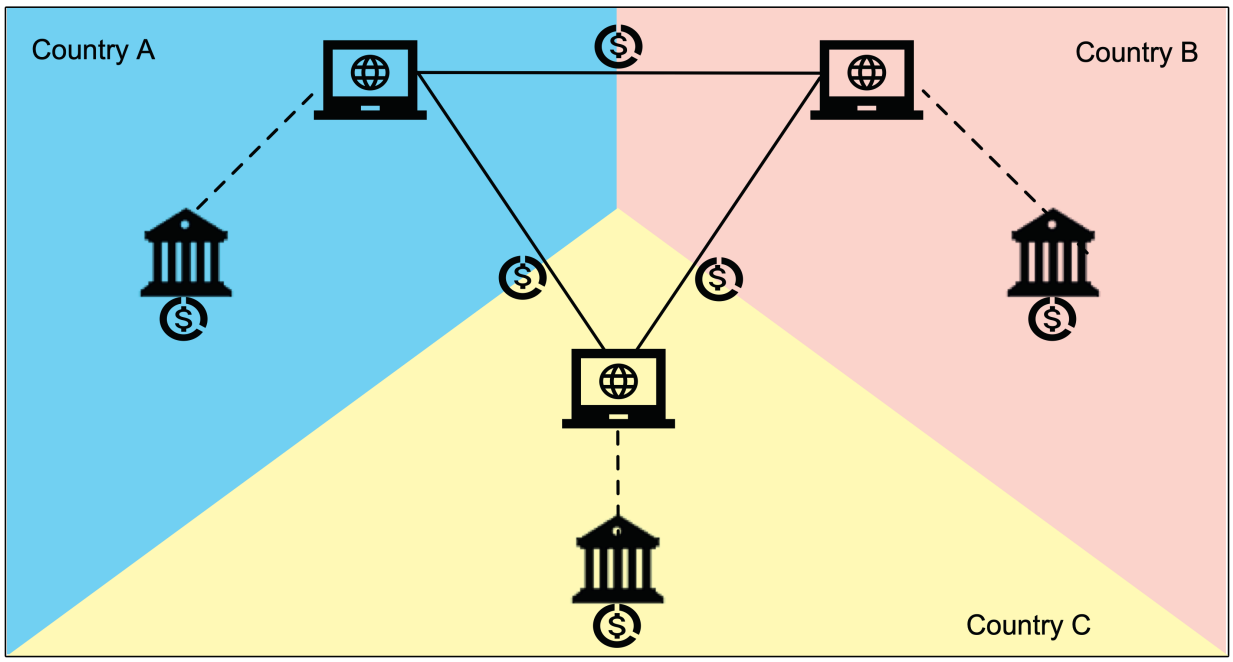

Fig. 5. **mCBDC Model 2 (Bilateral Links Option)**
Source: Compiled by the author based on CPMI, BISIH, IMF, WB. Options for Access to and Interoperability of CBDCs for Cross-border Payments. Report to the G20. July, 2022, p. 17. URL: https://www.bis.org/publ/othp52.pdf (accessed on 01.05.2023).
Note: 1) CBDC systems are directly linked by technical and contractual agreements; 2) participants in one system can directly transact with participants in the other; 3) currency exchange (FX) can take place at the PSPs or interlinking arrangement. Symbol value: – country A; – country B; – country C; ——— – interlinking arrangement; – – – – payment service provider (PSP) access to CBDC system; – PSP; – CBDC system; – currency conversion.

easy to implement.[27] Empirical experience shows that many projects do not yield the expected benefits or even do not reach the operational stage, despite significant investments.[28] The maim barriers are variances in national legislation, as well as differences in financial market organizational structure, business practices, and technical standards.

Nevertheless, the first wave experiments of wCBDCs for cross-border settlement, such as Jasper-Ubin, Stella, and others, as well as the second wave projects of rCBDC such as Icebreaker, have demonstrated the technical feasibility of transboundary settlement through the interlinking of national CBDCs. At the same time, implementation of any variant of the model of interlinked CBDC systems requires not only a more scalable, secure and flexible operating infrastructure than exists in settlement systems today, but also coordination of the efforts of all stakeholders and participants of the mCBDCs to realize the benefits of this model.

mCBDC Model 3 (single mCBDC system). This model assumes the highest level of collaboration among national central banks, allowing the integration of national CBDC systems into a single mCBDC. In other words, the agreements between the central banks enable the creation of a single multi-currency mCBDC system operating in different jurisdictions. The digital forms of the national fiat currencies of all participating countries can be used in such calculations (*Fig. 7*). This model is sometimes referred to as the integration model of a multi-currency digital currency system.

[27] See details: CPMI. Interlinking Payment Systems and the Role of Application Programming Interfaces: A Framework for Cross-Border Payments. Report to the G20. July, 2022. URL: https://www.bis.org/cpmi/publ/d205.pdf (accessed on 05.10.2023).

[28] World Bank. Guidelines for the Successful Regional Integration of Financial Infrastructures. January, 2014. URL: https://openknowledge.worldbank.org/entities/publication/05ce10a4–09ff-5baf-b9d8–1d53eb8d5911 (accessed on 07.10.2023).

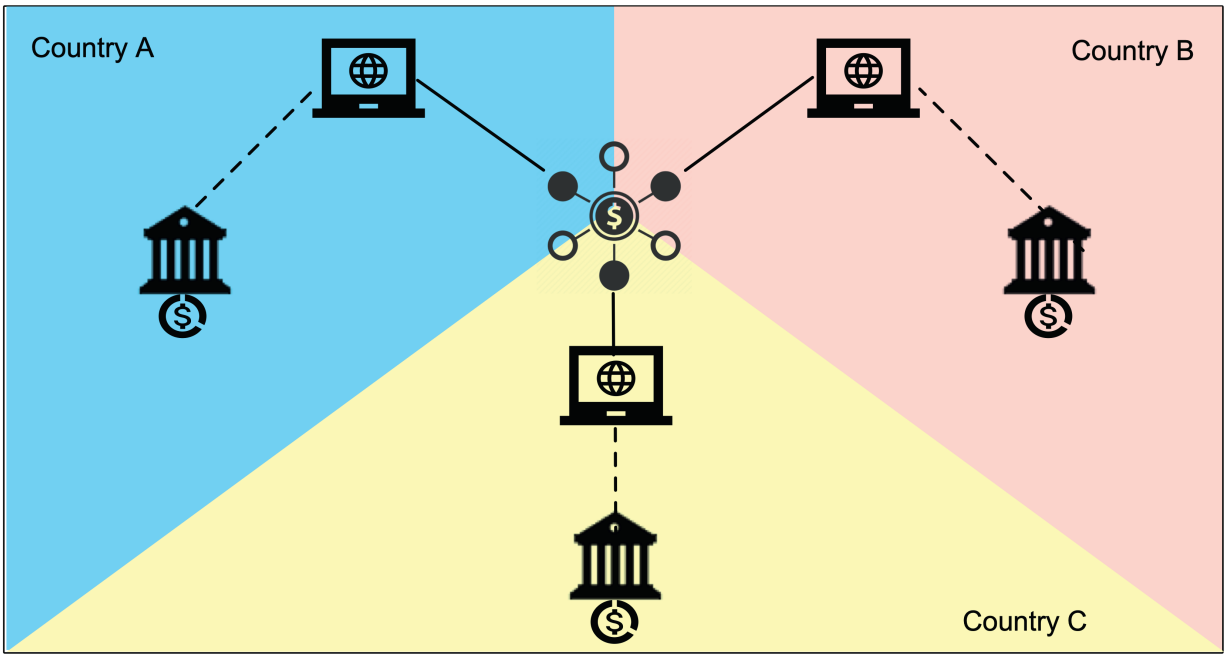

Fig. 6. **mCBDC Model 2 (Hub and Spoke Option)**
Source: compiled by the author based on CPMI, BISIH, IMF, WB. Options for Access to and Interoperability of CBDCs for Cross-border Payments. Report to the G20. July, 2022, p. 17. URL: https://www.bis.org/publ/othp52.pdf (accessed on 01.10.2023).
Note: 1) common hub connects separate CBDC systems of participating jurisdictions; 2) currency exchange (FX) can take place at the PSPs or interlinking provided by the hub. Symbol value: — country A; — country B; — country C; ——— — interlinking arrangement; – – – – payment service provider (PSP) access to CBDC system; — PSP; — CBDC system; — currency conversion; — hub linking CBDC systems.

As shown in *Fig. 7*, the model of a single (integrated) multi-currency system mCBDC is based on availability: 1) a single set of rules and governance arrangements, 2) the use of mutually recognize identification schemes; and 3) implementation of a single infrastructure and a transaction ledger. Moreover, deep integration provides potential for greater operational functionality and efficiency, but also improve the role of governance and control arrangements, as well as dependency on political geopolitical factors.

The single multi-currency mCBDC systems can be constructively significantly different not only from traditional payment systems, but also from each other depending on the scenarios of their use. For example, retail-oriented mCBDC systems may specialize in carrying out more transactions with lower amounts and a wider range of participants. By contrast, wholesale-focused mCBDC systems can focus on higher transaction amounts, faster settlements and a limited number of participants.

The model of single mCBDC system raises a number of policy issues for the central bank. One such issue is the development of common approaches to the joint management and management of the single mCBDC system. Another important issue is the consequences of releasing CBDCs for monetary policy, financial stability and payment systems, which must be elaborated for each central bank and may require compromise in the final design. For example, central banks should assess the extent to which they are prepared to renounce independent system control and operational monitoring in a single mCBDC system and to agree on common governance arrangements in such a system. In addition, Central banks should take into account geopolitical factors, in particular, decide how ready they are to platform integration with the national currencies of countries subject to financial and/or trade sanctions. In most cases, this factor may be of paramount importance

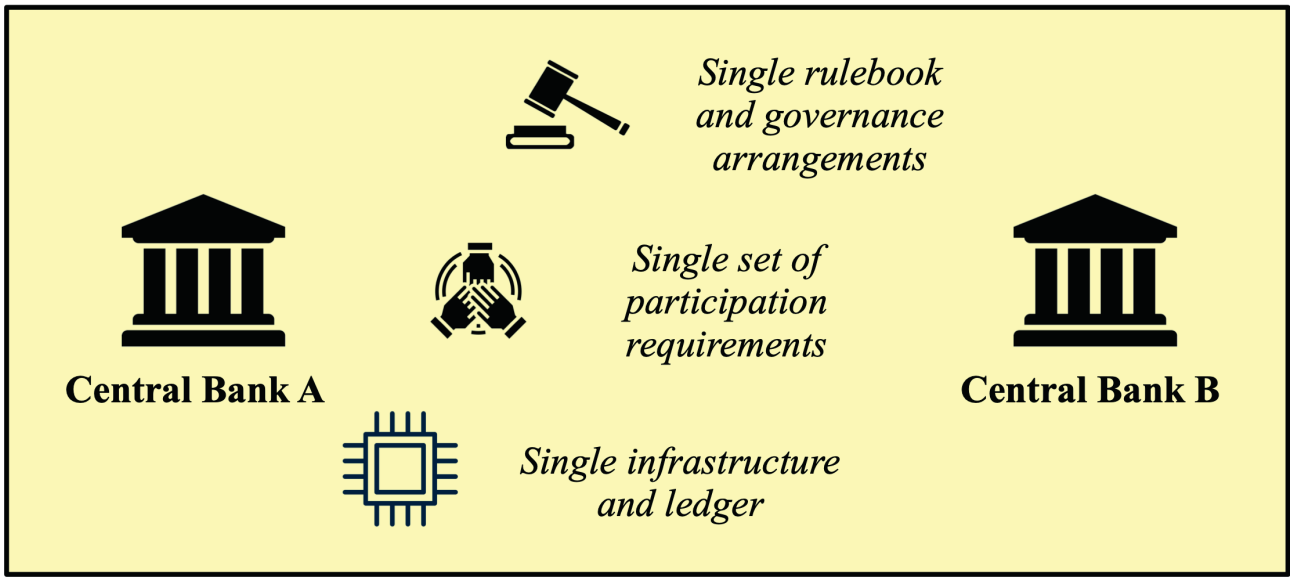

Fig. 7. **mCBDC Model 3**
Source: составлено автором по [1, p. 7] / Compiled by the author based on [1, p. 7].
Note: 1) multiple CBDCs run on a single platform; 2) central banks follow the single set of participation requirements including mutually recognise identification schemes; 3) central banks implement single infrastructure and a transaction ledger. Symbol value: – technical infrastructure; – participation criteria; – rulebook and governance arrangements; – payment system.

in determining the membership of the single mCBDC system..

EFFICIENCY IMPROVEMENT OPPORTUNITIES OF CROSS-BOARDER PAYMENTS WITH mCBDCs ARRANGEMENTS

Each of the interoperability models implemented in the mCBDC arrangements provides different ways of addressing the current problems of cross-border payments. *Table 1* summarizes these problems and outlines ways to improve them through the introduction of mCBDCs.

Thus, in the model of interlinked national CBDC systems, the creation of open, competitive and compatible domestic payment systems can allow different PBs and NBFIs to make central bank settlements. This appears to contribute to a better balance of fragmentation and concentration in payments than exists in current national and international calculations. Furthermore, this model provides relatively low investment and operational costs compared to other mCBDC models.

The model of interlinked national CBDC systems can provide a higher level of security for cross-border settlements than existing payment systems. In particular, payment vs payment (PvP)[29] calculations can be carried out through a technical interface between national CBDC systems. Common clearing mechanisms (centralized or decentralized) may also potentially improve payment efficiency, especially when they relate to currency exchange sites. This model entails relatively low investment and operating costs, which will depend on the option of its implementation (the lowest in the case of individual access points; the highest for a "hub and spoke" network).

The model of single multi-currency mCBDC system may offer the same improvements as the model of interlinked national digital currency systems, but with additional integration. For example, all currency

[29] "Payment vs payment" (PvP) is a settlement mechanism in which the final transfer of funds in one currency will only take place when the definitive transfer of money in another currency/currencies takes place.

settlements can be made on a PvP basis and do not require routing or calculation instructions. Exchange platforms can also be integrated with mCBDC arrangements on a platform-based basis, which can reduce fragmentation and concentration in foreign exchange markets.[30, 31] At the same time, compared to others, this model entails the highest investment and operating costs and the development of more complex governance arrangements, technical standards, legal and regulatory frameworks.

An important issue in the design and implementation of the mCBDC arrangements is access to the national central bank digital systems (primarily wCBDCs) of foreign PSPs. National central banks must decide whether and how foreign PSPs can access their national digital currency. In general, there are three options for such access:

1) closed access implies that only national PSPs can access, store and use digital currency. In this option, the central bank issue a digital currency to participators implemented in the CBDC system when they receive reserves from the payment service provider to their settlement accounts. Although foreign PSPs are not directly or indirectly involved in the national CBDC system in this case, the digital currency can be used in cross-border settlements through the interoperability mechanisms discussed above (in the framework of the first and second mCBDC models); [32]

2) indirect access means that foreign PSPs can access the national CBDC system (wCBDC or rCBDC) through an intermediary. Indirect access to CBDC system, similar to accelerated access in traditional payment systems, can take various forms. First form of indirect access — foreign PSPs rely on a direct (national) PSP for sending payment orders, clearing and settlements. In this case, the national payment service provider performs transactions in the CBDC ledger on behalf of the foreign PSP. The second form of indirect access is that foreign PSPs are allowed to own and make transactions directly with wCBDCs or rCBDCs. Nonetheless, foreign payment service providers will still have to rely on the national PSP to record and process transactions; [33]

3) direct access implies that foreign PSPs that meet the access criteria can directly own and conduct transactions with wCBDCs or rCBDCs issued by national central banks without intermediaries.[34] This option requires mutual agreement between national and foreign central banks on oversight of foreign PSPs by their national regulators.[35, 36]

[30] For example, the following currency exchange options can be implemented on a platform basis: 1) the mCBDC platform can automatically match PvP transactions to the highest available exchange rate on the FX Board and ensure that currency conversion operations are executed at the agreed rate; 2) the platform can provide direct currency quotations through the quotation request mechanism (RFQ), which also ensures that currency exchange is performed at the agreed rate; 3) mCBDC platform can accept exchange rates agreed on a bilateral basis outside the platform (on the basis of autonomous agreements) etc. See details: Bank of Thailand (BoT), Hong Kong Monetary Authority (HKMA). Inthanon-LionRock — Leveraging Distributed Ledger Technology to Increase Efficiency in Cross-Border Payments. 2020. URL: https://www.hkma.gov.hk/media/eng/doc/key-functions/financial-infrastructure/Report_on_Project _Inthanon-LionRock.pdf (accessed on 10.10.2023).

[31] A survey conducted by BIS in 2021 among leading central banks showed that more than a quarter (28%) of central banks included interoperability in their CBDC designs to reduce friction in cross-border and cross-currency settlements. The most preferred choice for a large proportion of banks (22%) was the mCBDC model, in which the national CBDC system are interlinked with the foreign CBDC systems. Some central banks have also considered taking a supervisory role in the exchange process in the CBDC system [16]. To learn more about how cross-exchanges in different currencies increase risks and costs in modern payment systems: Bank of Canada (BoC), MAS. Enabling Cross-Border High Value Transfer Using Distributed Ledger Technologies. Jasper — Ubin Design Paper. May, 2019. URL: https://www.mas.gov.sg/-/media/Jasper-Ubin-Design-Paper.pdf?la=en (accessed on 05.10.2023).

[32] For example, in projects Jasper-Ubin, HSBC and etc., was used closed access option.

[33] The Dunbar project is an example of wCBDC system, in which uses indirect access option.

[34] Even if foreign PSPs are given direct access to national digital currencies, national central banks can restrict CBDC issuance only to national PSPs. In this case, the foreign PSP will have to buy the national digital currency on the secondary market from the national payment providers.

[35] This variant of access has been implemented in mBridge, Jura and others projects.

[36] CPMI. Interlinking Payment Systems and the Role of Application Programming Interfaces: A Framework for Cross-Border Payments. Report to the G20. July, 2022. URL: https://www.bis.org/cpmi/publ/d205.pdf (accessed on 01.10.2023).

Table

Potential Improvements of Cross-Border Payments Through Implementation mCBDCs

Problems in existing correspondent bank agreements for cross border payments	Potential improvements		
	mCBDC arrangement based on compatible CBDC systems	mCBDC arrangement based on interlinked CBDC systems	Single multi-currency mCBDC system
Operational costs to sustain cross-border banking relations	Compatible systems enhance the effectiveness of existing international banking relations	A common clearing mechanism can reduce the number of interconnections and provide economies of scale	A single system does not require such relationships (although such a system can increase operational costs)
Mismatch of opening times across different time zones	All CBDC arrangements provide 24/7 operation, eliminating any mismatch of opening times		
Non-compliance of communication standards	Compatible financial message standards enable payments to flow without data loss between countries	The use of the international message standard adopted by the interlinkage arrangements would act to harmonies standards between involved domestic CBDC systems	Single financial message standard in the mCBDC system eliminates any mismatches and the need for different system standards
Non-transparency FX rates and unclear commission fees	Compatibility requirements for digital wallet providers allow users to predeterminate the amount of fees and rates before making a payment	Common procedure for calculating rates and fees for transfers using any interlinking systems will contribute to greater transparency FX rates	Single rules for currency exchange and commission settlement eliminate uncertainty regarding exchange rates and commission sees
Limited transparency of payment status	In all CBDC arrangements the settlement can be done almost instantly, reducing the need for periodic payment status updates		
High costs of compliance across borders standards	Compatible compliance regimes reduce uncertainty and costs	Interlinking systems do not impact multiple compliance requirements	A single set of access requirements to mCBDC means that domestic CBDCs must meet common standard

Источник / Source: составлено автором / Compiled by the author based on CPMI, BIS Innovation Hub (BISIH), IMF, World Bank (WB). Central Bank Digital Currencies for Cross-Border Payments. Report to the G20. July, 2021, p. 14. URL: https://www.bis.org/publ/othp38.pdf (accessed on 05.10.2023).

Our research shows that the mCBDC Model 1 is considered by many central banks, members of the Committee on Payments and Market Infrastructures (CPMI), as one of the benchmarks in designing and developing the concept of the CBDC national systems. As a result, the Central Bank Group considers international coordination of regulatory and supervisory efforts, as well as the development of common formats for the transmission of financial communications in cross-border payments, to be essential factors in achieving national CBDCs compatibility.[37] However, the model has not yet been tested in the framework of the known mCBDC projects, with the exception of Helvetia Phase II,[38]

[37] Group of Central Banks. Central Bank Digital Currencies: System Design and Interoperability. BoC, ECB, BoJ, Sveriges Riksbank (SR), SNB, Bank of England (BoE), Board of Governors Federal Reserve System (BGoFRS), BIS. No. 2. 2021. URL: https://www.bis.org/publ/othp42.pdf (accessed on 05.10.2023).

[38] Helvetia Phase II — is a joint project of the Swiss Innovation Hub of BIS, the National Bank of Switzerland (SNB) and the

since such a model does not envisage the realization of all the potential advantages of the mechanisms embodied in mCBDCs.

The mCBDC Model 2 was the focus of the Jasper-Ubin project in 2019–2020. Within the framework of the project, the national digital currency systems for wholesale settlements of the Central Bank of Canada (Jasper) and the Monetary Authority of Singapore (Ubin), built on different networks of distributed ledgers (Corda and Quorum, respectively), were interlinked to synchronize payments. Hashed time locked contracts (HTLCs) were used to project compatibility.[39] Their application has allowed PvP calculations to be carried out without the need to use a third party as a transaction validator. This project demonstrated that wholesale CBDCs can minimize the calculation risk, despite the use of different DLT-platforms in each country.[40] The mCBDC Model 2 is also applied in the Icebreaker project, which envisages the development of a platform for interlinking central banks' national retail digital currency systems for cross-border payments.[41]

Finally, mCBDC Model 3 is at the center of attention of most of the modern mCBDC projects, namely: Dunbar,[42] Jura,[43] mBridge[44] etc. At the same time, if the Dunbar project uses an indirect version of foreign PSP access to the national digital currency, the Jura and mBridge projects use a direct access option.

Despite the fact that it is too early to talk about the economic effects of mCBDCs, as many projects have not yet moved to the stage of large-scale implementation, available estimates demonstrate the high potential of cross-border payment mechanisms using digital currencies. Thus, PwC estimates that compared to correspondent banking calculations, the expected effects of the implementation of mCBDC arrangements may be as follows: the settlement time will be reduced from 3–5 days to 2–10 seconds[45]; the cost reduction will be up to 50%.[46] The overall cost reduction is expected to result from: 1) reduction in the cost of liquidity maintenance on "nostro-vostro" accounts; 2) reduction in operating costs for treasury operations; 3) reduction in the cost of conducting foreign exchange transactions; 4) cost reduction of compliance procedures.

Swiss Financial Market Infrastructure Operator (SIX). The project addresses the challenge of building a financial market infrastructure based on distributed leger technology (DLT), in which the settlement of transactions with tokenized assets will be carried out by wCBDCs. See details: BISIH, SNB, SIX. Project Helvetia Phase II. Settling Tokenised Assets in Wholesale CBDC. January, 2022. URL: https://www.bis.org/publ/othp45.pdf (accessed on 01.10.2023).

[39] (Hashed time locked contracts (HTLCs) are a type of smart contract with a temporary money lock that provides cryptographic confirmation of the legality of transactions when the transactions themselves are spaced in time. HTLCs combine two mechanisms for blocking transactions: by time (time lock) and by a secret number, the hash of which is recorded in the blockchain (hash lock). These mechanisms ensure the reversibility of the payment transaction when one of the parties to the transaction refuses to fulfil the prescribed conditions.

[40] Bank of Canada (BoC), MAS. Enabling Cross-Border High Value Transfer Using Distributed Ledger Technologies. Jasper — Ubin Design Paper. May, 2019. URL: https://www.mas.gov.sg/-/media/Jasper-Ubin-Design-Paper.pdf?la=en (accessed on 10.10.2023).

[41] BISIH, Bank of Israel (BoI), Norges Bank (NB), SR. Project Icebreaker: Breaking New Paths in Cross-border Retail CBDC Payments. March, 2023. URL: https://www.bis.org/publ/othp61.pdf (accessed on 05.10.2023).

[42] See details: BISIH. International Settlements Using Multi-CBDCs: Project Dunbar. March, 2022. URL: https://www.bis.org/publ/othp47.pdf (accessed on 07.10.2023).

[43] See details: Banque de France (BoF), BIS, Swiss National Bank (SNB). Project Jura: Cross-Border Settlement Using Wholesale CBDC. December, 2021. URL: https://www.bis.org/publ/othp44.pdf (accessed on 05.10.2023).

[44] See details: BISIH. Using CBDCs Across Borders: Lessons from Practical Experiments. June, 2022. URL: https://www.bis.org/publ/othp51.pdf (accessed on 07.10.2023).

[45] The data was obtained by the company in assessing the economic potential of the prototype of the project Inthanon-LionRock2, on the basis of which mBridge is currently developing. The project uses the mCBDC arrangement, in which participants in national digital currency systems are integrated into a common so-called "corridor" network managed by an operator under their joint control, allowing cross-border payments through depository receipts attached to CBDCs and stored in national systems.

[46] Bank of Thailand (BoT), Hong Kong Monetary Authority (HKMA), Digital Currency Institute People's Bank of Chine, Central Bank of U.A.E. Inthanon-LionRock to mBridge — Building a Multi CBDC Platform for International Payments. September, 2021. URL: https://www.bis.org/publ/othp40.pdf (accessed on 05.10.2023).

In conclusion, there are currently over 120 CBDC projects in the world.[47] As not all of them envisage international use of digital currency, some projects will have to improve design of national CBDCs for use in cross-border payments. We consider that, at the first stage, it is advisable for countries with high volumes of counter-export-import transactions to harmonize standards for the sharing of national CBDCs. The use of mCBDC arrangements could enable such countries to improve the efficiency of wholesale settlements related to trade financing and minimize the negative impact of economic sanctions. At the same time, such countries should be at the highest stage in the development of national digital currency systems and be guided by similar motives when implementing the mCBDCs.

In the second phase, countries interested in developing new trade relations and increasing the efficiency of cross-border payments, including in the retail sector, can join the mCBDC projects. In subsequent phases, it is expected that individual wholesale and/or retail mCBDCs will be merged on a single supranational platform to best realize the scale and network effects of cross-border multi-currency digital currency payments.

Finally, mCBDCs will contribute to the development of open, competitive and innovative payment services markets, enhancing the convenience and choice of payment tools for end-users. The mCBDC arrangements will also facilitate greater monitoring and control by the Central Bank of capital movements and the emergence of offshore holdings. We consider that, in the medium term, the compatibility factor of national digital currencies with other countries' cryptocurrencies will be one of the main motivators for the development and implementation of CBDCs in both developed and emerging markets.

[47] CBDC Tracker. Today's Central Bank Digital Currencies Status. 2023. URL: https://cbdctracker.org (accessed on 05.10.2023).

CONCLUSION

Implementation of central bank digital currencies for cross-border payments addresses the main disadvantages of modern transboundary settlements. mCBDC arrangements are capable not only of increasing the speed of final settlements, reducing transaction costs and minimizing settlement risks, but also of reducing the number of payment providers, harmonizing technical and operational standards and making cross-border settlement more transparent. As a result of the introduction of mCBDCs, the time of international settlements can be reduced to 2–10 seconds, and the cost of cross-border payments can decrease by at least 50%.

The main challenges associated with the introduction of central bank digital currencies for cross-border payments are: "digital dollarization", "spillover effects" of economic and financial shocks, the possibility of using central banks' digital currency for tax evasion, the complication of internal supervision of the monetary system and the financial market, etc. The role of these risks, especially for emerging markets, should not be underestimated. However, in most cases, these risks can be minimized by improving the design elements of digital currencies, as well as through coordinated monetary and macroeconomic policy actions by the central bank.

Currently, there is no universal interoperability model implemented in the mCBDC arrangements, nor is there a uniform option for access to digital currencies for payment service providers that could be suitable for all cross-border settlements. Although model of compatible CBDC systems may be the least cost-effective mechanism for achieving functional compatibility, it cannot provide the same efficiency as the models of interlinked CBDC systems and the single multi-currency mCBDC system. The same applies to the option of foreign PSPs direct access to national CBDCs, which is more

effective, but also riskier, compared to the closed or indirect access option.

The main advantages of the model of interlinked CBDC systems are shorter transaction chains, fewer and more effective compliance procedures, improved quality of data transmitted, potentially lower transaction financing costs, increased competition, etc. For example, the model of interlinked CBDC systems on base of "hub and spoke" network may be the most popular for cross-border retail payments, due to its simpler implementation and greater cyber-risk resistance compared to other mCBDC models.

In the long-term, we consider that the most promising model for cross-border wholesale payments is the single multi-currency mCBDC system. This model, which fully integrates digital currency systems at the management, identification, infrastructure, and ledger levels, is suitable for reducing the impact of cross-border and cross-currency risks, improving infrastructural and technical interoperability capabilities, reducing the number of intermediaries, and increasing settlement security. However, given the complexity of the implementation of the single mCBDC system, associated with the high investment and operating costs, as well as the length of consensus-building procedures between central banks, it is highly likely that initially such systems will be implemented only in wholesales payments between countries with high trading volumes and between jurisdictions with similar implementation objectives and an equivalent level of technological and infrastructure development of national digital currency systems.

In the current geopolitical context, when deciding on the implementation of the various mCBDC models, central banks must not only take into account the level of technological and infrastructural development of the national CBDC systems of the participating countries, but also take into consideration the existence of sanctions restrictions and the economic risks associated with carrying out cross-border settlements with foreign jurisdictions.

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ABOUT THE AUTHOR

Dmitry A. Kochergin — Dr. Sci. (Econ.), Chief Researcher, Institute of Economics of the Russian Academy of Sciences, Moscow, Russia
https://orcid.org/0000-0002-7046-1967
kda2001@gmail.com

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