Cross-border interoperability of central bank digital currency

The digitalisation of the economy, flourishing online commerce, global supply chains and migration are making cross-border payments more and more important. Compared with domestic transactions, payments across the borders of currency areas are more expensive, slower, less widely accessible and less transparent. This is particularly true of payments by individuals and enterprises. Central bank digital currency (CBDC) could help to overcome these obstacles.

As CBDC would inevitably necessitate the development of new infrastructures, it could act as a catalyst for enhancements in the cross-border payments space. Examples of such improvements would be the use of common message standards along the entire payment chain and faster settlement due to shorter process chains made up of fewer participants. Likewise, CBDC could present an opportunity to integrate currency exchange functionality into payment settlement. CBDC for financial institutions (wholesale CBDC) could also improve liquidity management in cross-border payments. In addition, programmable interfaces could help to link CBDC systems with one another or with other financial market infrastructures.

A multilateral approach is most likely to enable CBDC to help reduce the frictions currently hampering cross-border payments. This would involve central banks providing CBDC for use in their own currency area, but facilitating cross-border payments through interoperability of their own CBDC infrastructure with other payment systems. Such an approach would avert the macroeconomic risks associated with a unilateral approach whereby, outside of its domestic market, a currency area's CBDC would be held and used as a foreign currency. Depending on the extent of cooperation, a multilateral approach in the form of compatible systems, interlinked systems or a common platform could open up varying degrees of potential for faster, cheaper and more transparent payment settlement.

A higher degree of interoperability requires close cooperation between the central banks involved. Differences in legislation and national standards for data handling or cyber security provisions can hinder efforts towards greater interoperability. Differing national interests, fears over losing autonomy and control, and a lack of confidence in joint governance structures may also pose barriers to increased international cooperation.

The G20 countries have set 2027 as their target date for improving cross-border payments. As things currently stand, CBDC is unlikely to be able to make a meaningful contribution in the near future. In the medium term, however, the development of CBDC will provide a favourable foundation for establishing interoperability between payment systems through stronger cooperation among central banks; this offers prospects for mitigating the effects of the global retreat of correspondent banks. For that to come to fruition, central banks' work to develop CBDCs needs to be geared towards international usage and common standards from the outset.

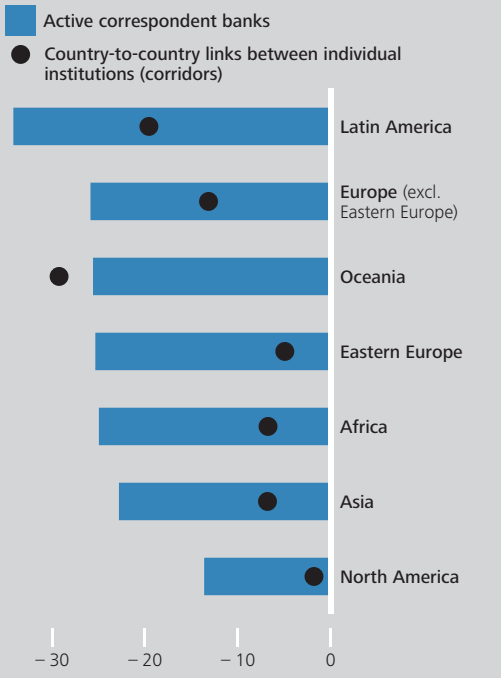
Introduction

The importance of cross-border payments is growing, …

A combination of factors has driven a dynamic evolution in international payments over recent years.[1] Irrespective of the current disruptions, global supply chains have led to a growing number of payments between firms in different countries. Increasing migration generally leads to a growing number of credit transfers being made by migrants to family members in their home countries (referred to as remittances) that constitute a significant inflow of funds for numerous countries relative to gross domestic product (GDP). New modes of working, increasing international tourism and the rise in international trade fuelled, in part, by e-commerce are making cross-border retail payments more and more important.[2] However, when it comes to settlement, which is predominantly conducted via correspondent banks and money transfer services (such as Western Union, MoneyGram and the like), there is significant room for improvement.[3] With this in mind, talk has now also turned to whether and how CBDC might contribute to efficiency gains.

Global decline in the number of correspondent banks between 2011 and 2019

%



Sources: SWIFT BI Watch and National Bank of Belgium.
Deutsche Bundesbank

… whilst, at the same time, banks are retreating from this business

For some years now, cross-border payments have additionally been suffering from the complete or partial retreat of financial institutions from correspondent banking activities in an effort to de-risk. Business relationships have been terminated, with the mounting costs of regulatory compliance being one of the motivating factors. The number of such links has fallen by almost one-fifth since 2011 and has made for significantly weaker competition. Particularly hard hit by the decline in correspondent banking relationships have been the regions of Africa, Latin America and Oceania, where some countries are heavily dependent on incoming remittances.[4]

Diminishing competitive intensity could ultimately lead to higher prices. There is also the risk that payment channels between certain countries will end up shut down altogether, leaving some regions entirely cut off from global payments. Last but not least, the dwindling of correspondent banking relationships could fuel recourse to payment channels that are less closely regulated and monitored (e.g. cash transfers or crypto-tokens).

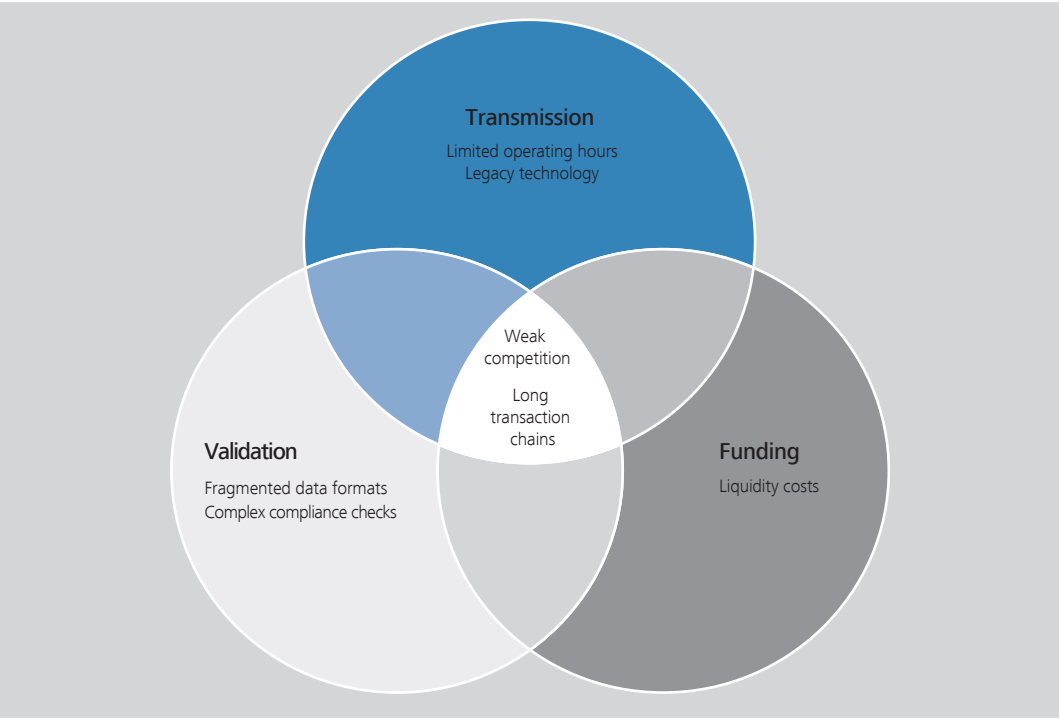
Frictions in cross-border payments and objectives for reducing them

Cross-border payments less efficient than domestic payments

Settlement of domestic payments has improved significantly in many countries in recent years; by contrast, cross-border payments are generally more expensive, slower, less transparent and are often only accessible to a smaller set of users than domestic payments. Having said that, this does not hold true for payments within the euro area, where – facilitated by a single currency – substantial investment has

1 See Rice et al. (2020).
2 See Financial Stability Board (2020a).
3 See Financial Stability Board (2020a).
4 See Rice et al. (2020).

Frictions in cross-border payments



Sources: Bundesbank chart based on Financial Stability Board (2020b).
Deutsche Bundesbank

gone into integrating national payment systems and creating a single European market for payments.

A number of frictions are causing these inefficiencies

As part of its work to enhance cross-border payments, the Financial Stability Board (FSB)[5] has pinpointed areas of friction that play a major role in the existing inefficiencies, which include high costs, low speed, limited access and limited transparency.[6]

- Fragmented and incomplete data: the use of fragmented data formats for the transmission of payment data means that important information – such as the know your customer (KYC) data essential for verification of the payer or recipient – sometimes does not get transmitted or is only communicated in truncated form. This makes automating payment processing more difficult and pushes up the cost of the transaction if the payment requires some manual processing.
- Complex compliance checks: different legal frameworks for the prevention of money laundering and terrorist financing lead to additional costs for the participants in the payment chain, and these are passed on to the end users.
- High liquidity costs: the complexity of the correspondent banking relationships between the institutions involved means the need for liquidity in various currencies is high; this entails commensurate costs.
- Frictions at settlement level: legacy technology, limited opening hours and long trans-

5 The FSB is an international body tasked with identifying any vulnerabilities in the international financial system and proposing and monitoring implementation of any action needed to address them. Its members include the central banks, supervisory authorities and finance ministries of the G20 countries as well as Hong Kong, the Netherlands, Spain, Singapore and Switzerland.
6 See Financial Stability Board (2021b). See also McKinsey and SWIFT (2018) for a look at the types and amounts of the various costs involved in cross-border payments.

G20 countries' targets for enhancing cross-border payments

Challenges	Payments segment		
	Payments between financial institutions (wholesale payments)	Payments between individuals and businesses (retail payments)	Remittances
Cost	No target set.	By the end of 2027, global average costs to be limited to 1% of payment amount. Costs no higher than 3% in any corridor.	By 2030, global average cost for a transfer of US$200 to be no higher than 3%. Costs no higher than 5% in any corridor.
Speed	By the end of 2027, 75% of cross-border payments to be settled within one hour, with the remaining 25% settled within one day.		
Access	By the end of 2027, all financial institutions to have at least one option (several, if possible) for engaging in cross-border payments.	By the end of 2027, all end-users to have at least one option for engaging in cross-border payments.	By the end of 2027, more than 90% of people (including those without a bank account) to be able to use electronic payment services for remittances.
Transparency	By 2027, all payment service providers to supply both the payer and the payee with a minimum standard of information regarding cross-border payments: (i) transaction costs (all costs along the payment chain, exchange rates and currency conversion fees); (ii) the expected time to deliver the funds; (iii) tracking of payment status; and (iv) terms of service.		

Source: Bundesbank table based on Financial Stability Board (2021).

Deutsche Bundesbank

action chains increase processing time and costs and make international payments less transparent.

Ultimately, these frictions also contribute to high barriers to market entry, resulting in the lack of competition in the cross-border payments space that we have already mentioned.

G20 have formulated targets to be achieved by 2027

In 2020, the G20 countries devised a roadmap with a view to addressing and eliminating the frictions described above. It consists of 19 building blocks that fall into a total of five focus areas. These include global harmonisation of regulatory frameworks, improvements to data quality, the expansion of existing payment infrastructures and the development of new infrastructures, as well as the definition of a common vision for enhanced cross-border payments.

As part of this common vision, concrete objectives for the various segments of cross-border payments have already been set, with the target of achieving them by 2027 (see the overview above). They address payments between financial institutions as well as retail payments, plus remittances, which are usually listed separately.

The goal is for payments by individuals and businesses to not cost any more than 1% of the transaction value and for the cost of remittances not to exceed 3% of the amount being transferred. Furthermore, 75% of all payments should be available to the payee within one hour. In addition, certain information is to be made transparent to payers and payees, such as the total cost of the transaction and the time it will take to settle.[7] Alongside the efforts of central banks and legislators, private sector initiatives can also help to achieve the objectives set by the G20 countries.[8]

7 See Financial Stability Board (2021).
8 For example, initiatives such as SWIFT gpi and SWIFT Go are intended to make for speedier and more transparent international payments.

Central bank digital currency – a new start?

CBDC is being explored throughout the world

The crux of the structural problem with international payments lies in the fact that such payments have to pass through several domestic payment systems with different designs (normally, the country where the payer is sending the funds from and the country of the payee). On top of this, a bridge (e.g. in the form of correspondent banking) is usually necessary as well to provide the technical connection between both systems and, where necessary, perform any currency exchange. Against this backdrop, investigations are currently under way looking at whether and how CBDC will open up options for creating new structures and thus the possibility of placing cross-border payments on a common footing.

Discussions around CBDC have gained noticeable momentum in the last few years. A survey conducted by the Bank for International Settlements (BIS) found that around 90% of the respondent central banks are exploring CBDC. One-third are at the pilot phase or already in development.[9] Work is going into both wholesale CBDC[10] and retail CBDC.[11] Initiatives are being motivated by different drivers in individual cases, with financial inclusion, monetary sovereignty and increased efficiency of domestic payments among the reasons cited. However, the desire for more efficient cross-border payment transactions is also playing into the central banks' efforts.

The Eurosystem is currently investigating the feasibility and possible design of a digital euro in the form of a retail CBDC. The ongoing investigation phase is set to run until October 2023 and reach a conclusion as to whether a digital euro should actually be developed and issued.[12]

Cross-border payments play a role in deliberations about CBDC

CBDC will not just be a means of payment; it will also require an infrastructure enabling issuance and circulation. For CBDC to be used in cross-border transactions, establishing interoperability between individual CBDC infrastructures is a must – in other words, they need to be able to work together as seamlessly as possible. Pilot phase CBDC projects being pioneered by central banks are concentrating on wholesale CBDC, with a focus on international payments in the interbank market (e.g. the Dunbar and mBridge projects described below). There are also initiatives in the private sector that are looking to create infrastructures for the cross-border use of wholesale CBDC (J. P. Morgan Onyx,[13] for instance).

Yet enhancing the cross-border payments landscape is also an important motivator behind retail CBDC projects, especially for emerging market and developing economies.[14]

Interoperability beyond the G20 roadmap is important

However, the majority of retail CBDC projects are currently geared more towards domestic payments, as the development of CBDC, even in the domestic context, raises numerous issues of a conceptual, technical and legal nature. Moreover, the timeframes that most of the projects are working with are unlikely to be compatible with the deadline set in the G20 roadmap. Nevertheless, it is still imperative that cross-border payments be included from the outset in the thinking going into designing CBDC. The new CBDC systems will only be able to aid in enhancing cross-border payments in future if they are interoperable. As well as generating stiffer competition by offering an additional settlement channel, CBDC and its unique technical design could enable efficiency gains

9 See Kosse and Mattei (2022).
10 In this context, wholesale CBDC describes a CBDC which is primarily designed for use in payments between credit institutions/financial market infrastructures.
11 Retail CBDC describes a CBDC which is designed to be used for payments by non-banks (e.g. the public, enterprises, public authorities).
12 The European Central Bank (ECB) is part of a consortium of eight central banks looking into the basic design of CBDC. Cross-border payments are one of the aspects feeding into their considerations. See Bank for International Settlements (2020).
13 J. P. Morgan Onyx is a blockchain platform for exchanging payments, digital assets and payment information.
14 See Kosse and Mattei (2022).

that are difficult – if not impossible – to attain using traditional instruments.

Ways in which central bank digital currency could mitigate frictions

Development of new structures can enable CBDC to act as a catalyst for smoothing frictions

Some of these efficiency gains can be achieved through the "accelerant" effect of new systems, as they promote a reinvention of the system landscape with the cross-border dimension in mind.[15] The scope for improving existing systems could be limited if expanding their functionality takes them to the bounds of what is technically feasible or if the costs of adapting them are higher than those of developing a new system. Meanwhile, the development of new payment settlement infrastructures can present a host of advantages that, over the medium term, outweigh the short-term investment costs. In many countries, CBDC systems are being developed precisely with the aim of increasing financial inclusion. This opens up the possibility of simultaneously expanding access to cross-border payments as well. Depending on how a given CBDC is designed, payment service providers that have so far been dependent on the services of banks could take on a greater role in the settlement infrastructure. Banks, too, could provide new services. For those banks that engage in international correspondent banking, the incentive to improve or participate in new systems would depend on how potential new income might measure up against the potential loss of previous business. Overall, competition at the customer interface could intensify and more innovative services could be offered.

New data standards and real-time settlement can increase efficiency

Newly developed systems can ensure efficient and transparent data processing through, for example, the application of uniform messaging standards.[16] This could cut down the need for (costly and time-consuming) manual intervention at the individual stages of the payment chain. In addition, transactions could be settled directly and in real time.[17] This would mean that payers and payees, in cross-border payments especially, could receive confirmation of successful settlement in a matter of seconds, which would minimise costs associated with risk monitoring and hedging. That would directly address two key challenges – a want of transparency and the high costs – where cross-border usability is concerned.

Integration of currency exchange functionality could generate significant efficiency gains

However, this would require currency exchange functions to be built into CBDC systems from the outset. This could be done, for example, via selected third parties or a market mechanism that is also incorporated into transaction settlement in real time.[18] Currency exchange in real time, enabled by the use of a wholesale CBDC, would – for example – serve to mitigate the issue of liquidity management in cross-border payments. In this way, wholesale CBDC could also support alternative private sector solutions for improving cross-border payments.

New systems for CBDC may encourage harmonisation of technical and legal standards

At the same time, new CBDC systems could encourage a harmonisation of legal frameworks or settlement standards. Besides the shared messaging standards[19] already mentioned, that might include, for example, more homogenised conditions for access to payment systems, harmonised rules for establishing settlement finality and extended operating hours for payment systems. CBDC could also prove to be a catalyst for digitalisation initiatives in the payments sphere.[20] In the European Union, for instance, CBDC forms part of the general digitalisation strategy, which also includes the interoperability of digital identities. In ths context, Member States have been called upon to cre-

15 See Bank for International Settlements (2021a).
16 For example, ISO 20022, which establishes a uniform standard for payment messages.
17 In correspondent banking particularly, the large number of parties involved in settlement mean that transactions can sometimes be hard to track. It is not possible for the payer and payee to check the whereabouts of a payment at all given moments. SWIFT has just recently successfully introduced the SWIFT gpi initiative, providing better tracking of transactions in the SWIFT network.
18 See European Central Bank (2021).
19 For example, ISO 20022 (https://www.swift.com/standards/iso-20022).
20 See Bank for International Settlements (2022b).

ate a toolbox for the provision of digital identity wallets, which could also be used for payments and the digital euro.[21]

Open interfaces could lend a significant boost to interoperability with other systems

The implementation of open interfaces would offer further advantages. From a technical perspective, this could be done using, say, application programming interfaces (APIs)[22] or trigger solutions,[23] enabling, for example, payment-versus-payment settlement in different currencies. Payment-versus-payment settlement in international transactions minimises settlement risk for buyers and sellers, since the funds denominated in different currencies change hands simultaneously.[24] With the help of such setups, CBDC systems could be made interoperable without a huge amount of effort, or could simplify international capital flows by means of linkages to securities settlement systems, for example. Open interfaces would also allow new CBDC systems in one country to be linked to traditional payment systems in another country. This could enable differences between countries and regions in terms of their development paths and the solutions that they are pursuing to be accommodated.

International central bank digital currency: multilateral cooperation instead of unilateral issuance

International CBDC: unilateral approach or multilateral cooperation

Many of the outlined opportunities of using CBDC to mitigate current frictions in cross-border payments assume a certain degree of international cooperation among central banks. A multilateral[25] approach of this nature could, in particular, see participating central banks issuing local-currency CBDC to be primarily held by residents of their currency area.[26] Cross-border payments would be made possible through the above-mentioned interoperability with other CBDC systems. By contrast, it would be possible to follow a fundamentally different approach, whereby central banks issue CBDC unilaterally and design it in such a way that it can be held across borders and be used internationally.

Unilateral approach: no need for interoperability between CBDC payment systems, …

Under a unilateral approach, cross-border payments would therefore be made within a single, closed payment system in a single, digital currency. There would be no need for interoperability with other CBDC systems in order to transfer money across national borders and no need for a currency exchange mechanism within the system. In practice, however, an option for converting foreign-currency CBDC into the respective national currency following a cross-border transaction would be required. Foreign payment service providers, for example, would also have to maintain foreign-currency accounts. This could result in additional costs for the end user, especially in situations where the foreign-currency CBDC could not be used to pay for goods and services abroad. A unilateral approach would therefore not be able to do away with a link to foreign payment systems entirely either; rather, such a link would be placed in the hands of private agents.[27]

… but associated with a number of economic risks

In addition, from an economic perspective, a number of risks place a question mark over the usefulness of a unilateral approach. At first glance, these primarily concern those countries in which CBDC would be used as a foreign currency but, on closer inspection, also the currency area issuing the CBDC.

If foreign-currency CBDC were to be used as a means of payment, for example a digital US

21 See European Commission: European digital identity (https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/european-digital-identity_en).
22 APIs are programming interfaces that allow regulated access to the systems of the respective parties. In Europe, these are regulated, inter alia, by the Payment Services Directive (PSD 2).
23 See Deutsche Bundesbank (2021a).
24 See Deutsche Bundesbank (2021b).
25 This approach includes a conceivable bilateral solution.
26 It may also make sense to make domestic CBDC available to non-residents spending time in the country (e.g. tourists).
27 Major card companies and IT service providers have already launched initial projects heading in this direction.

Consequences for the currency area using foreign-currency CBDC, …

dollar in the euro area, the domestic economy would be more affected by foreign economic developments. Model-based analyses, for instance, demonstrate that spillovers of economic shocks to the domestic economy are amplified in such cases. Domestic monetary policy would then have to respond to external developments to an increasing degree in order to stabilise economic and price developments at home.[28] At the same time, the scope for conducting effective monetary policy could be narrowed. To the extent that usage of CBDC as a means of payment also leads to the foreign currency being increasingly used as a unit of account at home, domestic monetary policy would lose force: if prices and wages are increasingly expressed in foreign currency, it will become more and more difficult for the central bank to use monetary policy measures to influence domestic prices and economic activity.[29] Not least for this reason, a central bank's unilateral effort to ensure that its own CBDC can be used internationally could be perceived abroad as undermining domestic monetary policy autonomy.

… and also for the issuing central bank, …

However, the expanded use of CBDC abroad would also have significant consequences for the central bank issuing the CBDC that can be used internationally. As CBDC is a liability of the issuing central bank, demand for CBDC from abroad would generally further extend its balance sheet. As a consequence, balance sheet risks would tend to increase. If the central bank were to issue CBDC against a foreign currency, for example, and build up foreign-currency holdings accordingly, its balance sheet would be more vulnerable to exchange rate fluctuations. In addition, such transactions would be the equivalent of foreign exchange market interventions at the expense of its own currency and, as such, subject to the commitments pledged by the G7 Finance Ministers and Central Bank Governors.[30] If, on the other hand, the central bank were to hold additional assets in its own currency, the value of its currency would tend to rise as a result of the additional demand from abroad. This, in turn, could have negative consequences for the competitiveness of the domestic economy.[31,32]

… especially if several central banks adopt a unilateral approach

If several central banks were to adopt a unilateral approach at the same time, this could ultimately also have a knock-on effect on their own ability to conduct monetary policy. If each country's CBDC is freely available abroad, foreign-currency means of payment would compete directly with domestic forms of money in all countries. Model-based analyses suggest that such currency competition could tend to lead to a convergence of interest rates

28 Ferrari Minesso et al. (2022) model the unilateral issuance of CBDC abroad, which can also be used for domestic payment purposes. As the foreign-currency CBDC increases the stock of foreign-currency assets held by domestic residents, any adjustment in response to exchange rate movements is stronger. This amplifies economic spillovers from the country issuing the CBDC and triggers a stronger domestic monetary policy response in the model.
29 Ikeda (2020) models such a "digital dollarisation" in which domestic prices and wages are denominated in foreign currency. Domestic monetary policy becomes less effective as digital dollarisation deepens, while the monetary policy of the foreign country that issues the digital currency used in the home country has a greater impact.
30 The communiqué from the G7 Finance Ministers' and Central Bank Governors' Meeting held in Bari, Italy, on 12 and 13 May 2017 states: "1. […] We reaffirm our existing G7 exchange rate commitments to market determined exchange rates and to consult closely in regard to actions in foreign exchange markets. We reaffirm that our fiscal and monetary policies have been and will remain oriented towards meeting our respective domestic objectives using domestic instruments and we will not target exchange rates for competitive purposes. We underscore the importance of all countries refraining from competitive devaluation […]". In the London communiqué of 5 June 2021, the G7 reaffirmed their adherence to these commitments.
31 Even in such a case, additional balance sheet risks may arise for central banks. This occurs when the stock of safe assets in its own currency is limited, necessitating the holding of increasingly risky securities.
32 If issuing CBDC were to lead to prices and wages being chiefly denominated in the domestic currency abroad, too, a currency appreciation would not have a significant impact on the domestic economy's competitiveness. This is because, for countries that predominantly use the same currency as a unit of account and as a means of payment, exchange rate fluctuations in another currency, which is hardly used for these purposes anymore, are generally less important.

between countries.[33] Instead of increasing their own international monetary and economic policy influence, such a system could actually narrow the scope for all participating central banks to conduct an independent monetary policy. The impossible trinity of international economic policy[34] could morph into a dilemma: although exchange rates could continue to fluctuate, were capital to move freely across borders, there would be less scope for independent monetary policy.

Restrictions could help to avoid risks, but they could run counter to the desired improvements

The above-mentioned risks associated with a unilateral approach could, in principle, be mitigated by designing the CBDC appropriately.[35] Indeed, debate in the euro area on potential caps for holding a possible digital euro (holding limits), for example, suggests that such restrictions may also be necessary in an international context. If, for example, the volume of domestic CBDC held abroad were to be strictly limited or if transactions were to be capped, the side effects would also be contained. Such restrictions, however, would run counter to the aim of using CBDC to address frictions in cross-border payments in the first place.

Multilateral cooperation approach preferred

For these reasons, instead of proceeding unilaterally, a multilateral approach could prove better suited to realising the potential of CBDC for cross-border payments. The participating central banks would then issue CBDC primarily in their own currency area,[36] but would make it interoperable across borders. Since large-scale holding or use of CBDC in foreign currency would not be envisaged, the macroeconomic risks of a unilateral approach would not arise.

These considerations apply to both retail CBDC and wholesale CBDC. For example, all current projects that use wholesale CBDC to simplify cross-border payments are characterised by strong multilateral approaches. These projects are also examining whether, for the purpose of simplifying payments, it would make sense to open up access to CBDC to foreign banks. If this were to happen, it would no longer be necessary to involve another bank in the recipient country. The experiments have generally shown that the issuing central bank would technically be able to obtain complete transparency about the CBDC held by foreign banks and implement various control and steering measures that enable a politically desired cap on wholesale CBDC circulating abroad. At present, however, in many countries access to central bank ac-

33 Benigno et al. (2022) model the impact of a global crypto-token that can be used internationally for payment purposes and thus competes with currencies issued by central banks. Because the token can be freely converted across national borders, changes in the value of the token in one of the countries have a direct impact on the exchange rate of the currencies to each other. Benigno et al. (2022) show that, while the currencies of the individual countries therefore do not compete directly, they may well do so indirectly. Under the model assumptions, this leads to a forced convergence of bond yields, i.e. the opportunity cost of holding money, between countries if the agents maintain equilibrium holdings of both the crypto-token and the respective local currency. In the model, this could only be avoided if central banks were to deviate from interest rate equality and lower their rates – which could lead them to the zero lower bound at which they would be unable to lower rates further. The outcome of this model can be applied to the context of international CBDC: if CBDC that can be used abroad were to compete directly with the respective domestic currency – not indirectly through a global crypto-token – interest rates would also tend to converge. The more similar the various forms of money in the model are, i.e. the more substitutable they are as means of payment from the user's perspective, the more this holds true.

34 In the economic literature of open economies, the impossible trinity describes the inability to simultaneously achieve the three potential objectives of free capital flows, fixed exchange rates and independent monetary policy.

35 In the model employed by Ferrari Minesso et al. (2022), described in footnote 28, for example, transaction restrictions for users of CBDC abroad mean that economic shocks from the country issuing the CBDC are transmitted less strongly across national borders.

36 Depending on the technical design, limiting the use of domestic CBDC to residents could be complex at an operational level, but so too would be implementing reliable identity and anti-money laundering controls for non-residents. If, for example, the CBDC is made available as a hardware token or in a purely decentralised network based on distributed ledger technology (DLT), it will be virtually impossible to restrict usage to a certain user group. By contrast, an account-based CBDC or a software token in a permissioned DLT network will enable usage to be restricted, for example, by refusing to open an account or set up a wallet as part of an identity check. Cross-border interoperability is likely to ensure that restricting usage to residents is not perceived as unduly restricting the free flow of capital. It will also be essential to ensure that the differing ways of treating various forms of central bank money do not give rise to a difference in value between cash and CBDC. The points outlined here also apply to the unilateral approach whereby, as mentioned above, at least a partial restriction of CBDC usage abroad would probably also be appropriate.

counts is restricted to domestic banks for risk, supervisory or monetary policy reasons.

Options for interoperable central bank digital currency

The concrete design of interoperability within the framework of a multilateral approach could take several forms.[37] The appropriate concepts can be roughly divided into three categories, although the distinction between them is not always clearly delineated:[38]

- compatible CBDC systems;
- interlinked CBDC systems;
- a single CBDC system.

Compatible systems

Compatible systems limit interoperability to compliance with common technical standards and harmonised legislation

The first option comprises CBDC systems that operate independently but are compatible. Interoperability is limited to compliance with common technical standards and, where necessary, harmonised legislation.[39] Common technical standards, such as those relating to message formats, cryptographic techniques and user interfaces, can reduce the operational burden on those involved.[40] Harmonised rules and standards simplify, for example, know your customer (KYC) and transaction monitoring processes. In principle, this applies both to CBDC and to private sector providers' means and methods of payment.

Despite these advantages, in practice there are major obstacles to overcome before systems are compatible, although these are probably smaller than those described below. This is because common standards can only be drawn up in joint coordination processes which, in turn, produce coordination costs. In addition, implementing common, uniform message standards can take years, as the example of ISO 20022 has shown. In 2004, the International Organization for Standardization (ISO) already published the 20022 standard for financial messages with the aim of harmonising cross-border payments and improving communication between stakeholders. In 2025 – 21 years later – it is due to be used across the board as a universal standard, at least in large-value payment systems.[41] At the same time, work on the G20 roadmap mentioned at the beginning of this article is aiming to harmonise the application of ISO 20022. Simply having a common standard does not necessarily mean that it is interpreted in the same way globally.

Yet at the same time this option still requires recourse to correspondent banking or alternative mechanisms in order to transfer a payment from one system to another.

Interlinked systems

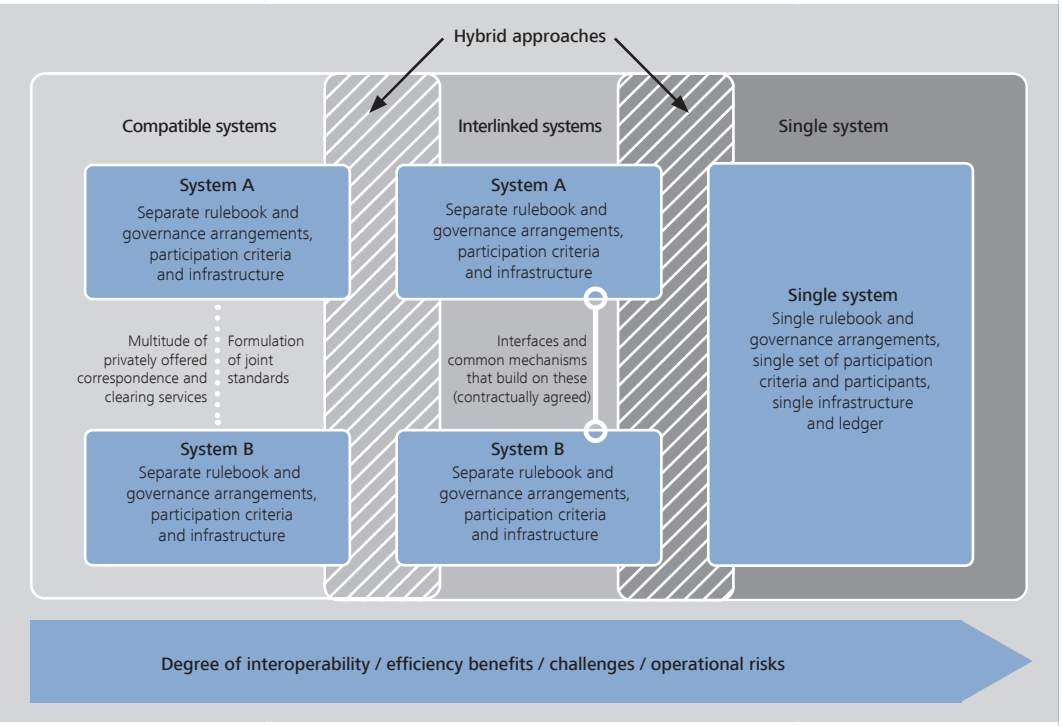
Systems can be linked using interfaces and common clearing mechanisms

The second option is to link various CBDC systems. This would enable a participant to make a payment from one CBDC system directly to a participant in another CBDC system without having to participate in the other CBDC system themselves. Such a set-up requires common technical interfaces and standards that enable information to be exchanged and thus payments to be made across different systems.

In addition, settlement could be simplified by using a central clearing agent to transfer payments to the other system or a common clearing mechanism. Such a clearing mechanism

37 Interoperability can and should, in principle, also be established with systems other than those for CBDC. However, this article focuses solely on cross-border cooperation between CBDC systems.
38 See Bank for International Settlements (2021a).
39 Central banks in six countries (Canada, Japan, Sweden, Switzerland, the United Kingdom and the United States), the ECB and the BIS have already begun to collaborate on fundamental questions regarding the design of CBDC; see BIS (2020). In future, initiatives such as these could form the basis of a cooperative approach or further-reaching joint activities.
40 In order to settle transactions, it may be necessary for at least one agent to participate in both systems as a liquidity provider.
41 As part of the TARGET2/T2S consolidation project, ISO 20022-compliant messages will be used across all TARGET services from November 2022 onwards.

Interoperability approaches for CBDC systems



Source: Bundesbank chart based on Auer et al. (2021).
Deutsche Bundesbank

could, for example, be designed in such a way that payments are booked via settlement accounts with a central agent. It would, for instance, keep accounts in different currencies for the participating central banks.[42] The alternative would be a decentralised approach in which each participating central bank holds accounts with all the other central banks. When currencies need to be exchanged, the central banks could either do this themselves or with the help of private sector intermediaries. This means that, if necessary, the central bank from whose currency area a payment request in CBDC is made would exchange the corresponding amount on the foreign exchange market and ultimately have it credited to the central bank in whose currency area the payee is located. The amount would then be credited to their account in local-currency CBDC.

The introduction of common mechanisms, such as technical interfaces, faces hurdles similar to those to agreement on uniform standards in the first option. It should also be borne in mind that the direct technical linking of the systems would require a much higher degree of detail within the necessary agreements.

Interlinked systems are being tested, for example, as part of the "Jasper-Ubin"[43] and "Jura"[44] projects, which look at the cross-border use of wholesale CBDC. Both projects show how transactions on interface-linked DLT systems can be synchronised over time to reduce, for instance, the risks – and thus the costs – of cross-border transactions involving multiple currencies. The Jura project successfully tested the cross-border purchase of a DLT-

42 See, for example, https://www.bundesbank.de/en/tasks/payment-systems/publications/amplus
43 The "Jasper-Ubin" project is being conducted by the Monetary Authority of Singapore and the Bank of Canada. See Accenture (2019).
44 The "Jura" project is being conducted by the Swiss National Bank, the Banque de France and the BIS Innovation Hub in collaboration with a private sector consortium. See Bank for International Settlements et al. (2021).

based security against wholesale CBDC in euro (delivery-versus-payment), followed by an exchange of the euro against wholesale CBDC in Swiss francs (payment-versus-payment). Technically, the security and the respective CBDC are issued on sub-systems, which in turn are linked via a common platform, with central banks retaining control over the issuance of their respective CBDC and the authorisation to participate in their sub-system.

Single system

Single CBDC systems in the form of multilateral platforms

The third option is based on the idea of a single CBDC system as a multilateral platform. As a general rule, it is not necessary to ensure compatibility or to link different CBDC systems. Instead, the concept provides for a single rulebook, a single technical system and a single set of participation criteria. Operators could be international institutions, a consortium of central banks, or a public-private partnership of central banks and the private sector. Given that the use of CBDC is to be seen as an integral component of this, platforms that are operated solely privately are unlikely to be an option.

Such a platform could have a single settlement currency or be capable of processing multiple currencies. If in the first case the single settlement currency were a national currency, such a system would have the properties of a unilateral approach. This system would thus also share the macroeconomic problems of unilateral approaches described above. If, on the other hand, a supranational settlement currency of its own were envisaged, fundamental questions would arise, such as what amount of such a currency would be issued and according to which rules. For these reasons, the current deliberations are focusing instead on multi-currency platforms. One advantage of using DLT could be that it would have a single technical platform with a single rulebook, yet still include decentralised elements, if necessary, and could provide some independent operational scope for the parties involved. Like in the Jura project, sub-networks could exist, but they would be more strongly integrated than systems linked via the common platform. Even in the case of multi-currency platforms, it would still be necessary to find a way for currency to be exchanged in cross-border transactions. One of several options is the automated market-maker using wholesale CBDC described in the box on p. 71.

Single systems are likely to offer their users greater operational functionality and efficiency than the options described above. Owing to the high degree of integration, a large number of the advantages of using CBDC in cross-border payments as described above could be achieved as no cross-system communication would be necessary for the individual transactions. At the same time, however, this increases the initial investment and the coordination costs between the parties involved in order to set up the system and to establish the requirements for common governance. The mBridge[45] and Dunbar[46] projects are practical examples of conceptual studies for single systems, i.e. multi-currency DLT platforms based on wholesale CBDC. The innovative settlement of cross-border and cross-currency transactions aims to reduce transaction costs, settlement times and operational complexity.

Hybrid systems

Forms combining different options could prevail

It is not always possible to distinguish clearly between the individual options, however. Hybrid approaches combining elements of the various options are therefore also conceivable in principle. For example, a single system could

45 The mBridge project is run by the BIS Innovation Hub Hong Kong Centre, the Hong Kong Monetary Authority, the Bank of Thailand, the Digital Currency Institute der People's Bank of China and the Central Bank of the United Arab Emirates. See Bank for International Settlements (2021b).
46 The Dunbar project is operated by the BIS Innovation Hub Singapore Centre, the Reserve Bank of Australia, Bank Negara Malaysia, the Monetary Authority of Singapore and the South African Reserve Bank. See Bank for International Settlements (2022a).

Automated market-makers

Apart from involving central banks or private intermediaries, currencies could, in principle, also be exchanged via automated market-makers (AMMs) on a common system for central bank digital currency (CBDC) based on distributed ledger technology.[1] AMMs could be integrated into the software protocol of such a system and automatically process currency exchange.

This involves banks provisioning an omnibus account with liquidity in the form of CBDC, which, in turn, can be withdrawn by other participants in exchange for other CBDC. This would mean liquidity would be centrally available to all participants, which could lead to a particularly good liquidity allocation within the system, without participants being dependent on intermediaries.[2] AMMs are already used as part of decentralised trading platforms in the decentralised finance sector. Nevertheless, practical problems may arise. One key challenge is in designing an appropriate incentive system that encourages banks to provide liquidity. On the one hand, banks would receive "liquidity tokens" for the funds that they have contributed, via which, in turn, the fees accrued for trades are distributed – as compensation and an incentive to provide liquidity. On the other hand, liquidity providers also bear the risk of price changes when it comes to re-exchanging the liquidity tokens for the funds that they have contributed. This is because trading transactions add an asset (e.g. a currency) to the omnibus account, while the respective other asset is withdrawn from it at the same time. The transaction therefore shifts the volume ratio of the tokens in the omnibus account. On the basis of an algorithm, these changes lead to opposing price changes. The price of the added asset decreases and the price of the withdrawn asset increases, whereby the user who carried out the exchange loses out (slippage loss). Prices therefore do not necessarily reflect supply and demand in the market, but rather encourage users to carry out opposing arbitrage transactions in order to restore the original volume ratio. The greater the shift an exchange transaction produces in the value ratio of a trading pair, the greater the slippage loss. It is therefore important that the omnibus account is sufficiently large, especially for less-traded currencies.[3] The incentive problem described above is one of the obstacles that would have to be removed before AMMs could potentially be used in a CBDC system.

1 See Bank for International Settlements (2022a).
2 See Bank for International Settlements (2022a).
3 See Deutsche Bundesbank (2021b).

be used within a region, which, in turn, is linked bilaterally to CBDC infrastructures in other countries. In practice, such hybrid systems could play a greater role in the future, especially because diverging national interests may make global agreement on a single approach appear unrealistic and possibly not even be desirable. It is more likely that various approaches will be implemented in a region, which could in turn be interlinked.

Examples of this can also be seen in some current projects. For example, the Jura project described above (interlinked systems) also contains elements of a common platform, which, in turn, is more consistent with the third option (single systems).

By contrast, although the mBridge project is based on a common platform, it also includes the possibility of linking this platform to other CBDC systems or other platforms. This, too, entails switching between interlinked and single systems. Future interoperability models may include different elements of each option in order to meet the needs of each currency area.

Potential and challenges for the cross-border use of central bank digital currency

All options could be an improvement over the current correspondent banking system

Compared with the current correspondent banking system, all three options promise significant improvements. In theory, interlinking CBDC systems may lead to faster, cheaper and more transparent cross-border payments. Depending on the design of the respective CBDC, this could also give additional user groups within the general public access to cross-border payments. At the same time, the degree of improvement depends on the version of the multilateral cooperation model that is chosen. The overview on p. 73 summarises the potential that each of the options for interoperable CBDC offer compared with the current correspondent banking system.

The degree of interoperability may also increase efficiency gains, challenges and risks

The degree of interoperability and potential efficiency gains will increase, whether in compatible, interlinked or single systems. However, as the degree of interoperability rises, so too will the complexity of the systems and thus the difficulty of implementing them. This will hold even if the new CBDC systems are only designed as compatible systems (as in the first option). It would need to be clarified, for example, which standards (e.g. messaging standards or standards for the transmission of data for anti-money laundering purposes) in payment processing are to be migrated from the existing systems and which ones are to be abandoned in favour of new, internationally compatible standards. The introduction and implementation of these international standards could pose major challenges for system users and would entail considerable costs. In addition, divergent national interests or different perspectives may hinder closer international cooperation and significantly delay work on the common standards or even bring it to a halt.

In-depth international cooperation can restrict each country's autonomy

To a certain extent, the in-depth international cooperation required for the interlinked and single systems is associated with ceding autonomy in favour of common governance structures, which represents an additional obstacle to linking payment systems.[47] This hurdle can be circumvented or at least mitigated by factoring at an early stage the cross-border use of CBDC systems into the development of new CBDC systems, before their development becomes too divergent in different jurisdictions.

Another obstacle could be the relatively high investment costs for new systems, which might be incurred in addition to the ongoing costs of the current systems. However, elements of existing systems could also be reused, possibly after modification. In this respect, too, it is probably advisable to incorporate the thinking behind the development and operation of a common platform into a country's own project activities at an early stage, as it would become

47 See Bank for International Settlements (2021a).

Potential improvements resulting from alternative approaches to interoperable CBDC systems

Frictions in the current correspondent banking system	Potential improvements		
	Compatible systems	Interlinked systems	Single system
High operational costs and (settlement) risks due to multiple bilateral account relationships and balances	Possible reduction in number of business relationships could reduce costs	Common clearing mechanism and settlement in real time could reduce costs and risks	Final settlement in real time and, where applicable, using liquidity-saving mechanisms could reduce costs and (settlement) risks
Different operating hours	Same operating hours if operating 24/7		
Different communication standards	Compatible communication standards can reduce data loss	Harmonised communication standards more or less eliminate data loss	Single communication standard eliminates data loss
Limited transparency on exchange rates and fees	Common calculation of exchange rates could increase transparency	High transparency if common mechanisms, e. g. for currency exchange, are used	
Limited transparency on status of transactions	Transparency depends on the degree of compatibility	High transparency if final settlement is in real time	
Restricted access	Potentially enhanced access to cross-border payments depending on CBDC's access model		

Source: Bundesbank table based on Auer et al. (2021).

Deutsche Bundesbank

more unlikely to achieve such a platform once national CBDC systems have already been introduced across the board.

Different legal and regulatory frameworks can make interoperability more difficult

Moreover, differences in legislation will be a major impediment to the cross-border interoperability of new payment systems. There are differences between countries not only in terms of anti-money laundering and combating the financing of terrorism (AML/CFT), but also regarding the rules governing risk management, cyber security and the handling of personal data. International harmonisation of legal frameworks could have a significant impact on national legal systems that is politically either difficult or impossible to deliver and which is also not offset by the prospect of more efficient cross-border payments.

Spillover effects can create risks through stronger interconnectedness

Another critical factor when setting up interoperable infrastructures is the close interconnectedness between systems in different economic areas. Facilitated by tight integration between system users, for example, the effects of localised crises in individual economic segments or of participant defaults could spread globally (spillover effects). Faster transaction processing due to closer links or integration is also associated with higher operational risk. As a general rule, the decision regarding the desired degree of interoperability therefore always requires a detailed risk analysis.

Geopolitical aspects need to be considered

Last but not least, greater cooperation always involves an increase in dependencies, which may also have political implications. For example, when using a single system, clear and binding rules for contingency procedures are required, which may lead to the mandatory exclusion of participants from the system in an emergency. Potential conflict could also arise when implementing financial sanctions of various types if they are assessed and implemented differently by the cooperating countries.

Outlook and conclusion

CBDC will likely come too late to make a significant contribution to achieving the G20 objectives …

The work initiated by the G20 countries aims to significantly improve the efficiency of cross-border payments, which would require considerable efforts in a relatively short period of time. The corresponding measures should address as many of the weaknesses identified by the G20 countries as possible. In particular, purely technical approaches will not have a lasting impact unless they are accompanied at the same time by a globally consistent implementation of the relevant legal regulations and an improvement in the exchange of information.

The specific objectives that have been formulated so far are supposed to be achieved by 2027. If this timetable is kept, CBDC is unlikely to make any material contribution, as most CBDC projects are at a very early stage and will not be able to unfold much of their potential in cross-border payments during this period. In this respect, it will also be necessary to place a high priority on exploring other private sector approaches, such as the linking of real-time retail payment systems. In recent years, many countries have invested in setting up such payment systems, often based on international standards. In countries with strong political and economic integration, the use of common technical infrastructures for the settlement of cross-currency payments in real time could also be considered outside of CBDC. Such an approach is currently being investigated by the Eurosystem in its efforts to improve TARGET Instant Payment Settlement.[48]

… but it is still worth unlocking the cross-border potential of CBDC

Nevertheless, CBDC will offer the opportunity to increase the speed of settlement of cross-border payments in the medium term, to reduce transaction costs and to intensify competition in international payments. CBDC systems will be designed to provide easy access to CBDC and are likely to increase financial inclusion in many countries, thereby broadening the scope for participation in payment transactions. CBDCs could also unfold their potential in cross-border payments in conjunction with other technologies. For example, linked eID ecosystems could reduce frictions with regard to compliance with financial sanctions as well as AML/CFT measures.

Multilateral cooperation preferable to a unilateral approach

A multilateral approach thus offers the best chance for CBDC to help comprehensively reduce the frictions currently constraining cross-border payments. Various central banks would collaborate in this endeavour: they would issue CBDC, which would held primarily in their own currency area but would allow cross-border payments through interoperability with other CBDC systems. This seems more advantageous than the option of individual central banks making their CBDC usable for cross-border payments unilaterally. Moreover, such an approach would not resolve existing frictions across national borders. If central banks were to even design their own CBDC in such a way that large amounts of it could be held abroad, this would harbour a number of economic risks – not least for themselves. And ultimately, such an approach could be seen as an attempt to create monetary policy or technological dependencies.

Costs of coordination make a globally uniform solution unrealistic

By contrast, were individual central banks to cooperate with each other, the question arises as to how CBDCs should be made interoperable. Any efficiency gains from a higher degree of integration generally come with higher coordination costs. Moreover, a growing degree of integration always implies the ceding of sovereignty, which means that efficiency gains must be weighed against other policy objectives. For example, a single, common worldwide CBDC platform involving a large number of currency areas from the outset is difficult to imagine at this juncture.

However, the combination of various, possibly hybrid approaches could be a more viable option. A high degree of interoperability is likely to be achievable among currency areas that are

48 See European Central Bank (2021).

A combination of hybrid approaches could provide the necessary flexibility

closely linked economically and politically, where the willingness to coordinate and compromise is comparatively high and the potential for conflict is limited. Regionally highly integrated systems of this kind could then be made compatible with one another or be interlinked. Ultimately, this would cover a large number of currency areas without having to enter into a multitude of bilateral cooperation agreements. That said, it remains crucial that interoperability has to be taken into account from the outset when designing CBDC.

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