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Central bank digital currencies:
Can central banks succeed in the marketplace for digital monies?

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Abstract

The discussion about central bank digital currencies (CBDCs) has gained impressive momentum. So far, however, the main focus has been on the macroeconomic implications of CBDCs and the narrow perspective of developing a digital substitute for cash. This paper adds the microeconomic dimension of CBDCs to the discussion. We provide an overview of the existing payment ecosystem and derive a systemic taxonomy of CBDCs that distinguishes between new payment assets and new payment systems. Using our systemic taxonomy, we are able to categorise different CBDC proposals. In order to discuss and evaluate the different CBDC design options, we develop two criteria: allocative efficiency, i.e. whether a market failure can be diagnosed that justifies a government intervention, and attractiveness to users, i.e. whether CBDC proposals constitute attractive alternatives to users compared with existing payment assets and payment systems. Our analysis shows that there is no justification for digital cash substitutes from the point of view of either allocative efficiency or the user. Instead, our analysis highlights the option of a retail payment system organised or orchestrated by the central bank without a new, independent payment asset.

Keywords: *central bank digital currency, central banks, payment systems, international payments, financial inclusion.*

JEL codes: *E42, E44, E52, E58, G21, G28.*

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1 Introduction

The discussion about central bank digital currencies (CBDCs) has gained **impressive momentum**. Auer, Cornelli and Frost (2020) report that as of mid-July 2020, at least 36 central banks have published retail or wholesale CBDC work. At least three countries have completed a retail CBDC pilot and six retail CBDC pilots are ongoing. Among the speeches by central bank governors and board members about CBDCs, there have now been more speeches with a positive than a negative stance. In October 2020, the European Central Bank (ECB) (ECB 2020) published a comprehensive report on "a digital euro" and in July 2021 the ECB (2021) announced the start of a two-year "investigation phase" with the "aim to address key issues regarding design and distribution". This investigation phase would then be followed by a three year development phase until a digital euro could be issued (Panetta 2021). However, as Panetta (2021) clarifies the ECB has not yet agreed whether or not to issue a digital euro: "[A] decision about whether or not to issue a digital euro will only come at a later stage."

With the introduction of CBDCs, central banks enter a completely new sphere. For decades they have lived the **"quiet life" of a monopolist** (Hicks 1935) supplying private households and firms with cash. This product offers properties that no other financial asset can offer: it is legal tender and it allows for completely anonymous peer-to-peer transactions. But with more and more sophisticated digital payment instruments and payment systems, central banks have realised that their unique position as monopolistic suppliers of cash is in danger of being undermined.

As a consequence, many central banks are now looking at offering a **digital substitute for cash**. For example, in its report on the digital euro, the ECB (2020, p. 4) notes: "A digital euro could be designed to replicate some key features of cash that are useful in the digital economy, such as the ability to make offline payments." [1]

While there is an intense debate on the macroeconomic implications of CBDCs, especially on the financial intermediation by banks and the risk of digital bank runs (Bindseil 2020), the **microeconomic dimension of CBDCs** has so far received very little attention. But this dimension matters, as the issuance of CBDCs in whatever form means a **fundamental change in the role of central banks**. As suppliers of cash they have not directly interfered with the business of banks and other payment service providers. In addition, there has hardly been any doubt that the issuance of cash should be under a government monopoly. Hayek's proposal for a denationalisation of money (Hayek 1976) was never considered a realistic alternative to the current monetary system.

As suppliers of CBDCs, central banks would start something new. They would actively compete with the products and services offered by commercial banks and other payment service providers. When central banks become additional players in the competition between private financial institutions, fundamental questions arise that have hardly been discussed so far.

[1] See also Auer and Böhme (2020, p.86): "The consumer's prime need is that CBDC embodies a cash-like claim on the central bank, ideally transferable in peer-to-peer settings."

- How can such an expansion of government activities be justified from the point of view of **allocative efficiency**? Is there an identifiable market failure that can justify a CBDC?
- In contrast to cash with its unique features, it is by no means certain that digital products and services offered by central banks that are similar to those offered by commercial banks and payment providers would meet **enough demand from the private sector**. It would be anything but beneficial for the **reputation of the central banks** if they were to develop a digital product that would not be able to assert itself on the market against private competitors.

In principle, the discussion of these two crucial questions should take place before any macroeconomic analysis. For if it should turn out that there is no justification for the creation of CBDCs from the point of view of allocative efficiency, or that CBDCs cannot compete in the marketplace, the macroeconomic dimension would become superfluous, at least from the standpoint of policy relevance.

Our paper tries to deal with the microeconomic deficit in the CBDC debate. In order to answer the two key questions, we first develop a **comprehensive taxonomy** of possible forms of CBDCs. It is characterised by the fundamental distinction between

- a CBDC as an innovative **payment asset** used in existing payment systems; and
- a CBDC as an innovative **payment system** based on CBDC payment assets.

The categorical separation between payment assets and payment systems, which is usually overlooked in the CBDC literature, opens the way for the option that central banks may develop **retail payment systems** that do not necessarily have an independent payment asset.

In this paper, we discuss and evaluate the different CBDC design options under **two criteria**:

- **Allocative efficiency**: Any government interference with the market process requires the **diagnosis of market failure** (Carletti et al. 2020). The burden of proof lies with the central banks. They have to show that the objectives which they pursue with CBDCs are currently not satisfactorily met by the market. And even if public goods like financial stability or stability of the payment system are not optimally met, it is not obvious that a CBDC is the appropriate solution.
- **Attractiveness to users**: If CBDCs are designed as new payment assets that are used within existing payment systems, the user perspective implies that CBDCs must compete with existing payment assets (above all cash and traditional bank deposits). If CBDCs constitute new payment systems, their acceptance by private users must be analysed within the context of the existing payments ecosystem. In both cases, CBDCs have to offer **unique selling propositions** vis-à-vis existing solutions to generate adoption by users.

The microeconomic approach in our paper makes it possible to **critically review** the activities of central banks to date. Is it really a question of creating a **digital substitute for cash** as a means

of payment, or does the challenge of digitalisation not consist of finding **alternatives to global payment systems** such as PayPal or, in the future, Diem?

The central message of our paper is that there is no justification for **digital cash substitutes** from the point of view of allocative efficiency and that such products, as they are currently being discussed by central banks, would most likely not be widely accepted by private households and businesses.

In contrast, a clear market failure can be identified for **global payment networks**, which are based on monopolistic or oligopolistic structures. However, the central banks' response would then have to be supranational rather than national. Moreover, successful networks like PayPal show that such systems are not tied to a system-specific currency. The broad range of additional services such service providers offer to their customers shows that it will not be easy for central banks to develop an attractive alternative.

In **Section 2**, we begin with a short presentation of the **key features of the present payment ecosystem**. This leads to a **comprehensive taxonomy of CBDC design options**, which is characterised by the analytical separation between payment assets and payment systems.

In **Section 3**, we discuss the **two criteria for the evaluation of the CBDC design options**: allocative efficiency and attractiveness to users. We ask whether a market failure can be identified that would justify the supply of CBDC assets or the introduction of a retail payment system operated by central banks. From the user's point of view, the fundamental problem with all CBDC options is that their unique feature, absolute security, is irrelevant for most private households. Since balances at commercial banks are covered by deposit insurance up to EUR 100 000, there is no incentive for the most important target group of CBDC initiatives to open an account at the central bank for reasons of security.

Section 4 analyses retail payment **CBDC assets without stand-alone payment systems**, i.e. CBDC assets that can be used within the existing payment systems. The potential for **token CBDCs**, which can be regarded as a digital substitute for cash, suffers from the tight legal restrictions for e-money that aim at preventing money laundering and terrorist activities. Thus, it is unlikely that token CBDCs could become an alternative for cash, which today is especially attractive in the shadow economy and as a store of value in times of crisis. **Account CBDCs** without a stand-alone payment system would not be different from accounts held with commercial banks. If such CBDCs are designed with prohibitive interest rates, e.g. already for deposits exceeding EUR 3 000 (Bindseil 2020), and if they do not provide the broad spectrum of services that bank accounts typically offer, it is very unlikely that they would be met with great interest. In addition, there is no obvious market failure that could justify the provision of such assets and services by central banks.

Section 5 deals with **CBDC assets** that can only be used as a **store of value** so that only bilateral transactions between a commercial bank account and a central bank account are possible.

In the literature this variant of CBDC has not been discussed in detail. It is explicitly dismissed as central banks should not become financial intermediaries (Bindseil 2020). However, from an allocative point of view, store-of-value CBDCs could be justified with a **lack of "safe assets"** that only central banks can produce. Depending on the interest rate, they could be a very attractive asset for investors and firms with deposits exceeding EUR 100 000. With an auctioning mechanism central banks could perfectly control the amount of such CBDCs. Store-of-value CBDCs are especially relevant as **wholesale CBDCs**, i.e. as collateral for deposits held with payment service providers. While Alipay is already obliged to back its deposits fully with reserves held by the People's Bank of China, this approach could also be useful to keep Diem's activities under the control of central banks.

Section 6 discusses **stand-alone CBDC payment systems** that are based on CBDC assets. A relatively advanced model is the Swedish **e-krona** (Sveriges Riksbank 2018). The main problem with this system is its stand-alone architecture, which implies a **lack of interoperability**. Thus, a CBDC held with a central bank account cannot be used for payments outside the CBDC payment system. A related problem is the domestic range of this system and the focus on the national currency. In the case of a small country like Sweden, this must be considered a particular disadvantage. Hence, while the demand for CBDC payment assets is already likely to be small in general, the inability to make direct payments to commercial bank accounts makes it a non-starter. **The total neglect of the users' point of view** characterises the CBDC proposal by Kumhof and Noone (2018). In an attempt to design a scheme that cannot trigger digital bank runs, they propose a CBDC that is inconvertible in central bank reserves and commercial bank deposits. The projected **Diem system** (Diem Association 2020) would also suffer from a lack of interoperability, as payments are only possible from one Diem account to another. But in the case of Diem, the large number of Facebook users could at least partially compensate for this fundamental disadvantage.

The **"digital euro"** that the ECB (2020) has presented in an initial report is difficult to evaluate. It is so far not clear whether the ECB envisages the digital euro as a payment asset that can only be used in the existing payment systems or whether it should also be used in a stand-alone payment system. In the first case, the evaluation of Section 4 would apply and in the second the evaluation of Section 6. But without further details, a comprehensive assessment is not possible.

Section 7 discusses the option of a **retail payment system organised or orchestrated by central banks**. Such a scheme would not necessarily require central bank accounts for all. Successful payment systems like credit card systems and PayPal can operate payments without system-specific payment assets. Payers do not need positive balances on their account held with the system. In addition, such systems can operate international transactions where the currency of the payer differs from the currency of the payee. Thus, if central banks have the intention of developing an answer to the activities of international payment system providers, a completely different approach is required. Instead of a domestic solution that requires system-specific payment assets and is solely limited to the domestic currency, a **supranational multi-currency scheme** is required that can also deal with **accounts held with commercial banks**. As the example

of PayPal shows, a competitive global payment system must be capable of more than just the transfer of funds. It must offer a sophisticated bundle of services, especially for online trade. As it is questionable whether central banks are qualified to offer such products and services, one might envisage solutions where central banks orchestrate a payment system that is provided by private financial institutions.

2 A Systemic Perspective on CBDCs

2.1 The existing payment ecosystem

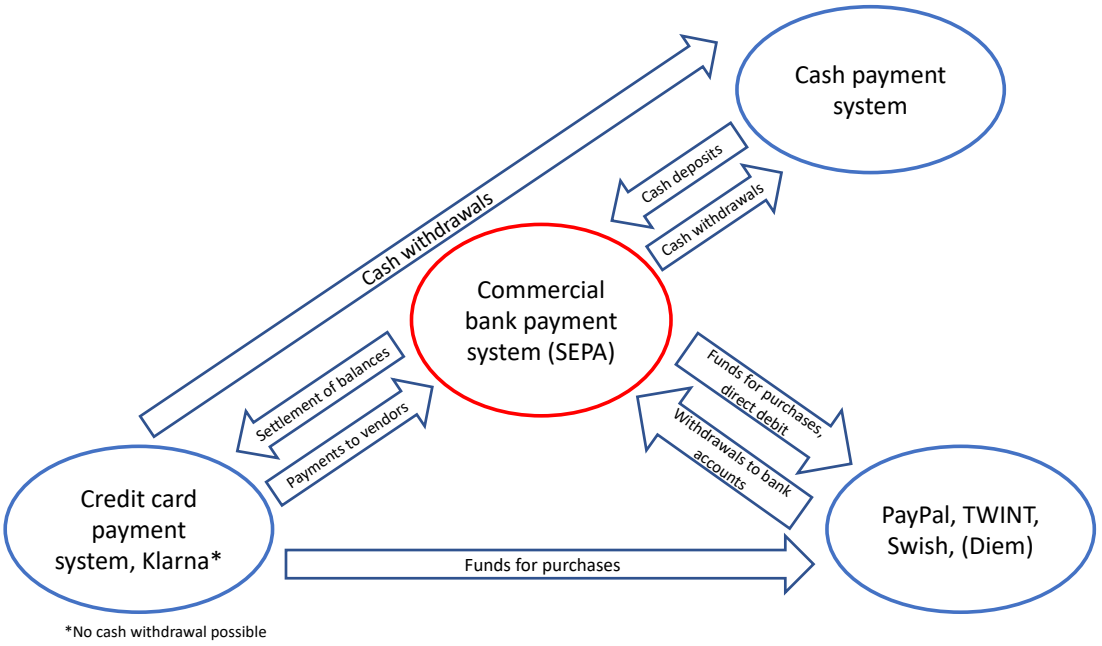
From a systemic perspective, CBDCs, however designed, constitute a new element or subsystem of the existing payment ecosystem. This suggests starting the discussion on CBDCs with a short presentation of the existing payment system.

Ugolini (2017, p.22) describes the payment ecosystem as follows:

> "(. . .) different payment systems actually coexist (often concerned with transfers of different nature, like credit card networks, derivatives clearinghouses, or foreign exchange markets), but it is the interaction among all of them that constitutes the economy's payment system proper. As hierarchies play a crucial role in networks, not all of the "regional" components will play an equally important role in the "global" architecture of the system. In the case of the payment infrastructure, the "core" of the system consists of the wholesale interbank network, to which "peripheral" components necessarily need to be connected in order to work efficiently."

The fact that there are different subsystems in the existing payment ecosystem can be ascribed to the concept of **unique selling propositions** of the individual subsystems. In principle, almost all financial services can be provided by the commercial bank payment system. The stable coexistence of the other subsystems shows that these must have unique selling propositions vis-à-vis other payment systems that ensure their persistence.

Figure 1: The existing payment ecosystem



Source: Bofinger and Haas (2021)

Cash payment system: As a means of regular payment, the unique selling position of cash is dwindling. However, for the US dollar, the yen and the euro, the circulation of currency relative to GDP has increased over the past two decades. The growing demand for cash reflects above all its advantages as a means of payment in the shadow economy. In addition, cash also has its attractiveness as an absolutely safe store of value, especially for amounts that go beyond the EUR 100 000 threshold, below which deposits are protected by deposit insurance. But even in the case of regular retail payments there are private households that prefer the anonymity of cash over digital payments.

Credit card payment system (Visa/Mastercard/Klarna): This system has the specific advantage that credit cards of the big providers can be used globally and with multiple currencies. This is also the case with bank cards issued directly by banks (Maestro), but their global acceptance is significantly lower. In addition, providers of credit cards also allow for short-term overdraft facilities and consumer loans and offer bonus programmes (e.g. "Miles and More") or insurance services. Credit card payment systems do not require system-specific deposits as they access bank deposits for settlement. Klarna's attractiveness derives from its relatively generous credit facilities.

PayPal: While central banks often explain their CBDC engagement with the risks associated with Facebook's Libra/Diem project, they almost never refer to PayPal. That is surprising, as the PayPal payment system has experienced impressive growth over the years which can be explained

by its attractive features:

- It is very user-friendly and easy to handle (no IBAN, no TAN) and allows for fast and costless P2P transactions.
- It operates globally and is able to transact with a variety of currencies.
- Non-commercial users do not have to pay fees, except for transactions with different currencies.
- It offers insurance services for consumers and vendors in online trade as well as loans to consumers and vendors and marketing services for vendors.
- It is possible to hold deposits directly with PayPal. But transactions can also be made whereby PayPal accesses a credit card account or bank account for settlement. Thus, as in the case of credit cards, system-specific deposits are not required.

TWINT: TWINT has emerged as "by far the most prevalent solution" (SNB 2021, p.33) of all installed mobile payment apps in Switzerland. While it has many similarities with PayPal, TWINT is a national alternative and thus only available in Switzerland. This has the advantage that TWINT works together closely with many national partners and offers services such as making restaurant reservations or paying for a parking permit via app. In addition to PayPal, TWINT can not only be used for online transactions but also at the point of sale in retail stores using QR-codes and in some cases also for offline payments (TWINT 2021).

This coexistence of the subsystems with the commercial bank systems provides a certain degree of competition. If one subsystem charges fees that are too high, customers can switch to the commercial bank payment system or another subsystem. The strong growth of Klarna or TWINT shows that it is still possible for new competitors to enter the market successfully. However, unique selling propositions are required for new competitors to assert themselves in the ecosystem.

2.2 The constituent elements of the payment system

After describing the existing payment ecosystem, a systemic analysis also requires a presentation of the essential features of this payment ecosystem. That enables the development of a comprehensive taxonomy of CBDC options. On this basis, one can discuss the innovations that central banks could introduce into this system with CBDCs. The constituent elements of payment systems can be classified as follows (Füssel and Kokkola 2010):

- a **network infrastructure** connecting payment institutions (banks and other payment service providers) for the transfer of funds from a payer to a payee, which can be a one-way or two-way transfer;

- **payment instruments** that connect payers and payees, as they trigger the flow of funds – cards, credit transfers, direct debits, and e-money;[2]
- **payment assets**, i.e. funds for settlement that are in the possession of the payer and that guarantee the finality of payments when they are received by the payee; and
- a **single currency or multiple currencies** in which the funds are denominated that can be used within the system.

Table 1: **The payment ecosystem and its constituent elements**

Payment system	**Market infrastructure**	**Payment instrument**	**Payment asset for settlement**	**Unit of account**
Cash payment system	Peer-to-peer Legal tender	Banknotes Coins	Banknotes Coins	National currency
Commercial bank payment systems	Euro area: SEPA/ TARGET/ SWIFT US: CHIPS/ Fedwire	Bank transfer Debit cards Cheques Mobile Payment	Bank deposits (between payer and payee) **and** Central bank reserves (between bank of payer and bank of payee)	SEPA: Euro CHIPS and Fedwire: US-Dollar Swift: Multi-Currency system
Credit card payment systems (Visa/ Mastercard/ American Express)	Systems have their own procedures for data transmission/ authorization/ clearing/ settlement	Credit cards Debit cards Mobile Payment Anonymous: e-money	Bank deposits (between payer and payee)	Multi-Currency schemes
PayPal	PayPal	PayPal-Transfer Mobile payments	Deposits on PayPal account or bank accounts (direct or indirect via credit cards)	Multi-Currency scheme
TWINT	TWINT	QR codes Mobile payments	Mainly bank deposits	National currency

Source: Authors.

The most basic payment system is the **cash payment system**. It has a decentralised network as funds are exchanged on a peer-to-peer basis. This informal network is supported by the legal tender status of banknotes. In this system, the payment instrument (i.e. banknotes or coins) is identical with the payment asset that is exchanged. The cash payment system is typically a one-currency system as banknotes can only be used within their own currency area. The role of the US dollar as a parallel currency in countries with weak domestic currencies is an exception.

[2]This follows the ECB's definition of payment instruments: "Payment instruments and schemes are an essential part of payment systems. Cards, credit transfers, direct debits and e-money are non-cash payment instruments with which end users of payment systems transfer funds between accounts at banks or other financial institutions." (ECB n.d.). A different definition is used by BIS (2020, p.3): "A CBDC is [a] digital payment instrument, denominated in the national unit of account that is a direct liability of the central bank."

Today, the most widely used payment system is the **bank-based payment system**. In the euro area, the infrastructure for this system is provided by SEPA and the TARGET network, which is operated by the European Central Bank. In the United States, two networks coexist: Fedwire is operated by the Federal Reserve Banks and CHIPS is operated by the banking system. A characteristic of this payment system is that it can be used with a variety of payment instruments. In addition to traditional instruments like bank transfers and cheques, payments can be triggered by bank debit cards and mobile payments. The funds that are exchanged are bank deposits and central bank reserves: the bank deposits of the payer decline and the deposits of the payee increase. If the payer and the payee have their accounts with different banks, the exchange of deposits is paralleled by an exchange of central bank reserves between the bank of the payer and the bank of the payee. In the euro area, this exchange is provided by the TARGET system. TARGET and Fedwire are one-currency systems.

Credit card payment systems play an important role in national and international payments. These systems (Visa, Mastercard, American Express) are typically one-way systems from the purchaser of a product to the seller and have their own infrastructures for data transmission, authorisation, clearing, and settlement. They offer debit and credit cards as well as mobile payments as payment instruments. The funds that are used for settlement are bank deposits. In the case of credit cards, an immediate settlement is not required. When prepaid cards (electronic money) are used, credit card payment systems can also be used without a bank account. In contrast to bank-based payment systems and the cash payment system, credit card systems are multi-currency systems.

A more recent development is the **PayPal payment system**. It began as a payment system for eBay but it is now a completely independent international payment system. Compared to bank accounts, PayPal accounts can be opened without information on the identity of the owner. Only an email address and phone number are required. Compared to credit card payments, PayPal is a two-way system and the payee does not require specific interfaces and a contractual relationship with PayPal. PayPal payment instruments are internet transfers and mobile payment solutions. In addition, PayPal uses credit card systems and bank-based systems for the transfer of funds. PayPal settlements can be made with deposits held with PayPal, but also with bank deposits. PayPal also allows for multi-currency payments and to hold deposits in different currencies. A more detailed discussion of PayPal will be provided in Chapter 7.3.

Similar to PayPal, **TWINT** has emerged as a popular payment solution, albeit it is not a multi-currency payment system but only a single currency payment system available in Switzerland. Similar to PayPal, TWINT offers its users the option to hold deposits directly with TWINT. However, holding system-specific deposits is not necessary to use TWINT, as settlements can also be made with bank deposits. As TWINT uses QR codes and their mobile app as payment instruments, it can also be used in retail stores at the point of sale.

In sum, the current payment ecosystem is characterized by a coexistence of a purely public payment system (cash payment system) with a purely private payment system (PayPal). The bank-based system is a hybrid, as it uses private bank deposits and central bank reserves as funds and the interbank payment network is provided by the central bank. In credit card systems the role of the state is reduced as the infrastructure is private and bank deposits are required only for the monthly settlement of balances.

Thus, if cash is no longer used for payments, this **does not imply that central banks have no more influence** on the payment systems. That would only happen with a declining role of the bank-based system which relies on central bank reserves and the real-time gross settlement (RTGS) system provided by the central bank. In other words, the real threat to the role of central banks in payment systems is not the decline in cash usage. It is the emergence of private payment systems like PayPal and possibly Diem. They could lead to closed payment systems that no longer rely on traditional bank deposits and subsequently on a central bank-operated payment network.

Box 1: "Digital currency areas": A useful concept?

The presentation of the existing payment ecosystem shows that a payment system does not need its own currency and that the same payment instruments, i.e. mobile payment solutions, can be used in different payment systems. This contradicts the views of Brunnermeier, James and Landau (2019, p.14) who argue that "a digital currency is inseparable from the characteristics of the platform on which it is exchanged". Furthermore, they "define a digital currency area as a network where payments and transactions are made digitally by using a currency that is specific to that network" (Brunnermeier, James and Landau 2019, p.19). "Specific" in this context is defined as either an "own unit of account" used by the network or the network operating a medium of exchange "that can only be used inside, between its participants" (Brunnermeier, James and Landau 2019, p.19).

As credit card systems and PayPal show, payment platforms are typically **multi-currency platforms**. Thus, they are able to perform payments between different currency areas. As our taxonomy above shows, some networks/payment systems (e.g. the PayPal system) can operate with multiple payment assets (PayPal deposits and bank deposits) whereas some payment assets (e.g. bank deposits) can be exchanged on multiple payment systems (e.g. commercial bank payment systems and credit card payment systems).

The development of the **Diem** project also reflects the insight that payment platforms do not need their own currency. The first white paper was based on the notion of a platform-specific currency, where Diem was to be designed as a basket of existing national currencies. This approach was in line with the definition of "digital currency area". However, the second white paper announced that in addition to issuing one global payment asset they would issue Diem-denominated ones in individual existing currencies, e.g. a euro-Diem, dollar-Diem or yen-Diem (Diem Association 2020). The single-currency Diems and multi-currency basket Diem are both compatible with the same (Diem-)payment system. The payment instruments (e.g. Diem wallets) are again independent of the unit of account of the payment assets.

Bitcoin is an exception as this platform can only operate with deposits denominated in Bitcoin. However, the role of Bitcoin as a global payments system is very limited compared with Visa, Mastercard or PayPal.

In addition, we use the term "payment instrument" differently from Brunnermeier, James and Landau (2019) as we differentiate between payment instruments (e.g. a credit card) and payment assets (e.g. a deposit on a bank account).Brunnermeier, James and Landau (2019, p.5) use the term **"payment instrument"** for what we would refer to as a payment asset:

> "We say a collection of payment instruments form an independent currency if the following two conditions hold:
>
> (i) The payment instruments are denominated in the same unit of account.
>
> (ii) Each payment instrument within the currency is convertible into any other"

Using the term "payment instrument" for payment assets has the problem that there is no specific term for what we (and the ECB) call payment instrument.

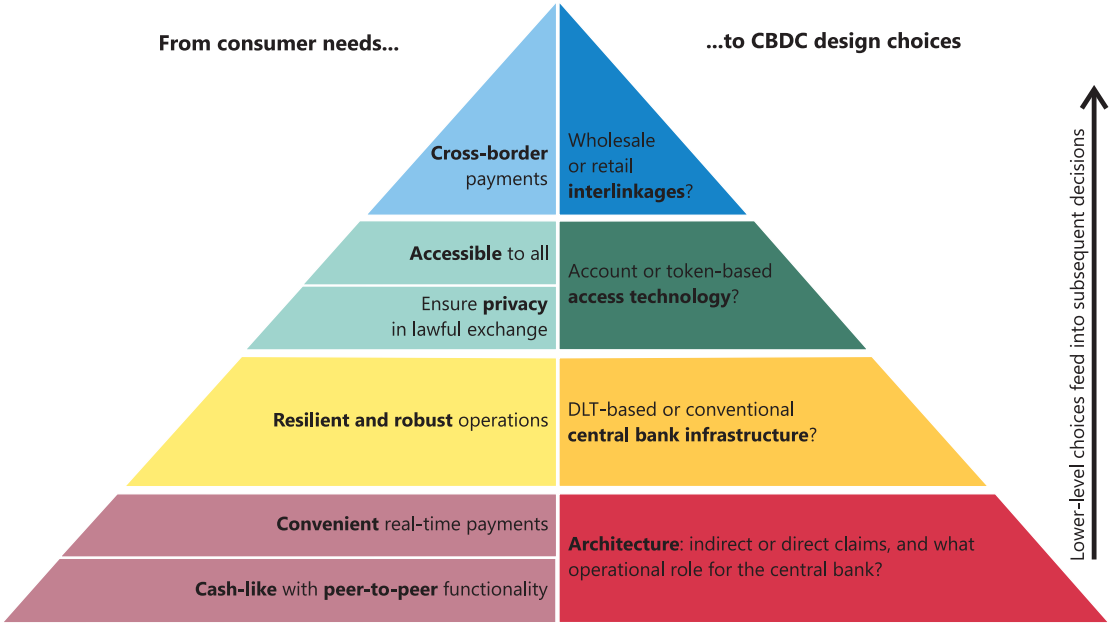
2.3 A systemic taxonomy of CBDC

The central banks' discussion about CBDCs is strongly influenced by the idea that the primary goal must be to develop a substitute for cash. The pyramid developed by Auer and Böhme (2020, p.87) (Figure 2), which is based on the property "cash-like with peer-to-peer functionality", reflects this focus on cash. In our view, this has narrowed the discussion on CBDCs. It has led to the implicit assumption that payment systems and payment assets coincide. An example is the following statement by the ECB:

> If industry efforts fall short of developing an innovative and efficient pan-European payment solution, the social need for it could potentially be met by issuing a CBDC. For instance, a CBDC with the status of legal tender could guarantee that all users have, in principle, access to a cheap and easy means of payment. ECB (2019*a*, p.3)

Thus, as a response to the challenge of global payment systems, the ECB seems to believe that it is sufficient to offer a new payment asset. But outside the cash payment system, there is no natural coincidence of payment systems and payment assets. As we have shown in Section 2.2, successful payment systems have the ability to deal with different payment assets that can also be denominated in different currencies. Therefore, for a comprehensive analysis of CBDCs the differentiation between payment asset and payment system is of crucial importance.

Figure 2: The CBDC pyramid



The CBDC pyramid maps consumer needs (left-hand side) onto the associated design choices for the central bank (right-hand side). The four layers of the right-hand side form a hierarchy in which the lower layers represent design choices that feed into subsequent, higher-level decisions.

Source: Auer and Böhme (2020, p.87)

From the systemic perspective, CBDC concepts can be presented in two separate but interrelated ways. CBDCs can be discussed from the perspective of

- **new payment or settlement assets** made available by central banks to the broader public that are used within the existing payment systems; and
- **new payment infrastructures or systems** operated by central banks.[3]

Combining these two dimensions leads to the institutional arrangements for CBDCs shown in Table 2:

Table 2: **Options for digital central bank projects**

		New payment system operated by central banks	
		No	Yes
New central bank payment assets	No	Status quo	Central bank digital retail payment system
	Yes	CBDC: Bindseil (2020) "direct CBDC"	e-krona, Kumhof and Noone (2018)

Source: Authors.

Some CBDC proposals, e.g. the proposal by Bindseil (2020), envisage the creation of a new payment asset that would be used in the existing payment systems. Under such an arrangement, which Auer and Böhme (2020) label as "direct CBDC", central banks would assume some functions of a commercial bank and compete with existing commercial banks.

The e-Krona (Sveriges Riksbank 2018) and the proposal by Kumhof and Noone (2018) envisage the creation of a new payment system within which the new CBDC payment assets can be used. These solutions compete with private retail payment systems. The proposal by Kumhof and Noone deliberately excludes the convertibility between CBDCs on the one hand and traditional bank accounts and central bank reserves on the other hand.

The "digital euro" project of the ECB is difficult to classify. As we discuss in Section 6.1, it is not clear, whether the ECB only envisages a new payment asset or whether it also plans to establish a new payment system.

From the perspective of central banks' control over the monetary sphere and the safeguarding of efficient payment systems, our systemic approach opens the view for solutions where central banks concentrate on **competing with private payment service providers** (e.g. PayPal) by establishing a new retail payment system (a central bank system for digital retail payments). For this approach it is not required that central banks issue new payment assets. The decision by 16 European banks to launch the **European Payments Initiative** can be regarded as a privately organised alternative. The initiative aims to create a unified payment solution for consumers and

[3] A similar differentiation is made by the Bank of England (2020, p.25): "There would be two main elements to any CBDC: (1) the CBDC itself (i.e. access to a new form of central bank money) and (2) the CBDC infrastructure that allows CBDC to be transferred and used for payments."

merchants across Europe, encompassing a payment card and a digital wallet and covering in-store, online and person-to-person payments as well as cash withdrawals (European Payments Council 2020).

2.4 CBDC as payment objects

For a comprehensive taxonomy, **different design options for CBDC assets** must be considered. We differentiate between "token-based" and "account-based" CBDCs as well as "payment" and "store-of-value" solutions as set out below.

- **"Token-based CBDCs"** are a substitute for cash. They are deposits stored on cash cards or other electronic media (wallets) that enable anonymous payments on a peer-to-peer basis. The ECB report envisages a digital euro which can be used offline.
- **"Account-based CBDCs"** are a substitute for cash but also for deposits held with commercial banks. They constitute deposits held in a central bank account. Among such CBDCs, one can differentiate between
    - deposits that can be used primarily for payments, but also (although only to a limited extent) as a store of value **("payment CBDCs")**; and
    - deposits that can only be used as a **store of value ("store-of-value CBDCs")** so that payments can be made only between the own traditional bank account and the CBDC account. In the literature, this CBDC option is not discussed explicitly. It underlies the concept of an "indirect CBDC" (Auer and Böhme 2020) where narrow banks hold deposits with the central bank in the form of 100% reserves. The same applies to proposals for synthetic CBDCs where a payment service provider uses CBDC accounts as backing for the deposits of its customers (Adrian and Mancini-Griffoli 2019).

A differentiation can also be made between "retail CBDCs" and "wholesale CBDCs":

- **"Retail CBDCs"** are generally accessible.
- **"Wholesale CBDCs"** are only available to selected users, such as larger companies or the operators of payment systems, which could thus offer 100% coverage by central bank deposits for balances held with them (synthetic CBDCs; Adrian and Mancini-Griffoli (2019)). It could also be used by **narrow banks**, which specialise in creating "safe assets" for depositors by depositing 100% of the deposits they receive with the central bank.

Table 3: **Design options for CBDC assets**

		Retail CBDCs	**Wholesale CBDCs** (Large companies and payment service providers)
Token-based CBDCs: (peer-to-peer payments)		Money cards ('e-money'), digital wallets	–
Account-based CBDCs	Means of payment	All-purpose CBDCs (Direct CBDC)	All-purpose CBDCs
	Store of value	Store-of-value CBDCs ('safe assets')	CBDC as trust accounts for payment service providers

Source: Authors.

By combining Table 2 (differentiating between payment systems and payment assets) with Table 3 (design options for CBDC assets), a comprehensive taxonomy of CBDC design options can be derived (Table 4, in the Appendix). As our presentation of the existing payment ecosystem shows, unique selling propositions are required in order for new competitors to assert themselves in this system. Thus, as we show in the subsequent sections, any proposal for a CBDC always means that the central bank enters a competition with existing market participants:

- a **retail payment CBDC** (a token CBDC or account CBDC) **without** a stand-alone payment system competes with private bank accounts (Section 4)
- a **store of value CBDC** (retail, for deposits exceeding EUR 100 000 and wholesale) **without** a stand-alone payment system competes with private bank accounts (Section 5)
- a **retail payment CBDC** (a token CBDC or account CBDC) **with** a stand-alone payment system competes with private retail payment systems (Section 6)
- a **central bank operated retail payment system** without new payment assets competes with payment service providers (Section 7)

The taxonomy makes it possible to classify concrete CBDC proposals and to evaluate them in a systematic way.

3 Evaluation of CBDC design options

For our microeconomic evaluation, we use two criteria. From an allocative point of view, one has to ask whether a market failure can be identified that justifies the supply of a specific CBDC design option by the central bank. From the users' point of view, we ask whether a specific CBDC design option is able to compete successfully with existing payment assets and/or payment systems.

3.1 An allocative perspective on CBDC

With each form of payment CBDC, central banks would compete with commercial banks or other payment service providers. Token CBDCs are a substitute for prepaid cards, which are offered by private companies. Account CBDCs are a substitute for traditional bank deposits. If central banks develop a separate CBDC payment system, it is a substitute for private payment system providers. If central banks decide to create a new retail payment system without a system-specific payment asset, they will compete with credit card systems or payment service providers like PayPal.

Some CBDC proponents, e.g. Bindseil (2020, p.26), do not consider the competition between the central bank and private financial service providers a major problem:

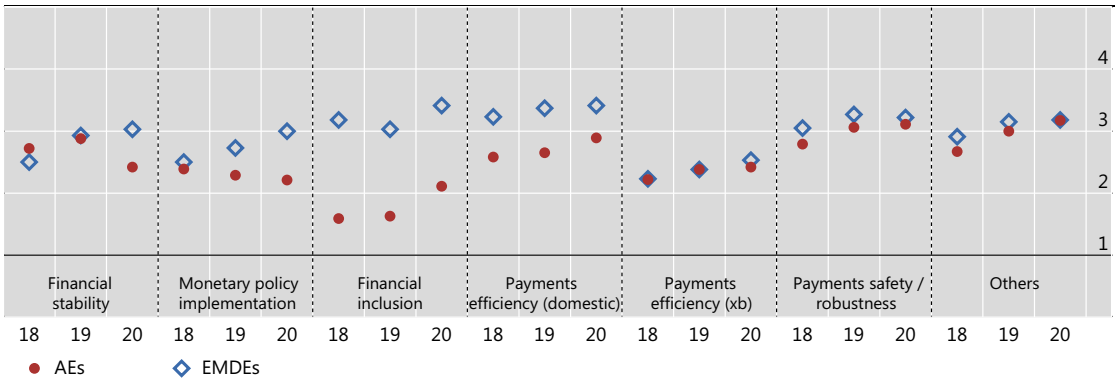
> In the long run, this should however not matter, i.e. if the provision of certain services is possible at low unit costs for CBDC accounts also because of the large number of accounts, then the central bank may conclude that it is legitimate to offer these services, even if it is in competition with commercial banks.

In the following subsections, we discuss the main arguments and motives of central banks for the introduction of CBDCs from the perspective of a possible market failure that could justify such activities.

3.1.1 Stability and efficiency of the payment system

The survey by Boar and Wehrli (2021) shows that central banks consider CBDCs an opportunity to increase the stability and efficiency of the financial system, to improve financial inclusion, and to create new forms of monetary policy implementation, thereby strengthening control over the monetary policy transmission mechanism (Figure 3).

Figure 3: Motivation for central banks for issuing CBDC



(1) = "Not so important"; (2) = "Somewhat important"; (3) = "Important"; (4) = "Very important".

Source: BIS central bank survey on CBDCs.

Source: Boar and Wehrli (2021, p.7)

While these are obviously important public goods, it is not clear whether there are currently major problems with these goals and if so, whether CBDCs could contribute to better performance. The lack of a convincing justification for CBDCs has been described very clearly by Panetta (2018, p.5):

> But the set of tools that permit almost frictionless and instantaneous payments is already large: today we can make a digital payment by wire transfer (through online banking), with credit or debit cards, using Paypal or Apple pay (to name just a few); we can do it via computers, smartphones or smartwatches, by simply putting our wrist close to a point of sale. Competition in the supply of payment services is already high, and the efficiency of the system will increase with the introduction in many jurisdictions of instant payments – yet another alternative to cash. From this vantage point the advantages of a CBDC are at best unclear: its potential benefits in terms of improving the ease of transactions are probably insufficient to justify the involvement of central banks in an activity that is well served by private suppliers.[4]

Given the prominence of these targets as motivation for central banks' CBDC efforts, it is surprising that so far, no attempt has been made to **identify specific problems in the international payment landscape**. In addition, the growing CBDC literature has so far not explicitly discussed how CBDCs could contribute effectively to possible flaws in this landscape.

[4]This view is also shared by the BIS (2020, p.16): "Today, vast sums flow within and between economies every day using the arrangements already in place. With a mandate for stability, central banks' introduction of CBDC should complement these preexisting systems. In broad terms, these pre-existing domestic retail payment systems work well. In the jurisdictions of the central banks contributing to this report, the current systems offer low-cost, fast and safe payments domestically through a mix of commercial banks, other payment service providers and cash." See also the Bank of Canada: "we have concluded that there is not a compelling case to issue a CBDC at this time. Canadians will continue to be well-served by the existing payment ecosystem, provided it is moderni[s]ed and remains fit for purpose." (Lane 2020, p.5)

3.1.2 Declining role of cash

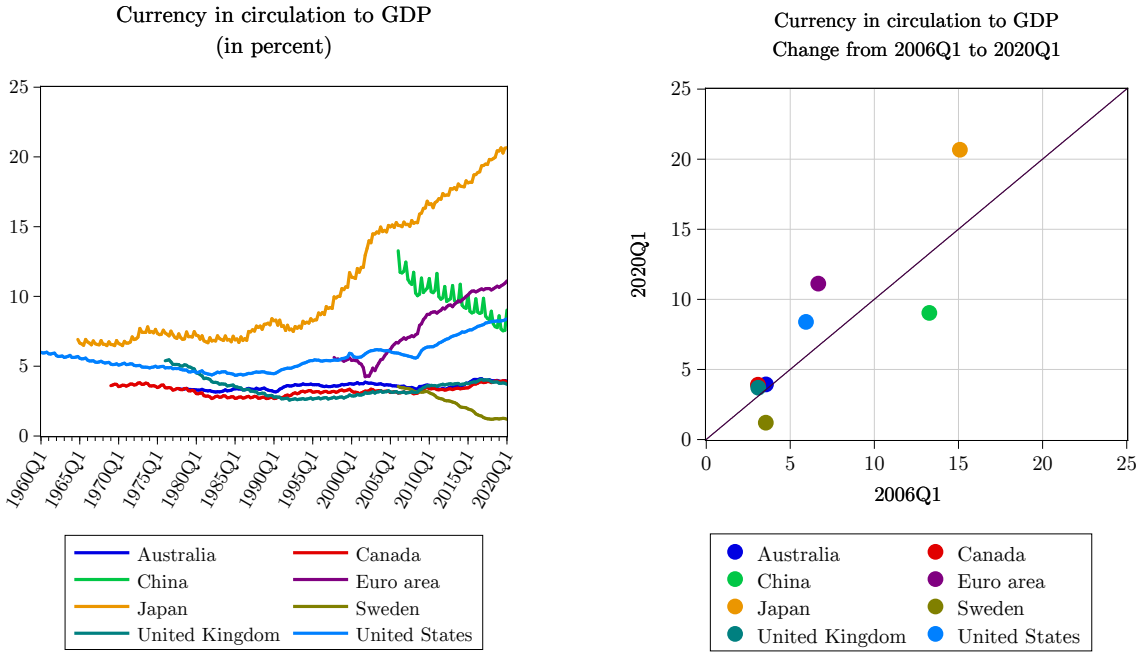
The most important motivation for central banks' CBDC initiatives seems to be the **declining importance of cash** as a means of payment. This explains the specific efforts of the Swedish central bank, which is facing a significant decline in the amount of cash in circulation. But with an increasing digitalisation of the entire economic system, a declining role of cash in payment transactions is by itself not yet an obvious problem that would require a CBDC in the sense of remedying a market failure. The ECB (2020, p.10) states:

> A decline in the use of cash in the economy would imply increasing dependence on private forms of money and private payment solutions in the euro area. Beyond a certain point, such a trend could endanger the sustainability of the cash infrastructure and hamper the provision of adequate cash services. European citizens would thus encounter difficulties in accessing the only means of payment that is provided by the public sector and that takes account of their needs, regardless of any commercial perspective.

However, so far there is **no evidence of a widespread collapse in the demand for cash**. On the contrary, as Figure 4 shows and in line with the analysis by Bech et al. (2018)), in advanced economies the relation of cash to GDP has even increased in the past decades. Sweden is obviously an outlier.[5] Similarly, the developments in China can also be regarded as an exception as we discuss below.

[5] Armelius, Claussen and Reslow (2020): "rather than being ahead of the curve, a unique combination of events and policy measures have led to the falling cash demand in Sweden."

Figure 4: Cash demand across countries



(a) Cash to GDP ratio (in percent)

(b) Change in cash to GDP

Source: National central banks, FRED St. Louis FED, Bank for international Settlement, own calculations

But even a collapsing demand for cash would not justify the introduction of a CBDC. As long as cash is not abolished altogether, CBDCs are not required to maintain the access of private households and firms to the central bank balance sheet. Of course, with a very low demand for cash in normal times private suppliers could no longer be willing to support an effective nationwide **infrastructure for cash withdrawals**. In this case, central banks would have to subsidise such a network as a public good.[6]

A case in point is a **Swedish draft law**[7] requiring credit institutions and branches that provide payment accounts with basic functions to consumers in Sweden to provide adequate cash withdrawal services to all consumers holding such accounts throughout Sweden. In an opinion of 26 November 2019, the ECB (2019*b*, p.3) explicitly "welcomes the core objectives of the draft law, namely to facilitate the continued use of cash in Swedish society by ensuring an adequate level of access to cash services throughout Sweden."

Auer and Böhme (2020, p.86) justify CBDCs with the risk that in crisis periods cash might no longer be generally accepted:

[6] In fact, the ECB (2020, p.19) considers subsidising intermediaries supplying CBDCs: "At this stage, it cannot be ruled out that the Eurosystem might even have to subsidise the services offered by these providers in order to ensure that the holders of digital euro do not have to bear any costs, by analogy, again, with the distribution of banknotes."

[7] Government Offices for Sweden, Govt Bill 2019/20:23 "Skyldighet för kreditinstitut att tillhandahålla kontanttjänster"

> Today, even consumers who normally prefer to pay electronically are confident that, if an episode of financial turmoil were to threaten, they could shift their electronic money holdings into cash. This flight to cash has been seen in many crisis episodes, including recent ones. The main concern is that if, in the future, cash were no longer generally accepted, a severe financial crisis might create further havoc by disrupting day-to-day business and retail transactions.

The evidence for this argument is not clear either. So far, severe economic crises have not affected the functioning of retail payment systems. As the authors state, the demand for cash typically goes up in crisis situations. Thus, it is not very likely that even with widespread digitalisation, retailers would repudiate cash payments. On contrary, the **"flight to cash"** would incentivise cash payments. If the crisis has the effect that electronic payment systems are temporarily not functioning, this will also affect CBDC payments. The only way to avoid this would be a completely isolated CBDC payment system. While this would be useful in an extreme **emergency situation**, it is a severe disadvantage in normal times. But as the Bank of England (2020, p.16) states, "CBDC would still be vulnerable to a large-scale outage of electricity and data networks, unless some kind of offline payments functionality is developed".

For this reason, the ECB (2020, p.33) is considering an offline version of the digital euro. "A digital euro based on infrastructures existing in parallel to those of other payment solutions could help to withstand extreme events such as cyber incidents and attacks, natural disasters, and pandemics."

However, it is not clear why in **extreme situations** an offline e-euro would be more useful than cash. The cash payment system has the advantage that it does not even require electricity. And for cash as well as an offline digital euro asset, payments in extreme events are only possible if sufficient precautionary holdings have been built up in normal times.

While central banks in advanced economies envisage a coexistence of CBDCs and cash, the **People's Bank of China** is a special case as it explicitly aims at the abolition of cash. For example Yifei (2020) speaks of

> a pressing need to digitalise cash and coins (M0) because: i) cash and coin issuance, printing/production, withdrawal and storage are expensive; ii) cash and coin circulation is based on multiple layers; iii) cash and coins are not very convenient to use; iv) it is relatively easy to counterfeit cash or coins, and they are used anonymously and thus may be used for illegal purposes.

In China, the aim of **better monitoring private transactions** is obvious:

> (...) the operating agencies should submit transaction data to the central bank via asynchronous transmission on a timely basis. This would allow the central bank to keep track of necessary data to implement prudent regulation and crack down on money laundering and other criminal offences, as well as easing the workload for commercial banks. (Yifei 2020)

In sum, the declining role of cash in retail payments is not a compelling reason for the introduction of a CBDC. First, the evidence for major currencies shows that this does not imply that the overall demand for cash is declining. Second, the access to central bank money can be maintained, even if the demand for cash is very low. This requires that central banks safeguard a nationwide infrastructure for cash dispensers. Even if this might require subsidies, it would most likely be cheaper than the establishment of a stand-alone CBDC payment system. In extreme situations cash would still be superior to an offline CBDC, as cash payments do not even require electricity.

3.1.3 Competition with private currencies

The **activities of Facebook** with its Diem system are repeatedly mentioned by central bankers as an argument for the introduction of CBDCs. The ECB (2020, p.9) puts this as follows:"A digital euro could be issued (...) if there is significant potential for foreign CBDCs or private digital payments to become widely used in the euro area."

From the point of view of allocative efficiency, a market failure can be identified when it comes to payment service providers. The BIS (2020, p.5) notes:

> Payment systems, like other infrastructure, benefit from strong network effects, potentially leading to concentration and monopolies or fragmentation. Payment service providers have the incentive to organize their platforms as closed-loop systems. When a small number of systems dominate, high barriers to entry and high costs (especially for merchants) can occur.

But as we show in the following discussion, the appropriate response to such initiatives is not "central bank deposits for all" or a "digital euro". The solution is the introduction of a supranational payments system operated or orchestrated by central banks that does not necessarily require genuine payment assets and is not tied to a specific currency.

3.1.4 Fostering the international role of the euro

In its report on a digital euro the ECB (2020, p.14) argues that the introduction of a CBDC could help to foster the international role of the euro:

> The issuance of CBDCs by major foreign central banks could enhance the status of other international currencies at the expense of the euro. In such a situation, the Eurosystem might consider issuing a digital euro in part to support the international role of the euro, stimulating demand for the euro among foreign investors.

While the benefits of a stronger international role of the euro are not obvious, this aim could not be reached with a retail payment CBDC. There could be strong interest by foreign investors in keeping large amounts of money directly with the ECB. But this would require the willingness of the ECB to allow the use of a CBDC as a store of value. As we discuss below, the ECB is strongly opposed to the use of the digital euro as an investment vehicle.

Thus, except for network externalities there is no obvious market failure that would require central bank action. At the same time, it is not clear how specific CBDCs can make a substantial contribution to the goals that central banks want to achieve with a CBDC. This also applies to the reasoning of the ECB (2020, p.9) that a digital euro would support

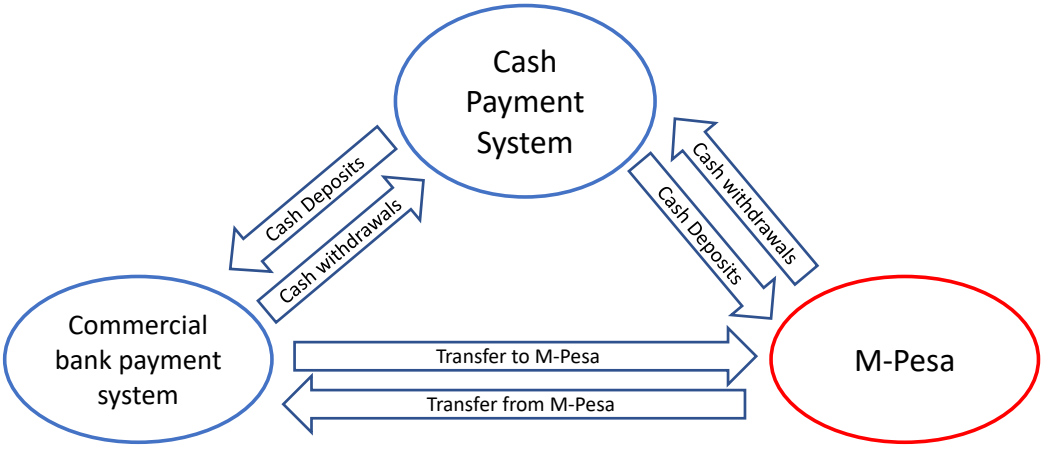
- "the digitalisation of the European economy" and
- "improvements in the overall costs and ecological footprint of the monetary and payment systems".

Box 2: CBDC and financial inclusion in emerging economies

Although this study is mainly concerned with CBDCs in advanced economies, the topic is also often discussed for emerging economies. As the BIS survey by Boar and Wehrli (2021) shows (Figure 3), for central banks in emerging and developing economies with often high shares of unbanked adults (Demirguc-Kunt et al. 2018), financial inclusion is the most important motivation for issuing a CBDC. However, in many countries, the market has already found a very effective substitute for the commercial bank payment system.

While access to the banking system may be limited, almost all people use mobile phones. This provides the basis for payment networks operated by mobile phone providers. The very successful M-Pesa system was launched in 2007 by Vodafone Group plc and Safaricom in Kenya. With local merchants and retailers as agents, it is not only possible to make transfers but also deposit and withdraw cash. In addition, such mobile payment methods offer an increasingly broader range of services including the provision of loans. These mobile payment systems are also connected and interoperable with the commercial banking system.

Figure 5: The payment ecosystem in emerging economies



Source: Bofinger and Haas (2021)

Given the growing role of such mobile phone-based systems in more and more countries (GSMA 2020), the need for a CBDC as an instrument for financial inclusion is not obvious. In addition, it would be impossible for central banks to establish a payment infrastructure that parallels the mobile phone infrastructure. Central banks need only to distribute SIM cards in order to reach out to citizens.

3.2 A user perspective on CBDC

In the intense discussion among central banks about CBDCs, the user perspective has remained largely unconsidered. As a rule, it seems to be taken for granted that any CBDC proposal would be readily accepted by private households and companies. However, this is anything but self-evident.

The user perspective has two dimensions:

- CBDCs as **new payment assets** would compete with existing payment assets, especially bank deposits and cash; and
- CBDCs as **new payment systems** would compete with traditional bank transfers, credit card networks and payment system providers like PayPal.

Of course, central banks could start to operate as fully-fledged online banks and offer the same services as the private suppliers at a lower price. This would enable CBDCs to penetrate the market quickly. From an allocative point of view, however, such a solution is not justifiable.

For the **reputation and credibility of central banks**, it is important that any CBDC solution is attractive enough for potential users to adopt it.[8] This is in line with the ECB's assessment that "if individual holdings of digital euro were too low, either because of rigid constraints or because of disincentives applied above a relatively low threshold, then the digital euro would be less attractive as a means of payment and less competitive than alternative instruments" (ECB 2020, p.18).

A unique feature that all CBDC assets can offer over traditional bank deposits is that they are a 100% **"safe asset"**. Yet, this advantage is only relevant for deposits above EUR 100 000, since up to this limit, bank deposits are also absolutely safe due to deposit insurance systems.[9] Thus, for the retail sphere, this key feature of CBDCs is of no relevance.

The allocative perspective and the user perspective make it possible to **evaluate the concrete CBDC design options** that we derived in our systemic taxonomy. Table 4 in the Appendix provides a comprehensive overview of the different proposals and their evaluation in terms of our two criteria, "allocative perspective" and "user perspective".

4 Evaluation of retail payment CBDC objects without a stand-alone payment system

The most basic version of a CBDC is a solution where central banks make new payment assets available that can be used like cash or commercial bank deposits within the existing payment

[8] The ECB wants to ensure "that payments in the euro area meet the highest standards and are conducted under its (the Eurosystems) direct control" (ECB 2020, p.12)

[9] Therefore, a CBDC is not needed to provide the general public with "safe money". If Armelius et al. (2020, p.81) "that it is simply a duty of the state to provide 100 per cent safe money" this is not necessarily an argument for CBDCs but for an effective deposit insurance scheme.

system. According to our taxonomy two design options can be discussed: a token CBDC and an account CBDC.

4.1 Token CBDC

A token CBDC is a substitute for cash as a payment asset. Without a stand-alone CBDC system, a token CBDC would be a form of electronic money (e-money) that allows users to make cashless payments with money stored on a card, a phone, or over the internet.

Tokenization of assets can to some extent be compared with **securitisation**. A token is a digital representation of an asset, good, right, or currency. Similar to securitisation, this enables the trade of ownership or part-ownership of the underlying asset. Although securitisation itself is not new, the encryption mechanism of distributed ledger technology could allow for a higher degree of anonymity. While the token is a unique representation of the underlying assets, the owner of the token remains anonymous. Thus, one can be sure about the validity of the token and avoid a potential "double-spending" problem, while preserving the anonymity of the owner. However, due to technological and legal restrictions, token CBDCs cannot mimic the anonymity features that cash payments provide as we discuss below.

From an **allocative perspective** the supply of digital cash by central banks could be justified as the provision of cash is one of their traditional core businesses. A CBDC would allow them to perform this function in an increasingly digitalised payments ecosystem.

From a **user perspective**, there are currently three motives for holding cash and using the cash payment system:

- Cash can be used for **regular payments and is widely accepted**.
- Cash can be used for **payments in the shadow economy** because of its anonymity
- Cash can be used as a **store of value** because of its safety. This function becomes especially relevant in a banking crisis (bank run) where people distrust the safety of bank deposits.

Although cash must be accepted as legal tender, contactless payments using radio frequency identification (RFID) technology and near-field communication (NFC) will speed up the decline of cash as a regular means of payment. The COVID-19 pandemic will accelerate this trend so that sooner or later the motive for using cash in regular payments will become irrelevant.

Therefore, the competition between token CBDCs and cash will concentrate on the two other motives. While it might be possible to design a token CBDC that allows **anonymous peer-to-peer payments**, it would never have the same degree of anonymity as cash.[10]

[10] Armelius et al. (2020, p.87) make the same point: "However, despite being bearer instruments, a token e-krona is digital and thus requires all transactions to be recorded in a register or a ledger to avoid the risk of fraudulent use or double spending. The ledger is in all relevant senses also a form of account. This is a contrast to other bearer instruments like cash which, once withdrawn, can circulate from user to user outside the banking system with no records of what it has been used for or by whom."

The Bank of England (2020, p.47) explains this as follows:

> In digital form, neither an account-based approach nor a token-based approach would enable cash-like transfers, where a payment can be made without reference to any third party or intermediary. In an account-based system, the accounts of the payer and payee need to be debited and credited by the operator(s) of the ledger. And in a token-based system, in order to prevent double-spending, ownership of tokens needs to be recorded in a ledger, which will need to be updated to reflect any changes in ownership.

In addition, there are strong **legal restrictions** that limit the potential of a token CBDC. With the 5th Anti-Money Laundering Directive, the conditions under which electronic money products can be issued anonymously are extremely strict (European Parliament and Council 2018; Schindele, Matthäus 2018):

- The maximum top-up amount for e-money that can be issued anonymously was reduced from EUR 250 to EUR 150. In addition, the maximum cash redemption amount was capped at only EUR 50. German legislators have set the limits at EUR 100 and EUR 20, respectively.
- Online payments conducted via anonymous electronic money products will not be allowed to exceed EUR 50.
- Acquirers may only process payments using anonymous prepaid cards from a third country if these cards were issued in the third country with similar restrictions.

Fernández de Lis (2018, p.50) describes the trade-off for central banks as follows:

> It is very difficult that the same central banks that require commercial banks to implement costly mechanisms to prevent money laundering and the financing of terrorism (the AML/CFT regulation) are issuing at the same time the means to carry such activities. One may argue that this is already the case with cash. But anonymity is intrinsic to cash, whereas in the case of CBDCs it would be a deliberate decision.

Accordingly, in its e-krona project, the Sveriges Riksbank (2018) explicitly states that its token-based CBDC should be traceable. The only exception for non-traceable transactions are cash/prepaid cards, "used as cash and handed over from one user to another" (Sveriges Riksbank 2018, p.16).[11]

With these tight restrictions, it seems unlikely that token CBDCs would be used on a large scale as a **store of value** in general or in times of crisis.

The prospects for account CBDCs in **offline payments** as envisaged by the ECB (2020) and BIS (2020) are also questionable. are also questionable. If cash is still provided to the public, offline

[11] The ECB (2020, p.30) makes a similar statement: "In the case of payments using bearer instruments, the central bank's requirement that only legally entitled users participate in a transaction would mean that all payment devices would require users to validate their identities. The device could, for instance, record information on physical attributes of the intended user (known as biometrics, e.g. fingerprint and iris recognition) and the user must provide matching elements when initiating a payment."

CBDCs constitute to some degree a parallel structure to the cash payment system as well as to that of other electronic payment solutions (ECB 2020, p.34). It is difficult to identify unique selling propositions of an offline CBDC vis-à-vis the cash payment system or digital payment systems such as bank cards. With respect to usage for regular payments, several effective digital solutions for payments are available already. And it is not very likely that people who still prefer cash for regular payments would adopt a digital euro. With respect to anonymity and the function as a safe asset, the anonymity of a digital euro can never be as perfect as it is with cash. Similarly, as some payment details have to be recorded, e.g. in the case of retailers for tax reasons, it is not clear that the recording of data by a commercial bank is worse than the recording of data by a central bank. Rigid limitations due to anti-money laundering (AML) or countering the financing of terrorism (CFT) rules limit the use as a store of value and for payments in the informal sector. As discussed above, especially in the case of extreme events, the robustness of an electronic device that also works offline compared with cash is uncertain and it is at least unclear why an offline CBDC solution is preferable to cash, as long as cash remains legal tender and can always be deposited in one's bank account or perhaps in a future CBDC account. While cash is currently broadly accepted, offline CBDC solutions would likely require sellers to obtain additional devices. Cash and offline CBDC solutions both require the user to transfer funds to their wallets or withdraw cash from bank accounts in order to use these payment solutions. For everyday transactions this implies additional transaction costs due to the parallel account structure, which can be avoided by using a bank card.

In sum, the case for token CBDCs is not very clear. For regular payments, very convenient digital payment systems are already available as a digital alternative to cash and the cash payment system. For payments in the shadow economy and as a store of value, the existing regulations make it very unlikely that token CBDCs could become an attractive substitute for cash as long as cash is not totally abandoned.

Box 3: "The digital, programmable euro": A use case for CBDC?

The FinTech Council (2020) of the German Ministry of Finance has developed the model of a "digital, programmable euro" based on a blockchain which could be issued as a CBDC.

In their report on a programmable euro, the FinTech Council lists several reasons for a programmable digital euro based on blockchain technology: enhancing fast (cross-border) payments, automation, allowing for micropayments, integration of payment and compensation (delivery versus payment), digital representation of values/rights, and improving overall IT stability. Furthermore, they argue that only blockchain-based systems are able to achieve all of these simultaneously.

But as a report by the BIS (2016) shows, the development and implementation of fast payment systems is proceeding quickly and reduces delays between payment initiation, execution, and finalisation. In their report on distributed ledger technology (DLT), the BIS (2017, p.12) even notes that: "(...) DLT arrangements may take longer to achieve settlement when compared with real-time gross settlement (RTGS) systems". It is also not clear whether DLT improves cross-border payments. The BIS (2018, p.29) argues that

> [r]ecent studies of the application of this technology to payments by central banks and others have identified a number of technical, legal and regulatory obstacles that will take time to overcome. It could thus be a while before the use of DLT results in significant improvements to cross-border retail payments.

Apart from faster payments, the report of the FinTech Council (2020) remains rather ambiguous on the applications and benefits of programmable money. Nor is it clear whether DLT is a prerequisite or whether existing payment systems could also allow for these applications. For example, micropayments appear to be more of a legal question. Technically, payments with very small amounts of money are possible already within existing payment systems. Programming tokens so that they can be spent only for certain products would not require a programmable euro. It would be necessary to classify and label all products. But then the payment could be made with cash cards or account-based CBDCs with existing payment systems.

In sum, the existing payment systems already allow for fast payments and for programmable payments (e.g. in the case of limit orders). While fast payment systems are already operating in several countries, the blockchain so far still has to prove its capability to work efficiently as a large-scale payment system. At the same time, the authors of the report do not elaborate in detail how the programmable digital euro could provide a concrete contribution to the targets that they enumerate in their report.

Finally, the report leaves open which specific role CBDCs should play in this regard and why private suppliers might not also be able to provide a "digital, programmable euro".

4.2 Account-based CBDCs without new payment system

For the sake of analytical clarity, we discuss in this section a model where a CBDC is offered as a deposit with the central bank, but it is still used within the existing RTGS system. In Section 6 we discuss CBDC options with a stand-alone payment system, especially the Swedish e-krona proposal. With the digital euro of the ECB it is not clear whether it envisages a stand-alone payment system or not. Without a stand-alone payment system, the following analysis, which discusses the CBDC model developed by the ECB Director General Ulrich Bindseil (2020), would also apply to the digital euro.

The Bindseil proposal is designed in a way that the usage of CBDCs as a store of value is strongly discouraged. Therefore, it envisages a **two-tier structure for the remuneration of CBDCs**:

- for **deposits of up to EUR 3 000** the interest rate would equal the rate of remuneration of excess reserves, but with a zero lower bound applying; and
- for **deposits exceeding EUR 3 000** the interest rate would be two percentage points below the remuneration of excess reserves, but with zero as a ceiling.

This mechanism should ensure that a CBDC is attractive as means of payment for private households, as a tier-one CBDC is remunerated with a competitive rate. The store-of-value function would be assigned to tier two and would be disincentivised through a prohibitive remuneration rate. With the EUR 3 000 threshold this CBDC option would not be attractive to firms.

Bindseil justifies the prohibitive rate for the store-of-value function with the argument that central bank money should not become a large-scale store of value. This would imply that the central bank becomes an investment intermediary of the economy, for which it is not particularly qualified. Apart from the disintermediation problem, another macroeconomic implication of CBDCs often mentioned is the enhanced risk of digital bank runs. However, in the event of a banking crisis, the tier-two interest rate would be insufficient for preventing digital bank runs. If investors fear large-scale losses, even very low annual interest rates would not prevent short-term shifts of bank deposits to CBDC accounts.

From an **allocative perspective**, the case for such a CBDC model is not clear. There is no obvious market failure in the provision of bank accounts and services supplied by commercial banks to their customers that would justify a competition between the central bank and commercial banks in this market.

From the **user perspective** a central bank account "for all" should provide the same services as an account with a commercial bank. But such accounts are not only a means of payment. Instead, they also offer a comprehensive bundle of financial services. Bindseil (2020, p.26) puts this as follows:

> The attractiveness of CBDC for payment purposes does not only depend on the amount of CBDC that would be remunerated at a fairly attractive level, but also on other

> features of the use of CBDC as means of payment. It will matter in particular whether account services of CBDC include the services that deposit accounts with commercial banks typically offer, like remote internet access, mobile phones and cards, periodic payments to other accounts, debit orders, user-defined maximums for different types of transfers.[12]

At least for the introductory phase, Bindseil (2020, p.26) assumes for CBDC deposits that "there would therefore still be a difference relative to the breadth of services by commercial banks".

But if central banks are not providing the full spectrum of such services, which is difficult to justify under allocative considerations, it is not clear why private households and firms would be willing to substitute a traditional bank account for a CBDC account. If they hold CBDC accounts in parallel to traditional bank accounts, the payments process would become more complicated. Depositors must avoid negative balances in the traditional account, which implies high interest rates. At the same time, the lack of overdraft facilities in the CBDC account could lead to the refusal of direct debits, which is also very costly.[13]

While payment CBDCs offer fewer services than traditional bank accounts, their advantage as a **safe asset** does not count in the retail sphere, as bank accounts are protected by deposit insurance schemes. This negative assessment is reinforced by the design of the specific CBDC proposals.

In sum, it is not obvious why a CBDC account should be attractive to a private household:

- The **absolute safety** of the central bank account is irrelevant as traditional bank deposits up to EUR 100 000 are fully protected by deposit insurance.
- A CBDC provides no **interest rate advantage**, as the tier-one interest rate would be zero today and thus similar to the interest rate for smaller sight deposits with private banks.
- The **account services** of CBDCs would be rudimentary and not competitive with the services offered by traditional commercial banks or online banks.
- Especially if the central bank deposit does not include an **overdraft facility**, depositors must permanently **monitor and manage** their accounts in order to avoid direct debits on CBDC accounts not being executed, which is associated with high costs.
- The **EUR 3 000 threshold** also requires active account management in order to avoid the **prohibitive interest rate** for tier-two deposits.
- Holding a **CBDC account in parallel** to a traditional bank account does not facilitate the management of payments for private households. It makes it more complicated.

[12] See also Carletti et al. (2020, p.107)

[13] The "waterfall" model as suggested by the ECB (2020, p.28) for absolute thresholds of CBDC holdings is also an unsatisfactory solution. If one's central bank account is credited beyond the threshold of e.g. EUR 3 000, the excess amount is transferred to a bank account. The benefits of such a central bank account are at least unclear.

- In the event of a banking crisis, the tier-two interest rate would be insufficient for preventing **digital bank runs**.

However, compared with CBDC proposals with a stand-alone system, which are discussed in Section 6, the model discussed here has at least the advantage that the CBDC deposits could be used in the existing payment networks like an ordinary bank deposit. Thus, interoperability problems can be avoided. But at the same time, with such a modest CBDC approach it would hardly be possible that a "CBDC offers a number of advantages with regards to the convenience, efficiency, stability and accessibility of retail payment" (Bindseil 2020, p.5).

In all, there are no obvious reasons why a private household or a firm should be interested in opening and managing a CBDC account as it has been developed in the Bindseil model. In principle, this finding corresponds with the allocative analysis where no significant market failures in the payment system could be identified that would warrant such an interference of the central bank in the payment system and justify this direct competition of central banks with commercial banks.

5 Evaluation of store of value CBDC design options

The model of a CBDC that is only used as a store of value has so far received little attention (Bofinger 2019). Conceptually, a store-of-value CBDC would allow depositors only two-way transactions between their own traditional bank accounts and their CBDC accounts. As a store-of-value CBDC would not be used for payments, it has no systemic dimension, i.e. it would be used within the existing payment system.

There are different **design options** for store-of-value CBDCs.

- It could be designed as a **retail CBDC "for all"**, e.g. private households and firms. Still, due to deposit insurance the absolute safety compared with a bank account is irrelevant for deposits below EUR 100 000.
- The access to a retail store-of-value CBDC could be limited to **deposits exceeding EUR 100 000**.
- A **wholesale store-of-value CBDC** could be used as backing for narrow banks (an "indirect CBDC") and for payment service providers (a "synthetic CBDC"). Such proposals implicitly assume the existence of a store-of-value CBDC.

If the ECB envisages increasing the **international role of the euro** by creating a digital euro, this could only be achieved with a **store-of-value CBDC**. International investors would hardly be interested in ECB accounts with a prohibitive interest rate for deposits exceeding EUR 3 000.

5.1 Allocative perspective: Only central banks can supply safe assets

From an **allocative perspective**, the provision of a store-of-value CBDC could be justified more easily than the provision of a retail payment CBDC. The global demand for safe assets is high. There

are studies showing that since the global financial crisis, demand has increased well beyond their supply (Habib, Stracca and Venditti 2020). In fact, the supply of safe assets has been negatively affected as large bank deposits have lost their safe asset status with the **Banking Recovery and Resolution Directive** (BRRD), which was adopted in spring 2014. According to the BRRD, bank depositors must be bailed-in if a bank resolution is required.

Assets with a 100% nominal value guarantee can only be supplied by central banks. This explains the attractiveness of cash as a store of value and the increasing demand for cash issued by major central banks (Figure 4). In large countries where government debt is denominated in the national currency, e.g. the United States or Japan, it is the implicit backing by the central bank which makes government bonds a safe asset. The supply of store-of-value CBDCs could therefore be justified by a **shortage of safe assets** that cannot be met by private suppliers. In this regard, a market failure could be identified.

While retail store-of-value CBDCs would compete with time and saving deposits supplied by commercial banks and with short-term government bonds, the competition is less problematic than in the case of retail CBDCs. For daily transactions private households and firms would still need to hold deposits in a traditional bank account. In addition, there would be no need for the central banks to engage in specific account services that would be required to make retail payment CBDCs somehow competitive vis-à-vis traditional bank accounts.

5.2 User perspective: The demand for safe assets is high

From a **user perspective**, one can assume that large firms, wealthy private investors, and financial market participants would in principle be very interested in such a new safe asset. In fact, as already mentioned a central bank account is only attractive for deposits exceeding EUR 100 000. The decisive factor for the demand for CBDCs is the interest rate for store-of-value CBDCs. As the Bindseil proposal shows, it is always possible to remunerate such deposits with a prohibitive interest rate, so that the demand would be very low.

However, in a full-blown banking crisis, it is not clear whether this mechanism would really work. If investors fear a significant loss on their commercial bank deposits, they could be willing to accept very negative interest rates on the CBDC account. For instance, if an immediate loss of 10% is expected, investors would be willing to accept even a 100% p.a. negative interest rate on the CBDC, if it allows them to keep their money safe, say, for one month.

A different approach, which would allow central banks perfect control over the amount of store-of- value CBDCs, would be an **auctioning process** for the determination of the interest rate. Successful bidders would be entitled to hold a certain amount of CBDCs for a certain period, e.g. one year, with the option to transfer them back and forth to their traditional bank within this period at their own discretion. The auctioning mechanism would prevent uncontrolled shifts from bank deposits into CBDCs with negative effects on financial stability. It would also fulfil the ECB's requirement to retain full control over the quantity of CBDCs in circulation (ECB 2020, p.18).

As store-of-value CBDCs would not be used for retail payments, problems of interoperability could not arise.

5.3 CBDC as trust account for payment service provider - a hybrid of traditional reserves and CBDC

While store-of-value CBDCs are not explicitly classified in the CBDC literature, they are the cornerstone for so-called synthetic CBDC proposals (Adrian and Mancini-Griffoli 2019). In such schemes, central banks offer payment service providers access to their reserve accounts as backing for the deposits that are held with these institutions.

Adrian (2019) gives three justifications for such a solution:

- "Through **effective supervision** [emphasis added], central banks could check that eMoney issuance is fully backed; there goes risk number one."
- "eMoney holdings would become **extra safe and liquid** [emphasis added] for customers, especially if reserve accounts were protected from other creditors of eMoney providers in case of bankruptcy. That would take care of risk number two, minus the hassle of claiming one's funds."
- "[C]entral banks would ensure **interoperability** [emphasis added] between eMoney issued by different providers by offering a common settlement platform between trust accounts; down with risk number three."

Adrian (2019) argues that a synthetic CBDC "outsources several steps to the private sector: technology choices, customer management, customer screening and monitoring including for 'Know Your Customer' and AML/CFT (Anti-Money Laundering and Combating the Financing of Terrorism) purposes, regulatory compliance, and data management — all sources of substantial costs and risks." Thus, the role of central banks is reduced to settlement between trust accounts, and to regulation and close supervision including e-money issuance.

The model for a synthetic CBDC is already in operation in **China**. Since 14 January 2019, all of China's third-party payment providers have been required to deposit their reserve funds with the PBOC, when previously they had been placed with commercial banks. This regulation especially aims at the two payment giants, Alipay and Tencent, which account for 93% of the Chinese mobile payments market (The Economist 2020).

From the **allocative perspective** the concept of a synthetic CBDC could be justified as a regulatory response to the **Diem project** of Facebook. The most serious shortcoming of the Diem design is the unclear legal status of Diem holders. While Diem promises a 1:1 backing for Diem deposits with highly liquid reserve assets, this is not a legally binding convertibility commitment comparable to the legal obligation of banks to convert sight deposits at any time into cash. The second Diem white

paper published in April 2020 explicitly states that Diem holders cannot expect 100% convertibility in "severe stress scenarios" (Diem Association 2020, p.14). In such situations the following measures can be adopted:

- "[r]edemption stays, which would delay Diem Coin redemptions and allow for additional time to liquidate the Reserve's assets during a window of time without incurring large fire-sale losses." (Diem Association 2020, p.14)
- "Early redemption haircuts, which would impose a fee for instant redemptions and require coin holders to internalize their negative externality (i.e. fire-sale losses) in a run." (Diem Association 2020, p.14)

In the case of a regular bank, the inability to pay out depositors would be a clear case of illiquidity which would trigger a resolution procedure.

Therefore, the regulatory approach to Diem could be a clear legal obligation that Diem holders are entitled to **full convertibility of their Diem deposits at any time**. In order to secure this obligation Diem should be obliged to keep its reserves in the form of deposits with central banks. In fact, Diem has explicitly mentioned this option in the second white paper:

> Moreover, our hope is that as central banks develop central bank digital currencies (CBDCs), these CBDCs could be directly integrated with the Diem network, removing the need for Diem Networks to manage the associated Reserves, thus reducing credit and custody risk. As an example, if a central bank develops a digital representation of the US dollar, euro, or British pound, the Association could replace the applicable single-currency stablecoin with the CBDC. Diem Association (2020, p.11)

But if synthetic CBDCs are used as backing for deposits with payment service providers, they would become economically not very different from **traditional bank reserves** held with the central bank. Diem would become a **narrow bank**.

Thus, from an **allocative perspective**, synthetic CBDCs can be justified in the same way as central bank reserves. This traditional monetary policy instrument generates a stable demand for base money, which is an important precondition for the control of the central bank over the process of money creation by commercial banks. If payment service providers are obliged to hold a 100% reserve, they are not able to create money autonomously and would operate as **"narrow banks"**. Such a regulation could be justified for the sake of financial stability.

The BIS (2020, p.4) argues that a ""(s)ynthetic CBDC" is not a CBDC", which is in line with its definition of CBDCs as "a direct liability of the central bank" (BIS 2020, p.3). While the BIS does not exclude the possibility to allow for such arrangements, it sees the risk of a potential liquidity mismatch between payment service providers' holdings of central bank reserves and their corresponding deposit liabilities. This could "result in users selling them at a discount to the par value of the currency" (BIS 2020, p.4). But such processes are only possible if deposits are not fully backed with central bank deposits.

The ECB also defines CBDCs solely as direct claims on the central bank. It sees a role for "supervised private intermediaries" providing "ancillary, user-facing services and to build new business models on its core back-end functionality" (ECB 2020, p.4). The option of a synthetic euro is not envisaged by the ECB.

From a **user perspective**, it is not clear whether payment service providers are interested in a 100% backing by CBDCs. The examples of PayPal and credit card systems show that successful payment service providers do not need access to the central bank balance sheet for their business models.

6 Account-based CBDCs with a stand-alone payment system

So far, we have discussed CBDC options where central banks make it possible for private households and firms to open a central bank account that can be used in the same way as a commercial bank account. Thus, within the euro area, payments from the central bank account to a commercial bank account would be made via the TARGET system. This would also be the case for token CBDCs in the form of e-money.

The ambition of several central banks goes beyond this basic solution. For transactions with CBDC assets they envisage a stand-alone retail payment system. In contrast to existing payment systems (credit cards and PayPal), such a system could not operate transactions with other payment assets, above all deposits in commercial bank accounts.

In this regard, such CBDC models are similar to the Diem project, which is designed as a payment system for transactions based on deposits held with Diem but not with deposits held with commercial banks.

6.1 The ambiguous design of the digital euro

In the report on the digital euro it is not clear whether the ECB envisages the creation of a **new payment asset** or whether it also plans to establish a **new payment system**.

The ECB (2020, p.6) defines the digital euro as a **payment asset**: "In this report, the term digital euro denotes a liability of the Eurosystem recorded in digital form as a complement to cash and central bank deposits."

From this definition one could conclude that the ECB is not looking at creating a new payment system. This view is supported by the following statement:

> The issuance of a digital euro would not inevitably lead to the introduction of yet another end-user solution in the already heterogeneous European landscape of retail

> payments. On the contrary, in line with the retail payments strategy of the Eurosystem, the digital euro could make use of – and thereby strengthen – existing pan-European payment solutions for consumers and merchants across Europe.(ECB 2020, p.20)

The ECB also mentions the problems that would be associated with a specific payment system for the digital euro: "A parallel infrastructure would also run counter to the aim of issuing a digital euro in order to improve the cost and environmental footprint of payments" (ECB 2020, p.34).

But in other parts of the report the ECB explicitly speaks of a separate payment infrastructure for the digital euro that "would de facto be parallel to that of other electronic payment solutions" (ECB 2020, p.34). "In order to improve the overall resilience of the payment system, the digital euro should be widely available and transacted via resilient channels that are separate from those of other payment services and can withstand extreme events" (ECB 2020, p.14).

And without creating a new payment system the ECB could hardly argue that "[i]t [the digital euro] should offer the basis for providing functionalities that are at least as attractive as those of the payment solutions available in foreign currencies or through unregulated entities" (ECB 2020, p.12).

For our evaluation we deal with this ambiguity as follows. If the digital euro is regarded as a **CBDC asset without a new payment system**, we have discussed this option already under the Bindseil model. In fact, Ulrich Bindseil is the ECB's Director General, Market Infrastructure and Payments.

If the digital euro represents a model that consists of a **new payment asset plus a new payment system**, an evaluation is difficult as the ECB report is not very specific on the details of such a system. While the ECB mentions the option to introduce its CBDC via intermediaries, it does not discuss in detail whether these intermediaries would use existing payment systems or develop a new payment system based on the ECB CBDC.

As we can only speculate about the design of the payment system for the digital euro, we focus in this paper on the e-krona model of the Swedish central bank. For this model, which aims at a solution where the e-krona is embedded in a new payment system, already quite concrete plans are available.

6.2 CBDC model with a stand-alone payment system (e-krona proposal of the Sveriges Riksbank)

In evaluating the e-krona proposal, the main arguments against the Bindseil proposal also apply. Compared with cash the lack of anonymity is a serious disadvantage. The safety of a central bank deposit is irrelevant for small sums. However, it is unclear whether the Riksbank is considering a ceiling for e-krona deposits or a two-tier interest rate scheme to deter major investors.

As a **competitor with private payment systems** (e.g. PayPal), the e-krona has the serious disadvantage that the system would not be fully connected with the existing payments ecosystem. For the Swedish central bank, the provision of **an independent payment system** plays an important role: "In the medium term, Sweden would no longer have a domestic infrastructure for retail payments, given the dominance of global card schemes, pan-European clearing and the ECB's trend towards multi-currency settlement systems" (Gnan and Masciandaro 2018, p.19).

Therefore, the e-kronor system is designed as a **stand-alone-system**:

- "All transactions in the e-krona network occur separately from existing payment networks, which, as stand-alone systems provide added robustness in the event of problems with the existing payment infrastructure. Payments occurring in the e-krona network will take place without the involvement of RIX, but the supply or redemption of e-kronor will be done via RIX" (Sveriges Riksbank 2020).
- "To be able to use e-kronor for payments, the digital wallet must first be activated at a participant connected to the e-krona network. After activation, the user can, for example, receive e-kronor as payment from another user, pay a retailer with e-kronor, make transfers from their bank account to the digital wallet (and vice versa), and check their e-krona balance" (Sveriges Riksbank 2020)

This solution would have the disadvantage that e-krona account holders could use them only for payments to other CBDC account holders. Armelius et al. (2020, p.85) describe this as follows:

> However, when a holder of e-kronor wants to pay to a recipient who does not have e-krona accounts or who does not wish to increase their e-krona holdings, there is a need to exchange e-kronor for commercial bank money, i.e. to go outside the e-krona accounts. This requires settlement in RIX.

This would be different with a CBDC option without a stand-alone system which we discussed in Section 4. In this model, a CBDC account would not be fundamentally different from other bank accounts, such that it could be used for payments to all other banks via the RTGS system.

The Bank of England (2020, p.23) makes this point very clear:

> CBDC should be designed to avoid creating closed-loop payment systems, in which payments can only be made between users of the same payments provider. Instead, CBDC payments should be interoperable, allowing payments between users of different providers, and between users of CBDC and users of deposit accounts.

The lack of interoperability is even more problematic for payments abroad (tourism or purchases on the internet). The **domestic focus** is a more general problem of most CBDC projects. As Auer, Cornelli and Frost (2020) show, almost all of them are either focused nationally or in the case of

euro area Member States focused on their own currency area.[14] For a small country like Sweden, the national range of the network is especially disadvantageous.

From an **allocative perspective** the case for a CBDC with a stand-alone system is not clear. While a token CBDC with offline functionality could be justified as a safety net for emergency solutions, this is not obvious for an account CBDC that requires a functioning internet connection. The "added robustness" (Sveriges Riksbank 2020) is also questionable as the e-krona system relies on the connection with the RIX system. A "domestic infrastructure for retail payments" (Gnan and Masciandaro 2018, p.19) is a political argument for CBDCs, but for a small country like Sweden, it is unrealistic that such infrastructure would be competitive with large global payment system providers.

From a **user perspective** the establishment of a stand-alone system makes a central bank account even less attractive to private households or firms. By transferring funds from a commercial bank account to the central bank account, their liquidity declines drastically as they can only be used for payments to other CBDC holders. Especially in the introductory phase with a small number of account holders, this problem would be huge and probably unsurmountable.

With the stand-alone solution, the e-krona payment system is not competitive with the existing payment system providers (e.g. Visa, Mastercard or PayPal). The key advantage of **credit card systems** is their ability to connect payers and payees with different deposit accounts from different countries and with different currencies. In other words, the usage of the system does not require holding **system-specific accounts** and it is not limited to a **specific currency**.

This also applies to **PayPal**, which requires that payer and payee must be registered with PayPal. But in contrast to the e-krona, the payer needs neither a PayPal account nor a positive PayPal balance, as the payer can use a credit card as an underlying payment instrument or directly a bank account as the payment asset for the payment. Thus, there is no unique selling proposition vis-à-vis commercial bank accounts or payment service providers due to the lack of interoperability and the likely limited services compared with commercial bank accounts or payment service providers.

While it is unclear how a **digital euro** would be designed, the problems of a stand-alone system are obvious. Adrian (2019) puts the problem caused by a lack of interoperability as follows: "If eMoney issued by different providers is not interoperable, only the largest providers will survive. The fat cats will eat the nimble and potentially more innovative mice. Even regulation mandating common technological standards will not resolve the issue."

[14] "Finally, while most of the projects in our sample are focused on domestic use, several of them – by the ECB, the central banks of France, Spain and the Netherlands, and the ECCB – are by construction focused on crossborder use among the members of a multi-country currency area." (Auer, Cornelli and Frost 2020, p.20).

6.3 The model of an inconvertible CBDC payment system (The Kumhof and Noone model)

While the e-krona model already suffers from insufficient interoperability, the proposal by (Kumhof and Noone 2018) deliberately tries to establish an isolated CBDC payment system. Their concept is characterised by the following features:

- the CBDC pays an adjustable interest rate;
- the CBDC and reserves are distinct and **not convertible into each other**;
- there is no guaranteed, on-demand convertibility of bank deposits into a CBDC at commercial banks (and therefore by implication at the central bank); and
- the central bank issues a CBDC only against eligible securities (principally government securities).

With this institutional framework, Kumhof and Noone try to design a CBDC system that avoids the **risk of a digital bank run**. The scheme would prevent bank depositors from exchanging their credit balances for CBDCs at any time in the same way that they are able to exchange bank deposits for cash.

However, the price for this protective measure is high. It implies that the CBDC payment system is not integrated with the settlement system for reserves. In the words of Kumhof and Noone (2018, p.21), "we take as given that a market for reserves with an RTGS system is present and that it operates separately from the CBDC system".

The lack of interoperability is a fundamental difference between the Kumhof and Noone proposal and the e-krona project, where integration with the RIX settlement system is envisaged.

Therefore, direct payments between traditional bank accounts and CBDC accounts would not be possible. This is a **strange design for a payment system** as the existing payment ecosystem is characterised by a high degree of interoperability of its subsystems. Ugolini (2017, p.24) puts this as follows: "In practical terms, this means that payment systems (unlike shopping arcades) can hardly work in isolation. New payment systems can emerge and enter the industry only as long as their connection to the 'global' payment system (the one that allows the final, legally recognized settlement) is provided."

From a **user perspective**, it is unlikely that such a CBDC payment system would be able to compete successfully with the existing national or international payment systems. It is not clear why the authors believe their system would provide "much greater functionality for retail transactions" (Kumhof and Noone 2018, p.4). In sum, the attempt to create a CBDC without risks for macroeconomic stability has led to a solution that would be completely unattractive to private

households or firms.[15]

As the authors focus on the macroeconomic dimension of CBDCs, they do not explicitly discuss issues that would be relevant from an **allocative perspective**.

6.4 The Diem model

In the context of CBDC payment systems, Facebook's Diem plan is an interesting project as it also envisages a stand-alone payment system that can only be used for Diem deposits.

The **lack of interoperability** has so far not received very much attention in the discussion on Diem. But as our analysis of the e-krona has shown, this could prove to be a major disadvantage compared with other payment systems. It implies that a transaction using the Diem system requires a Diem deposit and it can only be made to the holder of a Diem account. In addition, if a private household cannot execute all transactions via Diem it must still hold deposits in a traditional bank account. This is different from credit card systems without system-specific payment assets and from PayPal where a payer does not need a positive balance on a PayPal account for using the system.

7 Evaluation of options for a retail payment system without system specific deposits

In the debate on CBDCs the need to **develop an alternative to Diem** and other global payment platforms is often mentioned.[16] For example, Weidmann (2020) argued that a retail CBDC "is often seen as an alternative to commercial payment initiatives. There are concerns that international Big Tech companies could come to dominate the European markets for payment services, thereby gaining stronger footholds in markets outside their own core domains."

The differentiation between payment assets and payment systems in this paper opens the view for the option of introducing a **retail payment system organised or orchestrated by central banks** without a need to introduce a retail CBDC as a payment asset. So far, this option has received little attention in the debate about CBDCs.

7.1 Features of successful retail payment systems

Effective payment systems can function **without specific payment assets** that are held within the system. This is especially the case for credit card systems like Visa or Mastercard. While it is

[15] Therefore, the ECB report mentions as a "core guiding principle" for the digital euro that "(. . .) a digital euro would be just another way to supply euro, not a parallel currency. It should therefore be convertible at par with other forms of the euro, such as banknotes, central bank reserves and commercial bank deposits." (ECB 2020, p.7).

[16] In the digital euro report, the ECB (2020, p.11) justifies its CBDC initiative as follows: "(...) private actors – possibly outside the supervision of European financial authorities – including large technology firms, are developing payment solutions not denominated in euro (such as global "stablecoins") that could achieve a global footprint and become widely used for European retail payments. Such developments would foster innovation but could also threaten European financial, economic and, ultimately, political sovereignty. It is worth noting that recently some global 'stablecoin' initiatives have suggested that CBDCs could also be made available via their (private) infrastructure."

possible to hold deposits on a credit card account, users typically do not use this option. Instead, for all transactions a commercial bank account is used. The same applies to PayPal. In this system users can also hold deposits, but even without a positive balance, transactions can be carried out using an underlying bank account or credit card account.

The ability to perform transactions without the need to hold system-specific balances is a general advantage of payment systems. Users can **avoid the parallel holding** of sight deposits that can be costly if it leads to an overdraft of the commercial bank account. As already mentioned, the Diem initiative is special in this regard as this system is designed on a stand-alone basis so that only Diem deposits can be exchanged. However, this disadvantage can be at least partially compensated by the fact that 2.6 billion people are actively using Facebook on a monthly basis.

Thus, if central banks plan to develop an alternative to existing and projected global payment systems, a CBDC model based solely on a stand-alone system and a national currency (or the euro), is not the appropriate solution. Instead, a competitive payment system must be open for

- international transactions so that it can perform transactions where the **country** of the payer and the payee differ;
- different currencies so that it can perform transactions where the **currency** of the payer's and the payee's account differ; and
- different payment assets, so that it can perform transactions where the **payment assets** (i.e. deposits on specific bank accounts) of the payer and the payee differ.

7.2 Allocative perspective: Network effects justify central bank intervention

As already mentioned, from an **allocative point of view** a market failure can be identified when it comes to payment service providers. The externalities that are associated with network effects could justify a larger role for central banks as providers of retail payment systems.

Weidmann (2020) has argued that central banks could also act as a catalyst in this field so that innovative payment solutions can be developed by the private sector. A model for this is the "European Payments Initiative" launched by a group of 16 major euro area banks with the aim of a unified card and digital wallet that can be used across Europe (European Payments Council 2020).

7.3 User perspective: PayPal as best practice

From a **user perspective**, the standard for an attractive international payment system is currently set by PayPal, which in the second quarter of 2020 had almost 350 million active users. It is surprising that central banks repeatedly refer to the Diem initiative when justifying their CBDC activities, but almost never to PayPal.

A closer look at PayPal's business model provides useful insights about the features of a successful international payment system. This is especially relevant for the ECB, which wants to "ensure that European citizens have access to payments at the technological frontier" (ECB 2020, p.12) and which accordingly defines its requirement R3 as follows: "It [the digital euro] should offer the basis for providing functionalities that are at least as attractive as those of the payment solutions available in foreign currencies or through unregulated entities" (ECB 2020, p.12)

An obvious advantage of PayPal is its distinctive **interoperability**.[17] It allows usage of the system without having a credit balance at PayPal. PayPal transactions can be made by using a traditional bank account or a credit card account. In contrast to the e-krona proposal, there is no need for a double coincidence of accounts. A customer can pay into the merchant's PayPal account even without being registered with PayPal. The interoperability also applies to international payments. According to its own information, PayPal is available in more than 200 countries/regions and it supports 25 currencies.

Recently, PayPal (2020) has announced the "launch of a new service enabling its customers to buy, hold and sell cryptocurrency directly from their PayPal account, and signalled its plans to significantly increase cryptocurrency's utility by making it available as a funding source for purchases at its 26 million merchants worldwide". This adds another payment asset and another currency that can be held and used within the PayPal payment system.

A special feature of PayPal is its **simplicity and versatility**:

- Accounts can be opened **without an identity check**. PayPal only requires an e-mail address and a mobile telephone number.
- Instead of an IBAN, account users are **identified by their e-mail addresses**. For most people abstract numbers are harder to remember than names.
- In contrast to credit cards, PayPal can be used for **private, i.e. non-commercial, transactions** (like a bank account).
- For transactions, a **TAN is not required**, so transfers, e.g. within a circle of friends, can be easily made.
- Credits are **booked immediately**, which accelerates the processing of online transactions.
- There are **no fees for non-commercial use**, which contributes to **financial inclusion**.
- PayPal is accessible for users with a **bad credit history**, who would not be able to obtain a credit card.

Especially in **online trade**, PayPal offers a wide range of **additional services**.

[17] For example, with PayPal PLUS, merchants' customers can pay with the four most popular payment methods (PayPal, direct debit, credit card and purchase on account) – even customers without a PayPal account.

- **Buyers** receive insurance coverage for faulty deliveries if the payment is made via the PayPal account. In addition, PayPal covers, 12 times a year, the costs for the return of goods ordered online.
- **Merchants** receive insurance protection if goods are lost during shipping. Furthermore, they can easily obtain credit, which they can repay with their PayPal cashflows. The granting of credit depends on the account history with PayPal. So, there are no inquiries with credit bureaus that could have a negative impact on the credit score of the merchant. PayPal also evaluates customer transaction data and uses it to create marketing analyses that are made available to merchants.

In sum, if central banks want to provide a competitive alternative to global payment system providers the benchmark should not be Diem but PayPal. Alongside the advantages of simplicity and comprehensive services especially for online trade, PayPal shows that a successful payment system should be open for payment assets that are not system-specific and for payers that do not even have a system-specific account.

This implies that CBDC initiatives so far go in the wrong direction. Schemes that focus on new payment assets and on payment systems that can only operate with system-specific assets in the domestic terrain (e-krona) are misguided. It is unlikely that such efforts will lead to solutions that are able to withstand the competition with global payment system providers.

7.4 TWINT as a response to global payment systems

While we have shown that the existing proposals by central banks are unlikely to compete with global payment systems, the Swiss payment system TWINT has managed to **successfully establish itself as the most prevalent mobile payment solution in Switzerland** (SNB 2021). Similar to PayPal, TWINT is very user-friendly and easy to use. Account holders are identified by their mobile number and usually connect their TWINT account to their bank account. TWINT can also be used for non-commercial transactions as well as for online-trade without feeds. Additionally, TWINT can also be used at the point of sale in retail stores using QR codes and in some cases also for offline payments. Due to its national operating range, TWINT works closely together with national partners, thereby adding services such as booking restaurant tables to their app, which increases the network effects and utility user's get from the app. The example of TWINT thus shows that the private sector is able to develop solutions that can compete with global payment service providers **without the intervention of the central bank**.

8 Conclusion

So far, the debate on CBDCs has been dominated by a technical and a macroeconomic perspective. But the more fundamental questions are microeconomic issues. What are the market failures that justify central bank activities that compete directly with the business of commercial banks and other payment service providers? Are the solutions discussed and planned by central banks attractive

enough to assert themselves in the competition with sophisticated private payment solutions? Without a positive answer to these questions, the debate on the macroeconomic implications of CBDCs is of little practical relevance.

This paper discusses CBDCs from the standpoint of allocative efficiency and attractiveness to users. This allows an evaluation of different design options for CBDCs. We derive these options with a taxonomy that is based on a systemic perspective. It explicitly differentiates between payment assets and payment systems. Thus, a CBDC can be designed as a new payment asset, which is used in existing payment systems. It can also be designed as a new payment system within which CBDC assets can be transferred. The systemic perspective opens the view for a retail payment system operated or orchestrated by central banks which does not necessarily require a system-specific payment asset.

A narrow CBDC approach is the provision of CBDC assets that are used within the existing payment systems, above all the RTGS systems operated by central banks. Such CBDCs can be designed in a way that they are mainly suitable as payment assets. From the allocative perspective there is no obvious market failure that could justify the provision of an ordinary bank deposit by a central bank. From a user perspective, there are no obvious advantages of having a direct account with the central bank, as bank deposits below EUR 100 000 are protected by the deposit insurance schemes. The case for a token CBDC that could serve as a digital substitute for cash is not obvious either. While the allocative perspective would justify central banks providing a digital substitute for cash for which they have a monopoly, the need to comply with AML regulations sets very rigid quantitative limitations for such products. Accordingly, from a user perspective the demand for token CBDCs would be very low as they would not provide a substitute for cash, which is especially attractive for payments in the shadow economy and as a store of value in periods of financial instability.

An option that has received little attention so far is a CBDC that is designed solely as a store of value. Such a CBDC could only be used for payments to and from the commercial bank account of its holder. From the allocative perspective the supply of such a CBDC could be justified by the need for (nominally) safe assets that can only be provided by central banks. The demand for a store-of-value CBDC would come from firms and large investors with bank deposits of more than EUR 100 000, which would be bailed-in in the case of a bank restructuring. From the user perspective this demand would depend on the interest rate for such deposits. Central banks could auction store-of-value deposits, which would give them perfect control over their amount.

A store-of-value CBDC could also be designed as collateral for large payment service providers. In China, Alipay is required to hold deposits with the central bank. For Diem, a similar requirement could be imposed. This would make Diem deposits 100% safe and it would prevent the Diem system from being disconnected from central banks and their control of the monetary system. From an allocative perspective, such central bank intervention can be justified as it would de facto include payment service providers under the umbrella of the central bank's reserve requirements and hence

improve financial stability.

More ambitious CBDC models, like the Swedish e-krona, envisage a stand-alone system within which CBDC assets can be transferred. For the attractiveness of a CBDC bank deposit this is not necessarily an advantage. Without a specific payment system, CBDC deposits could be used like a commercial bank deposit. With a stand-alone payment system, CBDC deposits can only be used for payments to other CBDC accounts. Especially in a small country like Sweden, the domestic focus is a serious drawback of a CBDC payment system.

Therefore, if central banks want to develop a serious answer to the dynamic activities of global payment service providers, they must rethink their whole approach to CBDCs. Instead of national schemes that can only operate with the national currency and can only make transactions with system-specific accounts, the solution must be supranational with a multi-currency operability and an openness to payment assets that are not system-specific. While a "digital euro" has the advantage that it is by design supranational, it is questionable whether this is sufficient to compete with systems operating internationally. But even if central banks realise their task is not to develop a digital substitute for cash but a digital alternative to global payment systems, it will be difficult for them to achieve the high level of sophistication that these global players can offer to their users. Yet in contrast to narrow CBDC models, from an allocative point of view there would be an obvious justification for retail payment networks operated by central banks.

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A Appendix: Evaluation of CBDC proposals

Table 4: **Evaluation of CBDC proposals***

	Payment CBDC						**Store of value CBDC** (No separate payment system)		**Payment system without assets**
	Without separate payment system		With separate payment system				Retail	Wholesale	
	Token CBDC	Account CBDC (Bindseil)	Digital euro token (Offline)	Digital euro Account based	e-Krona	Kumhof/Noone		CBDC as trust accounts for payment service provider	
Can a market failure be identified?	• Declining use of cash in payments is no justification for CBDC In most countries, the demand for cash is rather stable • Access to central bank balance sheet does not require CBDC, but nationwide infrastructure for cash dispensers • No evidence of deficiencies in national and international retail payment systems that would require CBDC • In situations with extreme events, a digital euro is not a better solution than cash						Lack of safe assets which cannot be provided by private banks	See retail store of value CBDC plus: Central bank control over payment service providers	Natural monopolies of US and Chinese internet platforms. Lack of a European platform
Use case in relation to **cash and bank accounts**	**Relative to cash**: **Means of payment**: Cash provides absolute anonymity. **Store of value** Cash can be held without limits. **Extreme cases**: Cash functions without electricity and internet access	**Relative to cash**: see token CBDC **Relative to bank deposits**: Deposits below EUR 100 000 are insured. Banks offer more services (e.g. overdraft) Prohibitive CBDC interest rate above EUR 3 000	See Token CBDC	See Bindseil	See Bindseil Unclear whether restrictions (ceiling or tiered interest rates) will be applied	See e-Krona	Relative to cash and bank accounts; Provision of a liquid and safe asset for deposits > EUR 100 000	Collateral for stable coins and payment system providers De facto identical with central bank reserves	Usage of existing payment assets. CBDC assets are not required
Use case in relation to other **payment systems**	No advantage compared with pre-paid debit cards.	No advantage compared with traditional bank account	Need for offline use is not obvious. Unclear whether merchants must open e-euro accounts	Details of digital euro system are unclear. Unclear whether merchants must open e-euro accounts	National use only Specific account for using the network is required	Very low due to inconvertibility and a lack of interoperability	Usage within existing payment systems		Lower costs of public retail system compared with a private platform

*We assume here that the digital euro would be established with a stand-alone payment system.
Source:Authors.

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