D-EURO: ISSUING THE DIGITAL TRUST

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ABSTRACT

Since 2008 new schemes such as digital currencies have emerged in limited forms. Currently, digital technologies enjoy a widespread use in the area of payments and, as a result, central banks have started contemplating the costs and benefits of issuing a digital currency for broad use in payments and settlements. This paper defines Central Bank Digital Currency (CBDC) and classifies it alongside existing forms of money. Further, it highlights the properties that such a currency should have, and analyses the main motivations behind the potential issuance of an account-based retail CBDC (called here the "d-euro"). We argue that the latter should involve a public-private partnership whose effectiveness will be enhanced by the establishment of separate and distinct roles. This paper briefly discusses legal considerations, monetary policy implications and financial stability issues arising from d-euro. In doing so, it further analyses d-euro's underlying principles, which would at the same time constitute its key benefits. We provide a general framework and propose the technical design of our so called "two-dot model". Issues concerning parity, supply limits and anonymity are dealt with. The proposed technical design seems an effective and workable solution that boosts the autonomy and resilience of the European payment systems. Finally, we argue that the initial introduction of d-euro as a retail payment medium may establish it as the new cash of a digitalised ecosystem, reflecting a new digital trust issued by central banks.

Keywords: CBDC; d-euro; money; Dedicated Digital Account; TIPS

JEL classification: E58; G21; O33

D-EURO: ΕΚΔΙΔΟΝΤΑΣ ΤΗΝ ΨΗΦΙΑΚΗ ΠΙΣΤΗ

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ΠΕΡΙΛΗΨΗ

Από το 2008 περίπου τα ψηφιακά νομίσματα έχουν εμφανιστεί με διάφορες μορφές. Σήμερα, καθώς οι ψηφιακές τεχνολογίες χρησιμοποιούνται ευρέως στο χώρο των πληρωμών, οι κεντρικές τράπεζες έχουν αρχίσει να μελετούν τα κόστη και τα οφέλη της έκδοσης ενός ψηφιακού νομίσματος με ευρεία χρήση στις πληρωμές και το διακανονισμό. Το παρόν άρθρο δίνει τον ορισμό ενός τέτοιου ψηφιακού νομίσματος κεντρικής τράπεζας (CBDC) και το ταξινομεί σε σχέση με τις υπάρχουσες μορφές χρήματος. Στη συνέχεια, διευκρινίζει τις ιδιότητες που πρέπει να διαθέτει και εξηγεί τα κύρια αίτια για τη δυνητική έκδοση ενός CBDC το οποίο προτείνεται να βασίζεται σε τραπεζικό λογαριασμό (και θα ονομάζεται d-euro). Η προσπάθεια αυτή απαιτεί τη σύμπραξη δημόσιου και ιδιωτικού τομέα, η αποτελεσματικότητα της οποίας θα ενισχυθεί από τον καθορισμό διακριτών ρόλων για τον κάθε τομέα. Το άρθρο παρουσιάζει συνοπτικά τους σχετικούς νομικούς προβληματισμούς, καθώς και τις δυνητικές επιπτώσεις μιας ενδεχόμενης έκδοσης του d-euro σε θέματα χρηματοπιστωτικής σταθερότητας και νομισματικής πολιτικής. Επίσης, αναλύονται οι βασικές αρχές του νομίσματος, οι οποίες συγχρόνως θα αποτελούν τα βασικά του πλεονεκτήματα. Προτάσσεται ένα γενικό πλαίσιο λειτουργίας που συνοδεύεται από το τεχνικό σχέδιο του αποκαλούμενου "μοντέλου δύο σημείων". Στη συνέχεια, επεξηγούνται θέματα σχετικά με την ισοτιμία, την προσφορά χρήματος και την ανωνυμία. Ο προτεινόμενος τεχνικός σχεδιασμός κρίνεται ως μια κατάλληλη και εφαρμόσιμη λύση, ικανή να ενισχύσει την αυτονομία και την ανθεκτικότητα των ευρωπαϊκών συστημάτων πληρωμών. Τέλος, υποστηρίζεται ότι μια ενδεχόμενη αρχική υιοθέτηση του d-euro ως μέσου πληρωμών λιανικής θα μπορούσε να οδηγήσει στην καθιέρωσή του ως της νέας μορφής μετρητών ενός ψηφιακού οικοσυστήματος, αντανακλώντας μια νέα ψηφιακή πίστη προερχόμενη από τις κεντρικές τράπεζες.

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1 INTRODUCTION

A few years ago one frequently heard that the use of physical cash would eventually decline (Cœuré 2018). A decade ago one read lines suggesting that "we have proposed a system for electronic transactions without relying on trust" (Nakamoto 2008, p. 8). Nowadays, it is common to see someone pay at a supermarket by swiping a card or by waving their mobile phone, irrespective of the currency or the amount to be paid. In the near future, one may decide to pay for a pizza by using stablecoins, i.e. cryptoassets[1] with value stabilising characteristics. Such assets, mainly used through widespread social messaging apps, could make payments cheaper and faster. However, they have to overcome regulatory and supervisory challenges at the international policy level, especially regarding risks to financial stability and monetary sovereignty, data protection and compliance with anti-money laundering and counter-terrorism financing rules (G7 Working Group on Stablecoins 2019; European Central Bank 2019c; FATF 2020).

This paper does not intend to rake over the coals of the stablecoins issue once more. It simply uses this new type of cryptocurrency, which applies stabilisation mechanisms in order to minimise price volatility, as an introductory point of my discourse about digital currencies (see for example Bullmann et al. 2019). It is a starting point for central banks in their efforts to use new technologies in order to enhance the efficiency and resilience of the payments landscape by issuing to the public an instant, safe, cheap, and potentially semi-anonymous digital currency, i.e. a retail Central Bank Digital Currency (CBDC)[2].

We start by mentioning a set of truisms. Digital currencies have existed for a number of decades. David Chaum (1983), who is widely recognised as the inventor of digital cash, introduced the cryptographic primitive of a blind signature that could prevent double spending. In 2008, Bitcoin was the first cryptocurrency that used permissioned blockchain protocols, relying heavily on cryptography, thus accomplishing nearly anonymous transactions through decentralised means. The key innovation in this regard is the introduction of a "distributed ledger", which allows a digital currency to be used in a decentralised payment system (Böhme et al. 2015; Narayanan et al. 2017). A common feature of developed economies has been the wide variety of ways in which payments are made as well as the many forms of money used. There is also a wide range of economic agents whose liabilities can function as money. The most prominent issuers of money are central banks, which provide central bank money in the form of both banknotes and liquidity through the financial system, and commercial banks, which generally issue private money (commercial bank money) in the form of deposits (Bank for International Settlements 2003; Kokkola 2010). Contrary to the various decentralised forms of assets, central banks also offer a form of digital currency to certain institutions, the so-called reserve balances, i.e. deposits held with the central bank (Friedman 2000; Agarwal and Kimball 2019). On the other side, commercial banks offer to the public deposits that can be converted to cash (legal tender) through withdrawal (Middleton and Sinha 2019).

In this context, the European Central Bank (ECB) does recognise that, in today's continuously changing payments ecosystem, great attention should be given to the front-end of European retail payments systems, and in par-

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1 See Chimienti et al. 2019 and European Central Bank 2019a.

2 CBDC or d-euro are here used interchangeably.

ticular to the point-of-sale and online payment solutions (Cœuré 2019c). The necessity for a retail payments strategy has been the result of three main reasons. The first relates to the strategic autonomy and resilience of the European payments system, both of which underpin the euro's international role (Cœuré 2019c). The second is the rapid technological transformation that has occurred in peoples' lives. The third focuses on the public criticism to the role of central banks due to their handling of the recent financial crisis (Cœuré 2019b). This comes in contrast to the fact that they stand as a pillar of stability of the financial system and ensure the smooth and secure functioning of the European payments markets. Thus, by weighing the costs and benefits, central banks have to reassess and redefine their role in the payments ecosystem (Habermeier et al. 2018; Cœuré 2019b).

These issues are explored in more detail in the rest of the paper, which examines the prospects of a retail account-based CBDC and is divided into four sections. Section 2 investigates the taxonomy of money, the digital currency ecosystem and the main properties that a retail account-based CBDC has to fulfil. Section 3 describes the main motivations for issuing an account-based CBDC as well as the existing central bank policies, and focuses on the possible implications of such policies. In the light of this analysis, Section 4 simulates the issuance of an account-based CBDC in the current Eurosystem's payments environment. Finally, Section 5 provides some concluding remarks.

2 CBDC AND THE TAXONOMY OF MONEY

What will the money of the future look like? Today, one pays for a croissant at the corner bakery by using either physical cash (banknotes and/or coins) or an electronic means of payment at the point of interaction (POI). Regardless of the price of the good or the currency used to pay for it, an electronic payment is usually performed by initiating a credit transfer or a card payment. In the former case, one initiates the transaction by giving an order to irrevocably debit one's payment account whereas, in the latter, one uses a payment card with a debit, credit or delayed debit function at the POI. However, one could pay for the good just by waving a mobile phone or a wearable to the terminal using near-field communication (NFC) or augmented reality (AR) technology, scanning a quick response (QR) code or receiving a request to pay (RtP) and accepting the payment. What ten years ago was considered science fiction is today's reality. The digitalisation of payments has coincided with the dematerialisation of financial assets. Nowadays, the digital penetration in the retail payments arena is such that, for example, payments are regularly initiated through mobile apps.

Indeed, digitalisation in the payments ecosystem has been widespread and profound. In the front-end retail sector, numerous and fancy solutions are available to the customer who wishes to initiate a payment. At the back-end, Distributed Ledger Technologies (DLTs), the best known of which is blockchain, promise greater resilience, immutability, transaction privacy, as well as higher speed and scalability (Gandal and Halaburda 2014; Robleh et al. 2014; Middleton and Sinha 2019; Fleuret and Lyons 2020). Nevertheless, DLT, although highly promising, is not mature enough to replace the traditional account-based Real Time Gross Settlement System (RTGS)[3] (Kahn and Roberds 2009), which forms the central bank's basic tool in order to implement monetary policy and ensure financial stability (Kokkola 2010). In addition, DLT, although resilient to malicious incidents and able to confront single point of failure issues, is currently using consensus protocols[4]. Consequently, it

3 In Europe TARGET2, the RTGS owned and operated by the Eurosystem, is the system that settles payments related to the Eurosystem's transactions, as well as to bank-to-bank and commercial transactions.

4 The author's proposal, presented at the 1st EUROchain Hackathon, for issuing retail account-based CBDC by using permissioned DLT, uses central bank blind signature to verify the transactions in order to prevent double spending.

does not fully comply with the legal and regulatory notion of ultimate finality, as required in the payment chain of a credit transfer, and also suffers from interoperability and accountability issues among the different DLT networks[5] (Tobias and Mancini-Griffoli 2019; Middleton and Sinha 2019; Ward and Rochemont 2019). Irrespective of this argumentation and regardless of the technology used at the back-end of a payment system, the question remains: What will the money of the future be like?

A number of fiat, digital currencies and payment solutions, including EUR, USD, JPY, Bitcoin, Libra, Alipay, and Apple Pay, compete to dominate our physical or digital wallet[6] (Tobias and Mancini-Griffoli 2019). Normally, questions are raised about the autonomy, trust, and habits of our everyday payment transactions. However, surprising as it may sound, what is money? Money is fundamental to the operation of a modern economy and, strictly speaking, must serve three basic and not mutually exclusive functions as: a unit of account, a medium of exchange, and a store of value (Quinn and Roberds 2014; McLeay et al. 2014; Bjerg et al. 2018). A unit of account refers to a standard numerical monetary unit of measurement of price or cost of goods and services, for example EUR 100 to buy and EUR 10 to rent a bicycle, respectively. In order to successfully fulfil the aforementioned attributes, money must exhibit a stable price[7]. The Eurosystem, by targeting inflation, enhances trust between the various economic agents and helps them take rational economic decisions. As a medium of exchange, money is universally accepted as payment for goods and services. As a successor of the barter system, it provides the most efficient, secure and universally available means of exchange. Finally, as a store of value, money has to be able to be securely stored and, when subsequently retrieved, to retain a stable level of purchasing power. Moreover, apart from the codification of money, some simple financial concepts should be presented prior to the analysis of the retail account-based CBDC. The reason is that "sound conclusions are sometimes supported by erroneous arguments, and the error is compounded when a sound conclusion is declared to be mistaken on the ground that the argument for it is mistaken" (Nagel 1963, p. 211).

Currency[8] is in fact money in circulation denominated in an existing unit of account, i.e. euro banknotes and coins, which serves as a medium of exchange (Kiyotaki and Wright 1989; Yang 2007; Brunnermeier and James 2019; Engert and Fung 2020). Thus, currency does fulfil the three basic functions of money. A further examination distinguishes between two main types of money according to who the issuer is, i.e. central banks (monetary base) or commercial banks (bank deposits). Cash is issued by central banks and remains the most widespread means of retail payment (Cruijsen van der et al. 2015; Bech et al. 2018) in the euro area[9] (Esselink and Hernández 2017). The main reason for holding and using cash in our everyday transactions is trust. People trust the central bank's promise that a banknote retains its face value, i.e. that it would be accepted by others at its face value[10], for example that a EUR 5 banknote buys EUR 5 worth of goods (Allen and Dent 2010). A second reason for using cash as a means of payment is because it constitutes fiat money by having legal tender status[11]. Fiat money has the unique property of being issued and accepted by a higher authority (the government) as a means of payment for salaries and taxes.[12]

5 DLT is currently falling short in scalability, energy efficiency, and payment finality (He et al. 2017).
6 For narrow finance solutions, see Pennacchi (2012) and Mancini-Griffoli et al. (2018).
7 Price stability is actually the primary objective of the ECB, which is clearly established in the Treaty on the Functioning of the European Union (2012, Article 2).
8 Deriving from the Latin word "currens" meaning: "in circulation".
9 Esselink and Hernández (2017, p. 19) argue that across the euro area in 2016, on average, 78.8% of all POI transactions were carried out using cash.
10 Greek drachmas bore the inscription "ΠΛΗΡΩΤΕΕΣ ΜΕ ΤΗΝ ΕΜΦΑΝΙΣΗ" meaning: "to be paid on demand".
11 On 1 January 2002, the euro became the sole legal tender throughout the euro area, as the then President of the ECB, Dr. Willem F. Duisenberg, declared.
12 Usually, people erroneously believe that paying by cash at a shop, the merchant is obliged to accept it because it is legal tender. This is not true. Only central banks do accept cash. Legal tender means that if we pay a debt with euro banknotes, then the creditor cannot sue us for failing to repay.

What does actually make cash such a popular means of payment in everyday transactions? In any case, taxonomy and terminology are unrelated to habits and daily economic behaviour. Cash is the most popular instrument for retail payments because it offers a real attractive advantage to users (Klee 2008; Arango et al. 2015; Wakamori and Welte 2017). A cash transaction offers full anonymity which, combined with convenience, is indeed a crucial benefit when using cash. Furthermore, cash has a number of additional benefits. It offers the capability to transact in real time, 24/7/365, irrespective of payment systems, intermediaries and infrastructures. In addition, it provides immediate and final settlement, with no single point of failure, and no settlement and cyber risk as both transacting parties are physically present (Weber 2015; Grym et al. 2017; Masciandaro 2018; Middleton and Lund 2018; Middleton and Sinha 2019; Tobias and Mancini-Griffoli 2019). Finally, it is possible for a person to negotiate a lower price when paying for goods and services in cash, also avoiding possible extra credit card surcharges (Rogoff 2014; Wakamori and Welte 2017).

However, cash can be used mainly for proximity payments, resulting in additional costs when a person wishes e.g. to send money to relatives and friends who live far away. Moreover, its use is limited to low value transactions (Wakamori and Welte 2017), it is expensive to store and handle, as well as heavy and bulky in large amounts, and costly to count and process. Additionally, it is vulnerable to theft and susceptible to counterfeit (Middleton and Sinha 2019). In financial terms, cash holders do not enjoy interest or dividend returns, as stored cash cannot be used for investment purposes. Regarding some current trends, cash is facing decreasing acceptance, mainly in Scandinavian countries, as well as restrictions on the maximum value of cash transactions set by many governments.[13] Finally, cash has a reputational cost, as it is widely used in the shadow economy and remains a facilitating medium of criminal activities such as money laundering, terrorist financing and the financing of the proliferation of weapons of mass destruction (Rogoff 2014; Wright et al. 2017).

It is important to understand that cash is a physical means of payment that does not require the existence of payment accounts to initiate a payment. Additionally, banknotes in circulation are part of central banks' balance sheet liabilities. Thus, if one wants to pay in central bank money, one has to pay by using cash. In other words, including central bank trust in payments means using cash stored in wallets or withdrawn from an ATM (thus reducing a commercial bank's account balance). In any case, the majority of money in the economy appears on the liability side of commercial banks' balance sheets, since it is kept in commercial banks' deposits which potentially can be converted into legal tender and hence central bank liability (Kokkola 2010). However, commercial banks do settle interbank, customer, and securities[14] related payments, as well as monetary policy operations in central bank money, i.e. money in an account held with a central bank[15].

Currently, commercial banks' deposits form the majority of monetary circulation in developed economies and can be safely kept in accounts, converted into legal tender, or used in various transactions (Bossone 2001; Kokkola 2010). The latter include credit transfers, instant credit transfers, card payments, and direct debits, i.e. the main instruments used in the euro area to initiate electronic payments (e-payments) from payment accounts. Irrespective of the user penetration and growth of said instruments, at the local or the European level[16], it should be noted that an e-payment transaction is not

13 In Greece the maximum amount of using cash in payment transactions is restricted to EUR 500. Usually, such restrictions are placed as measures against tax fraud and AML since the feature of anonymity encourages persons to conduct transactions in cash.

14 In Europe, securities transactions are conducted in central bank money. TARGET2-Securities (T2S) settles the transaction on a delivery-versus-payment (DvP) basis, i.e. money and securities change hands simultaneously.

15 The reserves are actually sight deposits held with the national central banks (NCBs) by credit institutions in order to settle payments, and meet the minimum reserve requirements and the deposit facility. Regarding allocating reserves to the general public, see Brunnermeier and Niepelt (2019) and Niepelt (2019).

16 Payment cards have overtaken credit transfers as the most widely used cashless payment instrument in the euro area.

anonymous but traceable. However, the crucial benefit of an e-payment, besides the obvious user convenience it offers, consists in its scalability since it is used both for retail and larger value payments. An e-payment serves not only proximity payments at the POI, like cash, but also e-commerce transactions. Additionally, an e-payment also offers 24/7/365 transacting capability and, in the case of the instant credit transfer, real time availability of funds to the payee[17] (Mancini-Griffoli et al. 2018).

One may argue that the initiation of an e-payment simultaneously creates the need for a backing payment system able to manage all forms of "settlement risk", i.e. systemic, credit, liquidity, operational and/or legal risk (Kokkola 2010). It is common knowledge that e-payments are vulnerable to fraud, operational failure, and cyberattacks. Yet it is important to insist that security, resilience and settlement in central bank money are of paramount importance when initiating an e-payment in the euro area (Cœuré 2019c; Bank of England 2020). In this context, it is important to stress that in Europe there is a single system of banking supervision, ensuring the safety and soundness of the European commercial banking sector, a single framework for resolving failing commercial banks, with minimal costs for taxpayers and the real economy, and a single resolution fund financed by the commercial banking sector[18] (Cœuré 2019c).

E-money[19] payments are currently of marginal importance and magnitude in the euro area (Tobias 2019). The ECB defines e-money as "an electronic store of monetary value on a technical device that may be widely used for making payments to entities other than the e-money issuer" (European Central Bank 2020a). Consequently, e-money transactions do not necessarily involve commercial bank accounts. Instead, they involve prepaid instruments mostly used to execute small value retail transactions (Chiu and Wong 2014, 2015). The user initiates an e-money payment from a digital wallet which stores: (i) secure information necessary for authenticating the user; and (ii) payment data necessary for initiating a payment transaction usually through a mobile-based application. The e-money directive (EMD) regulates the storage and use of e-money in retail payments. The result is a payment experience very similar to the use of a traditional commercial bank account. The key difference relates to the nature of the transaction, as e-money is neither a unit of account nor a widespread store of value, and by definition nor legal tender. Usually, full backing in local fiat currency, through deposits held with a supervised commercial bank, enables e-money institutions to retain one-to-one parity with said currency, i.e. the euro in the case of the euro area.

A cryptocurrency[20], such as Bitcoin, Ethereum or Ripple, has its own denomination, is created/mined by non-trusted intermediaries and is issued on a blockchain[21] (Milne 2018; Pichler and Summer 2018; Fatás 2019). In this respect, it is important to note that cryptocurrencies (unlike commercial bank deposits) are not easily converted into fiat currency and most importantly they are nobody's liability. In fact, even when they perform some of the functions of money, they remain speculative assets with unstable value that suffer from excessive volatility[22] (Yermack 2013).

17 Visa by launching a new service, Visa Direct, intends to offer a card payment solution very similar to an instant payment.
18 Single Supervisory Mechanism (SSM – Regulation (EU) No 468/2014), Single Resolution Mechanism (SRM – Regulation (EU) No 806/2014).
19 The e-money directive (EMD) sets out the rules for the business practices and supervision of e-money institutions.
20 As mentioned above, we rather consider cryptocurrencies as cryptoassets since they do not satisfy the three basic functions of money.
21 Blockchain refers to all types of distributed ledger technologies (DLT) including the protocol, network, and application layers. DLT refers to a combination of technologies that together create a digital, shared and automatically updated ledger of verified transactions or information among parties in a network. DLTs are designed to operate with varying degrees of control, ranging from centralised models through to instances where there is no control by a central authority(ies).
22 Currently some cryptoassets have been classified as "stablecoins". For example, Facebook, driven by strong network effects, seeks to stabilise Libra's price by linking its value to a basket of stable currencies. As noted in the Introduction, a detailed analysis of stablecoins is beyond the scope of this paper. However, the author does agree with the outcome of the G7 Working Group on stablecoins that "their adoption is, as yet, uncertain as they face significant legal, regulatory, supervisory and operational challenges. Stablecoins, regardless of size, pose challenges and risks to AML/CFT efforts across jurisdictions, as well as operational resilience (including for cyber security), consumer/investor and data protection, and tax compliance" (BIS 2019, p. 20).

Nevertheless, the main attractive feature of cryptocurrencies is their ability to offer anonymity of transactions to their users (Ali et al. 2014a, 2014b; Auer 2019). However, they are not used in large value transactions and are accepted only by a limited number of retailers (Biais et al. 2019). In addition, they do not fully satisfy the function of a medium of exchange since limited acceptance prevents them from being a universally accepted means of payment (Mancini-Griffoli et al. 2018). Finally, anonymity of transactions often facilitates money laundering and financing of terrorism and hence poses a direct threat to economic stability (Fung and Halaburda 2014; Bank for International Settlements 2015; European Central Bank 2015).

CBDC is defined as the digital cash which can be issued by central banks for payments and settlements (Bjerg 2017; Adrian and Mancini-Griffoli 2019). Thus, if one wanted to use cash in digital form, then one would have to use CBDC (called here d-euro (DEUR) in the case of the Eurosystem). The relevant literature (Bech and Garratt 2017; Mancini-Griffoli et al. 2018; Barontini and Holden 2019; Carstens 2019; Kahn et al. 2019) divides CBDC into two main categories, according to the accessibility criterion, i.e. retail and wholesale CBDC. Retail CBDC would offer public access to central bank liabilities and can additionally be divided into two sub-categories based on the verification of the transaction. The retail token-based CBDC is the case of central banks providing the general public with direct access to CBDC[23] (World Economic Forum 2020). In this direct tokenised form, CBDC can be stored either on a mobile phone or on a prepaid card. Retail account-based CBDC[24] is created when commercial banks provide the public with indirect access to CBDC through a specific type of commercial bank accounts[25] (Fung and Halaburda 2016; Bjerg 2017). In this indirect access form, central banks would create, maintain, hold, regulate and operate the CBDC accounts for commercial banks while the latter would provide the client interface, such as know your customer (KYC) and front-end innovative payment solutions[26]. This type of CBDC involves a partnership between public and private sectors (Lagarde 2018) whose effectiveness is enhanced by their separate and distinct roles (Kashyap et al. 2002).

In another type called wholesale token-based[27] CBDC, central banks provide commercial banks and/or other financial institutions with restricted direct access to accounts where they can settle interbank payments (Bank for International Settlements 2018). Such an innovation could improve cost efficiency, increase speed, and provide 24/7 access to payments. However, discussing the merits and costs of wholesale CBDC as well as its monetary policy implications lies beyond the scope of this paper. The latter focuses only on the implications of a commercial bank account-based CBDC providing access to central bank money to the general public, instead of a selected number of users (e.g. eligible counterparties that have the obligation to hold minimum reserves).

The following figures summarise the foregoing discussion. Figure 1 presents d-euro within the taxonomy of currently existing forms of money, on the basis of access criteria. Figure 2 shows an altered version of the money flower originally designed by Bech and Garratt (2017). This version highlights the property of convertibility, as shown in the red petal. In fact, the coexistence of central and commercial bank money requires that they are convertible at par, leaving the quantity of central bank money unaffected. Figure 2 stresses the fact

23 According to Kahn and Roberts (2009, p. 11), the main difference between an account and a token lies in the verification needed, since the account holder is verified through a messaging process and the token's validity is verified by the beneficiary (Bank for International Settlements 2018, p. 10).
24 Sometimes referred to as a "synthetic CBDC" (Tobias 2019).
25 An alternative (not supported by the author) is a retail direct account-based CBDC when central banks offer to the general public direct access to accounts.
26 The author's business model of issuing a retail account-based CBDC, presented at the 1st EUROchain Hackathon, proposed a special type of account called "Dedicated Digital Account" (DDA) for d-euro transactions via the TARGET TIPS service (TARGET Instant Payment System). A detailed outline is provided in Section 4.
27 Double spending is the main worry in the digital world, i.e. whether the token has already been spent.

Figure 1 The proposed d-euro within the taxonomy of currently existing forms of money

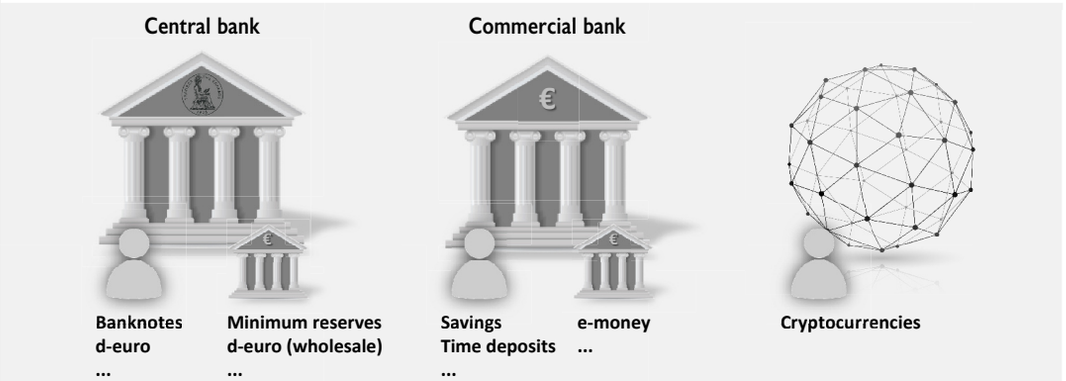
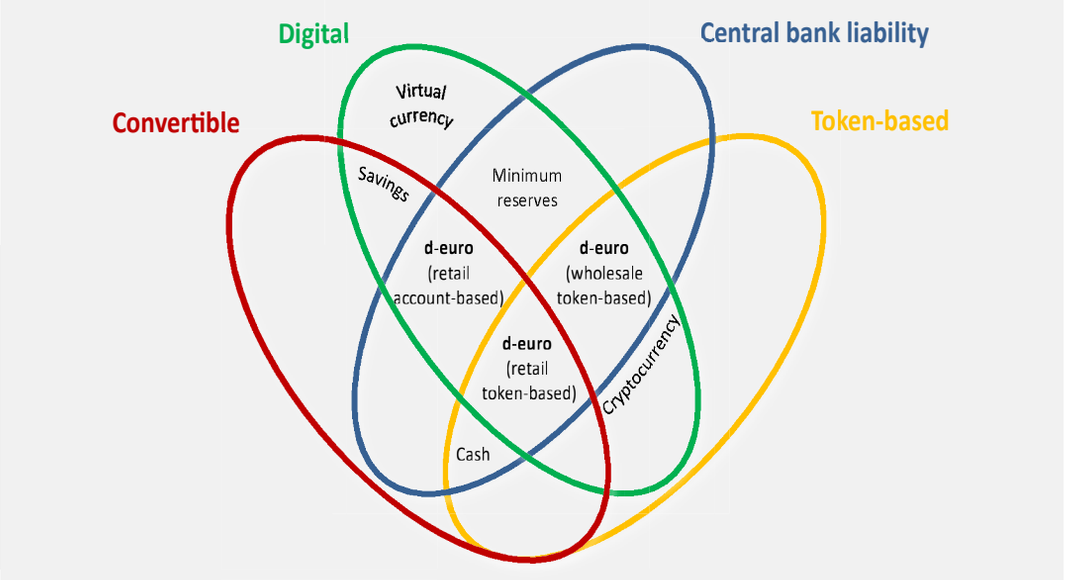


Figure 2 d-euro and the money flower



that cryptocurrencies, including Bitcoin, are inconvertible and not backed by any asset, unlike commercial bank money.

A close observation of the proposed d-euro as a retail account-based CBDC shows that it satisfies three of the four properties presented in the money flower diagram: it is convertible, it is digital and it constitutes a central bank liability.

For an account-based d-euro to be available to the general public, six principles have to be fulfilled (Bank for International Settlements 2018).

- **Principle 1: Anonymity.** This is the feature that makes cash the most attractive and popular means of payment nowadays (Athey et al. 2017). Accordingly, d-euro must offer a competitive degree of anonymity as a vital attractive feature to potential users (Mancini-Griffoli et al. 2018). In contrast to cash, which is fully anonymous and untraceable, providing an advantage in terms of privacy, the use of cash-like d-euro must

be semi-anonymous (Lagarde 2018)[28] (anonymity may be lifted due to AML concerns[29] – Garratt and van Oordt 2019; European Central Bank 201b, 2019c). This semi-anonymity[30] property makes d-euro an ideal alternative anti-money laundering solution unlike physical cash.

- **Principle 2: Trust.** The account-based d-euro must be fiat money with legal tender status. As by definition d-euro would be a liability on a central bank's balance sheet, it should inspire the same level of trust as cash. Such trust would emanate from the fact that d-euro would be issued by the central bank and would be convertible at par with all other forms of the euro[31]. The Eurosystem's national central banks (NCBs) would carry out the task of persuading the general public that d-euro's value is the same as that of euro banknotes and coins. It is envisaged that, by achieving a stable and safe asset status, the d-euro will create positive reputation and trust spillover effects for central banks. The latter are seen by the public "as part of a financial system which has failed to deliver growth and fairness" (Cœuré 2019b). Central banks should view the issuance of d-euro as an opportunity to respond to the rapid evolution of digital reality, the decline in the use of cash, as well as the multiplicity of FinTech solutions (He et al. 2017; Cœuré 2019b; Fatás 2019) and privately issued cryptocurrencies. Central banks must not be left behind but instead exploit their incumbent position and issue digital trust themselves. As Europeans show a positive attitude towards holding payment accounts, there is a significant potential for a public-private partnership in this area (Lagarde 2018; Bank of England 2020). It is the only way for central banks to underpin trust[32] in fiat currency and disincentivise the general public from adopting private sector front-end solutions[33].

- **Principle 3: Scalability.** The account-based d-euro would be used mainly for person-to-person (P2P), person-to-business (P2B), and person-to-government (P2G) payments (like physical cash). The pivotal role of d-euro lies in its efficiency and scalability in both online and POI payments. The issuance of the d-euro could play a widespread role in the use of the single currency in the European retail payments market, thereby contributing to the autonomy of the European payment systems as well as promoting the international role of the euro. In other words, d-euro should form the cornerstone both of the digital approach to the euro and of the effort to enhance its position as an international currency[34]. Therefore, it is expected to be a decisive step in the Eurosystem's attempts to meet the increasing needs of consumers for efficient and secure domestic and cross-border retail payments complementing already existing solutions[35] (Hasan et al. 2013; Cœuré 2019c). Summarising, scalability, combined with trust, will most probably be the decisive factors behind the wide adoption of d-euro.

28 The author's business proposal maintains semi-anonymity, as the NCB which participates in the consensus-driven validation process does not see the content of the transaction. The latter can be seen only by order of the AML officer.

29 In principle, under Article 2(2) of the 4th EU AML Directive (EU 2015/849), cash transactions are out of scope when there is not any intermediary intervention.

30 It should be underlined, strictly speaking, that in a given d-euro payment transaction the identity of the payer and the payee should be fully anonymous to all parties involved. Only the central bank can retrieve such information if and only if there is an AML officer decision, and given that there is reasonable suspicion of an illegal economic activity. In addition, at the 2nd EUROchain Hackathon in October 2018, the author's proposal was that the account-based CBDC should be fully anonymous for transactions of up to DEUR 500 (currently in Greece any P2B transaction in excess of EUR 500 is only allowed via e-payment) and semi-anonymous for payments above that ceiling.

31 The author's business proposal outlined the necessity of price stability in all economic circumstances and hence of the one-to-one parity rule vis-à-vis the physical euro.

32 Because the value of money resides in trust, one may argue that once people start using private money, they may lose a degree of trust in the sovereign currency.

33 Mobile payments platforms that are based on the network effect, like Apple Pay, have been witnessing a significant growth in the payments landscape.

34 Given that the US dollar is the dominant international currency, private initiatives have a competitive advantage in front-end solutions, brand loyalty and global acceptance, compared with central banks and as stated by Gresham's law, "bad money drives out good money" (Giffen 1891, p. 304), the issuance of the d-euro should be seen as the right step to a "euroized" digital economy.

35 Cœuré (2019a) has argued that "it is probably easier to connect a new currency to an existing network – the case of Libra – than to build a new network on an existing currency – the case of the euro". In other words, the issuing of [the d-euro] achieves a hybrid solution: it introduces a new digital currency to an existing network, i.e. TARGET services.

- **Principle 4: Interest rate.** The account-based d-euro should be interest rate free[36] and hence unable to function as a monetary policy tool[37]. Such a semi-anonymous d-euro, issued by the central bank, with a zero nominal return embedded in its initial design, is more trustworthy and likely to be adopted than most private cryptocurrencies. Thus, under normal economic conditions, d-euro should be designed so as to set the effective interest rate lower bound equal to zero (Hall 2013; Agarwal and Kimball 2015; McAndrews 2015; Dyson and Hodgson 2016; Engert and Fung 2017; Meaning et al. 2017; Middleton and Sinha 2019). However, that being said, the decision of whether or not the d-euro will be interest-bearing is an issue with multiple implications for monetary policy and financial stability (Eggertsson and Woodford 2003; Mancini-Griffoli et al. 2018; Agur et al. 2019; Keister and Sanches 2019; Kim and Kwon 2019).

- **Principle 5: Acceptance.** Initially, the account-based d-euro should be used in payment systems and by payment solutions that offer pan-European reachability with global acceptance as a long-term goal[38] (Cœuré 2019c). Global acceptance should reinforce economies of scale, support the euro's international role, and meet the increasing needs of European consumers for global reachability. In fact, Europe has made substantial progress in the promotion of the euro as an international currency since its introduction on January 1, 2002. Cash payments have been carried out using the single currency across the euro area with the same ease and convenience, but this has not been the case for electronic payments. The development and implementation of the Single Euro Payments Area (SEPA) in 2014[39] resulted in the creation of a single payments area for cashless payment instruments. Since the creation of SEPA, the d-euro seems the natural next step towards pan-European acceptance and reachability for both proximity and e-commerce payment transactions. While GAFA[40] are leveraging their extensive networks and are increasing their presence in the front-end retail payment environment in Europe, the issuance of the d-euro could be seen as turning this challenge into an opportunity.

- **Principle 6: Convenience.** The account-based d-euro should be designed according to customers' demands for convenience, speed, efficiency and global acceptance for both proximity and e-commerce payments. The d-euro issuance should be seen as a possible response of the Eurosystem to private sector stablecoin and cryptocurrency initiatives and card scheme global players (Cœuré 2019c). The d-euro has to cater for consumers' changing needs by combining the characteristics of cash and payment cards[41]. Thus, it must be user-friendly, equal to available instant payment solutions, and capable to offer 24/7/365 payments in real time. In addition, it should be available through different tools, payment instruments, and technologies, enhancing the payment experience and becoming synonym of convenience to both consumers and merchants. So far we have argued in favour of a public-private partnership between central and commercial banks, capable of creating a pan-European retail payment solution, like a European-governed payment card scheme, where central banks provide the back-end infrastructure and the private sector the front-end solutions.

As already stated, a CBDC initiative will have to serve the three basic functions of money, i.e.

36 The author's business proposal for the 1st EUROchain Hackathon outlined the necessity of the one-to-one parity rule vis-à-vis the physical euro and hence argued for a non-yield-bearing CBDC.
37 The next section considers the possibility of using the d-euro as a monetary policy instrument.
38 The key advantage of the stablecoin initiatives, based on their global clientele, is their cross-border functionality.
39 SEPA is an area where consumers, enterprises and public entities can make and receive domestic and cross-border electronic payments in euro under the same basic conditions and with the same rights and obligations. SEPA has created an integrated, competitive and innovative retail payments market, where all cashless euro payments are conducted via a single payment account and a single set of payment instruments in a fast, safe and efficient manner.
40 The non-European tech giants Google, Apple, Facebook and Amazon are often referred to collectively as "GAFA".
41 A payment card with a common European brand and logo, open access to NFC interfaces for proximity payments, and a global acceptance for e-commerce should be an efficient solution.

stable unit of account, costless medium of exchange, and secure store of value (Bordo and Levin 2018). Additionally, and in view of the aforementioned set of principles, the case for the d-euro raises a number of new policy considerations that merit further investigation (Andolfatto 2018).

3 CBDC AND THE ROLE OF CENTRAL BANKS

It is worth noting that digitalisation in the field of payments has affected consumers' payment behaviour (Cœuré 2019a). However, high demand for digital payment solutions may question public trust in major financial institutions. Consequently, many central banks have realised that they should respond immediately to the recent technological innovations in banking and payment systems, as well as to the digitalisation of money (Ahmat and Bashir 2017; Engert and Fung 2017; Bergara and Ponce 2018; Juks 2018; Kumhof and Noone 2018; Panetta 2018; Sveriges Riksbank 2018b; Norges Bank 2019; Bank of England 2020). In Europe, the Eurosystem has started to consider the issuance of a CBDC and to analyse its possible design and implications (Cœuré 2018). Thus, digitalisation has challenged the role of central banks, to the extent that they have to be involved in the retail payments market and to act beyond their traditional role as guarantors of price and financial stability and ensurers of the smooth operation of the payment systems. Central banks are presented with the significant opportunity of analysing the potential implications and risk considerations arising from the issuance of a digital currency such as the d-euro. By doing so, and by deciding that they must not be left behind in the digital race, they are also faced with a key question: what are the main motivations behind the issuance of an account-based retail CBDC and why might central banks wish to proceed with it?

Motive 1: Trust and the digital transformation of the economy. Facebook's Libra, based on permissioned blockchain technology (Libra 2019), is a token-based stablecoin backed by a pool of assets. It seeks to reach wide-scale adoption and global acceptance and expects to benefit from network effects and economies of scale (Cœuré 2019a). Indeed, Facebook (which claims 2.45 billion core active users in 2019[42], as well as 2 billion WhatsApp and 1 billion Instagram users) tailors its payment solutions to consumers' changing behavioural trends and attempts to turn a means of payment into a global currency (Gans and Halaburda 2013; Fung and Halaburda 2014; Cœuré 2019a). By entering the realm of retail payments and financial services, Facebook plans to provide both front-end and back-end solutions, thus eliminating the need for central clearing and settlement performed by central banks. Furthermore, Alipay and WeChat Pay,[43] using mobile payment solutions and non-social networking apps, together account for 93% of all digital transactions in China.[44] These third-party online and mobile payment solutions strive to become globally available by signing deals with European banks and digital wallet companies. By doing so, they intend to provide tailor-made services meeting the needs of European customers.

Moreover, Google Pay and Apple Pay are card-based wallet solutions that allow users to initiate proximity payment transactions at the POI and are prominently focusing on e-commerce payments. Thus, they offer services that have been traditionally provided by the banking sector. Given their branding power, they are gradually replacing the existing front-end banking solutions and provide additional back-end core banking services which usually lie outside of the banking perimeter (Cœuré 2019b). In addition, as these solutions are fast, cheap, user-friendly and offer cross-border functionality, they may eagerly be adopted by European customers for purchases at domestic or foreign merchants.

42 The world's population at that year was 7.71 billion.
43 Alipay and WeChat Pay provide mainly front-end services, while at the same time decreasing merchants' costs by using the QR code technology, which is cheaper than the card-based technology.
44 According to the People's Bank of China annual report.

Alipay, WeChat Pay, Google Pay, Apple Pay, and many others are targeting to shift consumers' payment preferences by importing proprietary practices that are alien to European consumers' habits and needs. In an extreme scenario, given information asymmetry and adverse selection, based on a winner-takes-all effect, the Eurosystem's market infrastructures services, TARGET2 and TIPS, may be impacted. In this case, the bigtech firms that offer payment solutions may exploit their comparative advantages, bringing about a significant decrease in the share of euro area banks in the European retail payments market and accordingly a tantamount drop in the volume of assets settled in central bank money, via TARGET2. Given that under the European payments strategy, the pan-European solution must be market-led and meet the objectives of the Eurosystem, the foregoing solutions offered could cause an adverse impact on standardisation, interoperability and reachability in the European retail payments market.

By acting as operators, overseers and catalysts, central banks are responsible for providing efficient and sound clearing and payments systems as well as for maintaining the value and trust of the currency (Kokkola 2010). The safe and efficient use of the currency as a stable medium of exchange is a basic pillar of consumers' trust in it. The fact that a privately issued stablecoin may replace traditional payment and financial assets is a wake-up call for central banks to start considering issuing a digital alternative that warrants maximum reachability, stability, and resilience. The d-euro should be an ideal answer, as it enables pan-European SCT-Inst-based[45] POI solutions via TIPS. By offering such pan-European reachability, it minimises any potential reputational risks regarding the role of the Eurosystem in the payments ecosystem.

In order to be prepared for the advent of 5G technology and to start promoting climate risk disclosure in their tasks, central banks have to be ready to take the leadership regarding the provision of technological innovation. In this context, the potential issuing of the d-euro can be seen as the next step in the digitalisation process of the retail payments market. Central banks would thus become active players in the process of money digitalisation in order to foster trust and to promote a reliable and efficient means of payment. In other words, the issuance of the d-euro as the digital version of a sovereign currency, i.e. the euro, would support the resilience and strength of the European monetary policy project. In addition, it would support the safety and soundness of the European retail payments market and could promote the international use of the euro as a stable and convenient currency. It is a well-established principle that "it is difficult to build a new network on an existing currency"[46]. The Eurosystem has created TIPS, a TARGET service, with the potential to ensure full pan-European reachability and settlement of instant payments in d-euro as well. Thus, and since TIPS has a multicurrency technical capacity, d-euro can be introduced from day one as a stable means of payment with immediate pan-European reach and potential global acceptance.

Motive 2: Decline in the use of cash. Cash is the dominant payment instrument in the euro area. However, an extreme scenario could materialise in the future where physical cash will not be generally accepted as a means of payment and demand for it will decrease. Currently, in some countries, most notably Sweden, the use of physical cash for retail payment transactions has been declining rapidly and a number of retailers do not accept cash at all[47] (see for example Bordo and Levin 2017). Additionally, according to the latest payment statistics,[48] the euro area has experienced a steady decline in the number of bank-operated ATMs and an increase in the number of card pay-

45 SCT Inst stands for SEPA Instant Credit Transfer.
46 See footnote 36.
47 The discussion of a cashless society goes beyond the scope of this paper (for a discussion about this subject-matter, see Engert et al. (2018a) and Gnan and Masciandaro (2018)). The Eurosystem treats all available means of payments on a non-discriminatory basis. The author does not entertain the idea that cash will be abolished and hence any theoretical discussion about cashless societies is at present meaningless.
48 ECB Payment Statistics.

ments. These trends are likely to further accelerate in the future, given the widespread adoption of open banking solutions and the introduction of new services offered by regulated third party providers (TPPs)[49], especially the payment initiation service providers (PISPs)[50]. The declining use of physical cash observed in many northern European countries may be a warning signal about possible structural changes in consumers' behaviour at the euro area level. Given the proactive stance that central banks are likely to adopt in the new digital paradigm and as Europe is moving towards a cashless payment environment (Engert et al. 2018a), one may ask: how will they fulfil their mandates of providing resilient, efficient and stable payment systems?

Cash constitutes a fraction of a central bank's balance sheet and of the money supply (M1). Its popularity rests on the fact that it is risk-free central bank money that settles payments with anonymity and finality. In addition, strictly microeconomically speaking, a cash payment[51] is a zero-sum game, where both parties (payer and payee) enjoy Pareto optimality, since a banknote is exchanged in order to redeem an obligation. Cash plays no role in the operation of TARGET services. There, payment orders are submitted to the platform for processing and are irrevocably settled via risk-free transfers between the respective dedicated cash accounts that the participants hold with the central bank.[52] Thus, a significant decline (or increase for that matter) in the use of cash cannot affect the back-end payment operations of the Eurosystem. Any change in the volume of physical cash in circulation will neither obstruct nor interrupt the continuous operation of TARGET services and hence will not affect the primary objective of central banks to promote the smooth operation of the payment systems and to ensure efficiency and sound clearing (Kokkola 2010). However, the demand for small-denomination coins is rather low as they are not used very often (Judson 2018). Hoarding of coins increases the opportunity cost of using cash against all other instruments and holding cash for saving reasons[53] due to its physical nature.[54] It can be argued that this decline in the use of physical cash may break the bond of trust between the public and the central bank, as the former loses confidence and starts to question the latter's mandate and role (Middleton and Sinha 2019). The trust that people place in cash is merely a reflection of their trust in central bank issuers. Hence, the issuance of the d-euro, as digital cash, could be seen as a credible way of avoiding reputational risks and regaining trust.

It must be noted that as part of a portfolio diversification strategy, people may hold certain amounts of cash as a precautionary reserve since it is the most trusted form of money. In fact, it has been observed that demand for cash increases dramatically during bank runs[55] as the public becomes more risk averse and looks for risk-free assets (Brown et al. 2017). During the recent euro area crisis, two major events were observed in Greece which was also going through a sovereign debt crisis: (i) an increase in demand for cash as a safe asset; and (ii) a realisation that access to commercial bank deposits is subject to regulatory and liquidity restrictions. In June 2015, capital controls as well as regulations enforcing the use and acceptance of electronic payment instruments (mainly cards) were imposed in order to stem capital flight. Argentina has experienced a phenomenal demand for foreign currency (i.e. the US dollar) and safe assets during its last economic crisis, as they were perceived as more stable and secure. Recommendations for the promotion of electronic payment instruments in a crisis environment are neither addressed only to the technology-adept generations, nor are they necessarily related to financial reasons, as the COVID-19 pandemic has revealed

49 The EU's revised Payment Services Directive (PSD2).
50 The PISPs are authorised to initiate payments from a user's payment account.
51 In strictly economic terms, a payment is indeed a transfer of funds by using either cash or deposits held with credit institutions and discharges an obligation on the part of the payer vis-à-vis the payee.
52 T2S settles securities transactions on a delivery-versus-payment (DvP) basis using optimisation and auto-collateralisation mechanisms to enhance settlement efficiency.
53 Store of value.
54 The cost of cash has been described in Section 2.
55 Financial crises have very low probability tails (Engert et al. 2018a).

with the nationwide lockdowns, the restriction of movement, and the "stay home" campaign.[56]

All the cases discussed above exhibit one common characteristic: at the moment physical cash has proved to be the only form of risk-free central bank asset available to the public. In particular, a decline in the use of cash gradually prompts consumers to depend greatly on payment solutions provided by the private sector and to lose their trust in efficient and reliable payment systems. Therefore, central banks, by issuing the d-euro as a semi-anonymous digital means of payment alternative to cash, would provide the public with access to central bank money that is a secure store of value and a stable means of payment in periods of financial (Mancini-Griffoli and Ranaldo 2011) and societal crisis. After all, is this not one of their roles?

Motive 3: Financial stability considerations.[57] One of the main issues related to financial stability concerns possible bank runs as a consequence of the d-euro's competition with commercial banks' deposits (Stein 2012; Dyson and Hodgson 2016; Raskin and Yermack 2016; Bank for International Settlements 2018). Such cases have attracted significant interest in the recent literature and policy debates and can be summarised in two main scenarios: (i) a surge in conversion of commercial bank deposits into d-euro during normal financial times; and (ii) conversion of commercial bank deposits into d-euro (rather than cash) during periods of financial crisis. It must be noted that in this analysis, d-euro deposits are interest-free as credit is provided entirely by commercial banks. In both scenarios the d-euro accounts are held with and managed by commercial banks, while deposits are guaranteed, up to a limit, by national deposit guarantee schemes[58].

The first scenario presupposes information asymmetry between account holders, which leads a part of them to hold d-euro as a safer store of value and hence to increase its demand. In such a case, central banks may intervene by issuing d-euro up to a specific amount per holder, providing a certain horizontal quota[59]. Thus, by imposing ceilings on the amount of d-euro allowed per customer, central banks can promote the currency's function as a medium of exchange instead of a store of value.[60] However, one could argue that commercial banks will react to the introduction of the d-euro by adjusting deposit rates even if limits are imposed on d-euro account holders, thereby leading to an insignificant deposit outflow into d-euro under a financial system in which the same authority guaranties both types of deposits. Commercial banks are expected to raise revenues from the management of accounts (in the form of fees, etc.) as well as from a number of customer-tailored payment solutions that will be provided and treated as premium services. Commercial banks will probably react and offer additional services to account holders, similar to those provided to card holders in order to make deposits more attractive to potential customers. Finally, as an alternative measure, they may raise interest rates on saving deposits in order to win clientele from their competitors. Such increases may spark a hike in lending rates, in order to readjust the interest rate margins to their initial level. In an extreme scenario, commercial banks should consider replacing part of their outflows of retail deposits with secured wholesale funding in order to reduce their dependence on them.[61] Central banks may consider

56 The decline in the use of cash experienced during the COVID-19 pandemic has helped to prevent the spread of the disease to a certain degree. Banknotes are coronavirus carriers and people opt for contactless payments instead (COVID-19 stays on a note's surface for a number of days and thus people using cash have to wash their hands regularly). However, attitudes adopted during such emergency periods may have a more permanent nature and can thus change consumers' payment habits, leading to a faster reduction in cash use.

57 Future work could consider a deeper analysis of this issue.

58 In the EU, deposit guarantee schemes protect depositors' savings up to EUR 100,000 and prevent the mass withdrawal of deposits in the event of bank failures.

59 Assuming there is parity between all forms of money, i.e. cash and commercial bank deposits, quotas must aim to enhance the efficiency of d-euro as a means of payment.

60 The author's business proposal at the 1st EUROchain Hackathon stressed that for social reasons this quota should be closely associated with the total amount of euro banknotes and coins in circulation. Thus, according to this proposal, the Eurosystem should introduce a single tier system for the account-based d-euro with a dynamic ceiling, given the decrease in the use of physical cash. The proposal called for an initial issuance of DEUR 4,000 per citizen.

61 Commercial banks with high retail deposits are more sensitive.

continuing to provide liquidity while accepting riskier collateral and thus a higher degree of credit risk. Theoretically speaking, this situation could lead to higher costs of funding, reduced and riskier profits and hence bank funding problems and financial instability, as d-euro deposits will not be available for lending. Yet again, given the low d-euro ceiling per account holder, the likelihood of reduced bank profits and undermined financial stability is arguably low in an environment where central banks and/or prudential authorities safeguard the stability of the financial system and operate in partnership with commercial banks.

So far we have argued that during normal financial times, deposits in central bank money, held with and managed by commercial banks, are both risk-free and perfectly liquid. However, during periods of financial crisis, citizens may perceive the d-euro as a safe-haven, risk-free store of value backed by the central bank, and when in panic they may cause a bank run. The Greek sovereign debt crisis, which led to a series of austerity measures and the debt swap through private sector involvement (PSI), has shown that risk-free assets do not exist in a financial crisis environment (see Jobst and Stix 2017). During periods of financial crisis and panic, d-euro may be perceived as an "asset of the last resort" offered by the central bank. Two major potential benefits from issuing d-euro become apparent in times of economic turbulence: (i) given that Greece as member of the euro area has lost its monetary flexibility, liquidity may stay longer in the country, as capital flight may, to some extent, be avoided (capital outflows would severely increase the NCB's liability vis-à-vis the ECB[62]); and (ii) trust in the central bank and the euro as legal tender may be underpinned,[63] thus averting any additional reputational costs. Before the Greek experience of capital controls, a shift towards safe assets (notably cash) had been observed. Central banks could also, in future, consider introducing a two-tier d-euro system in order to meet money demand for precautionary reasons (Bindseil 2020). Thus, besides the d-euro used for payments, central banks could introduce a tier-two d-euro which would act exclusively as a store of value to households and enterprises. The amount of each tier allocated to each account holder would be determined and subject to change by the central bank. The central bank would also be able to change the interest rate (Lenza et al. 2010) of tier-two deposits at will (Bindseil 2020), applying even a negative rate during normal times so as to make them highly unattractive. Nonetheless, the aforementioned concerns expressed in the literature regarding the possibility of digital bank runs should inform the exact CBDC design.

Finally, d-euro is expected to be preferred over cash as a medium of exchange, due to non-financial reasons such as the time-consuming process of visiting ATMs or the cost of holding cash (including the risk of being lost or stolen during transportation). As evidenced during the very recent COVID-19 pandemic crisis, the d-euro should appear to be suitable to serve as a semi-anonymous, cheap, secure, and efficient means of payments used for remote transactions (including e-commerce).

Motive 4: Monetary policy considerations. The potential impact from the introduction of the d-euro is expected to be of limited relevance for monetary policy (see for example Bordo and Levin 2017). As long as physical cash is not abolished in the near future (Niepelt 2018), d-euro is both highly unlikely and undesirable (on the part of policy makers) to bear interest and serve as a monetary policy instrument (e.g. Hamilton and Wu 2011; Edgar 2012; Goodfriend 2016; Rogoff 2016; Dell'Ariccia et al. 2017; Davoodalhosseini and Mohammad 2018). Conventional monetary policy dictates that when short-term interest rates are at or near the so-called zero lower bound (ZLB),

62 https://www.bankofgreece.gr/en/main-tasks/payment-systems-and-settlements/target-services/large-value-payment-system-target2/target2-account-balance.

63 In situations of panic, d-euro could also be affected and treated as a "lemon" because of adverse selection according to the well-known Akerlof's paper (1970) and thus d-euro holders should also be expected to withdraw their assets, thereby increasing the elasticity of demand for all deposits.

central banks cannot reduce them further in order to stimulate lending and demand when the availability of zero return physical cash serves as a stable floor for all interest rates (Dyson and Hodgson 2016; Borgonovo et al. 2018; Strournaras 2018). It can be argued that as d-euro is the digital equivalent of cash, and its supply is constrained by design, then it acts as an interest-free asset and a concrete floor to all interest rates in the wider economy. In a negative interest rate economy, people will prefer to hold a zero-interest bearing asset like cash, d-euro, a foreign currency (e.g. USD) or even a stablecoin, which should set the effective lower bound to zero (Engert and Fung 2017; Bordo and Levin 2018). By designing d-euro as an attractive complement to cash and keeping its supply constant (at a certain ratio to the amount of cash in circulation), there should be no effect on short-term interest rates and on the alleviation of the ZLB constraint. Thus, in fact, the circulation of physical cash (rather than the issuance of d-euro) is the main binding constraint to the application of negative interest rates during periods of deflation and limited aggregate demand[64]. On the other hand, one might argue that a zero-interest rate d-euro would free the Eurosystem from the ZLB issue. Niepelt (2018) argues that it would relax central bankers' ability to conduct monetary policy based on interest rate manipulation in order to stimulate the economy, thereby allowing them to focus on the primary objective of the Eurosystem's monetary policy, i.e. price stability.

Since it is not feasible to reduce interest rates below certain limits, there are alternative monetary policy tools that the d-euro could serve, with a view to boosting aggregate demand. Quantitative easing (QE) has proven to be one of the most effective policy tools in the euro area during the financial crisis. When central banks apply quantitative easing, they buy securities (e.g. government bonds) in order to push down interest rates and provide liquidity to the banking sector (McLeay et al. 2014; Meaning et al. 2018). The ECB has recently announced a new asset purchase programme[65] in response to the COVID-19 pandemic, ensuring "that all sectors of the economy can benefit from supportive financing conditions that enable them to absorb this shock ... equally to families, firms, banks and governments" (European Central Bank 2020b). The implementation of such a programme could be further facilitated if people were able to hold d-euro accounts. In another case, central banks could perhaps more easily provide liquidity directly to households and other designated account holders (e.g. firms, pension funds, etc.) in what is known as "helicopter money" (Reichlin et al. 2013; Dyson and Hodgson 2016; Ward and Rochemont 2019). Unlike QE where central banks purchase assets (using printed money) by increasing their liabilities, with helicopter money central banks make an impact on the economy by issuing money and distributing it directly to households and enterprises (Dyson and Hodgson 2016). Especially in cases like the COVID-19 pandemic crisis when firms close down and strategic industries suffer financial losses or face bailouts, d-euro could facilitate the implementation of a helicopter money scheme, which intends to help society cope with staff redundancies and lockdowns.

All in all, like cash, a d-euro would play a rather minor role in monetary policy implementation (Broadbent 2016; Agur 2018; Engert et al. 2018b; Albertazzi et al. 2020). However, d-euro may be used as a direct channel through which central banks can transmit monetary policy to households and enterprises. Central banks have been unwilling to open and manage public d-euro accounts. Therefore, this task should be assigned to commercial banks, along with the customer onboarding process as well as the provision of front-end payment solutions. The next section presents our case for a possible d-euro issuance that is based on exactly such a public-private partnership.

64 Altavilla et al. (2019) argued that when the ZLB has been hit, healthy banks are better off, compared with weak banks. However, one may argue that the former penalise depositors and could therefore accuse central banks of failing to deliver growth and fairness.

65 The so-called Pandemic Emergency Purchase Programme (PEPP).

4 TARGET SERVICES AND D-EURO AS A MEANS OF PAYMENT

The present section aims to offer a more detailed presentation of the design and functionalities of a prospective d-euro. Recently, much research activity has been devoted to the development of CBDC blueprints[66] (mainly Ahmat and Bashir 2017; Engert and Fung 2017; Bergara and Ponce 2018; Juks 2018; Kumhof and Noone 2018; Panetta 2018; Sveriges Riksbank 2018b; Yao 2018; Armelius et al. 2018; Norges Bank 2019; Bank of England 2020; Boar et al. 2020; Jung and Uhlig 2020). As a result, many similar theoretical models have been conceived and presented (see also Barrdear and Kumhof 2016; Gouveia et al. 2017; Engert et al. 2018b; Fernández 2018; Mancini-Griffoli et al. 2018; Kahn et al. 2019; Bank of England 2020; Bindseil 2020). Such models present several similarities and are often distinguished by subtle differences. The model presented here attributes to the proposed d-euro a number of features that may be shared by other theoretical efforts. Nevertheless, this project is marked by the unique characteristic of trying to implement a CBCD under the limitations and the design of the Eurosystem's current payment infrastructure. This is the main factor behind some of the specificities presented here, which will be scrutinised accordingly and through this prism.

Central banks that operate in the area of payment, clearing and settlement systems have to examine whether d-euro would improve the security and efficiency of retail payment systems and (in the case of the Eurosystem) TARGET services. In fact, central banks, in order to provide convertibility between different forms of money, operate RTGS systems (Martin and McAndrews 2008; Kokkola 2010) whereby commercial banks submit payment orders and settle interbank transactions without the use of cash. In addition, such systems are closely associated with monetary policy considerations (TARGET2 settles payments related to the Eurosystem's monetary policy operations and implements monetary policy decisions) and financial stability (it provides secured liquidity to the financial system). However, when issuing d-euro, central banks have to apply design features that would allow them to continuously fulfil their mandate of providing safe, stable, efficient, reliable and secure payment systems.[67]

First and foremost, the d-euro must satisfy the distinct properties of cash, i.e. to emulate cash in a digital environment. As can be seen in the following table, d-euro is designed as a low-cost and efficient means of payment that warrants maximum acceptance, accessibility, semi-anonymity, availability, convenience, scalability, reachability, and stability. In addition, the support of monetary policy and the improvement of financial stability should be the core considerations of the d-euro design. The two core principles behind d-euro issuance are: (i) convertibility at par with commercial bank deposits, which makes it a liability of the Eurosystem; and (ii) zero remuneration (like cash), which excludes it from serving as a monetary instrument. Moreover, some legal considerations related to d-euro's design should be clarified. Since the Court of Justice of the European Union (CJEU) and the Treaty on the Functioning of the European Union (TFEU) do not explicitly authorise the Eurosystem to issue a CBDC and given that d-euro should have legal tender status (Mancini-Griffoli et al. 2018), a clear authorisation for d-euro issuance does not exist.[68] Given that d-euro offers zero remuneration and that a priori its design should improve payment infrastructures' safety and efficiency, Articles 17 and 13.1 of the ESCB/ECB Statute are not relevant.[69] In addition, it seems that the issuance of the d-euro will not affect settlement finality and insolvency procedures as expressed in the

66 Some 66 central banks replied to a survey, covering 75% of the world's population and 90% of its economic output, and reported that more than 80% are working on CBDC (Boar et al. 2020).
67 Under Article 3.1 of the ESCB/ECB Statute.
68 Mersch (2020) argued that "without legal tender status, the legal basis would need to be clarified, as would the relationship between a CBDC and euro banknotes and coins, along with the process by which one could be exchanged for the other".
69 However, an important legal issue that is outside the scope of this paper is whether TFEU (for example Article 128) or other legal documents need to be amended.

D-euro as account-based retail central bank digital money

	Cash	d-euro	Reserves
Acceptance	High (majority of retailers still accept cash)	High	Low
Access	Anyone	Anyone	Supervised credit institutions
Account provider	–	Authorised credit institutions	Central bank
Anonymity	Anonymous	Semi-anonymous	Not anonymous
Availability	24/7/365	24/7/365	TARGET2 operating hours
Convenience	Medium (requires both parties to be present)	High	High
Convertibility	Par	Par	Par
Cost	Medium (withdrawal and storage)	Low	Low
Finality	Final	Final and irrevocable	Final and irrevocable
Form	Physical	Digital	Electronic
Interest rate	No	No	Yes
Legal tender	Yes	Yes	No
Limits	Yes	Yes	None
Scalability	Low and medium value transactions	All value transactions	Large value transactions
Settlement[1]	Immediate	Instant	Real-time
Reachability	Medium (only proximity payments)	High (pan-European and cross-border)	High (Eurosystem's supervised credit institutions)
Risk	Medium (counterfeit, steal)	Low	None

1 See Bech et al. (2017).

settlement finality directive (SFD) (Article 1 of SFD). PSD2, although not originally oriented towards instant payments, assigns central banks with the tasks of improving the efficiency of payments throughout the Monetary Union, ensuring a high level of consumer protection (from fraud), and respecting and protecting fundamental rights, including the ones of privacy and confidentiality (Articles 59, 68, 72-74, 94, 97). D-euro compatibility with KYC guidelines, adherence to AML/CTF requirements, and compliance with the GDPR are legal considerations that must also be taken into account, on a preliminary basis, in relation to the issuance of d-euro (Bank for International Settlements 2015). However, a further in-depth analysis should establish a robust legal regime.

D-euro is a retail account-based CBDC, whereby central banks verify the validity of instant payment transactions by using a centralised ledger structure[70]. According to this approach, households and enterprises do not have direct access to central bank liabilities but instead hold accounts with commercial banks. The latter are the administrators of these

70 DLT does look very promising. However, at present it is not mature enough to support the issuing of the d-euro. In a previous short article describing DLT, the author concluded that: "personally, I believe that this new technology could potentially prove to be as important as the internet. However, I also believe that we are still at the beginning of the exploration of its promises, while at the same time we need a careful analysis of its possible consequences both in terms of monetary policy and financial stability. In fact, the marriage of this new code with the existing infrastructure of the financial sector has just taken place. And the honeymoon, exciting and full of inspiration, will be long" (Korfiatis 2018, p. 12).

accounts and provide any account-related services. This specific d-euro implementation, whereby commercial banks act as intermediaries, requires a public-private partnership of a manner described later in this section. In fact, the objective of this section is to present the main features of d-euro and its technical design. The table compares d-euro as an account-based retail central bank digital currency with the other existing forms of central bank money.

The features[71] of d-euro in a two-dot model: given the proposed attributes shown in the table above, the designed features of d-euro in this paper were originally presented by the author at the 1st and 2nd 2018 ECB EUROchain Hackathons. Specifically, we propose a two-dot model account-based d-euro. Central banks (ECB and NCBs) are viewed as dot-one entities that settle all d-euro transactions by crediting and debiting account balances. End users do not interact directly with central banks but indirectly through Payment Service Providers (PSPs). PSPs can be viewed as dot-two entities and mainly function as intermediaries between end users and central banks. Commercial banks can act as PSPs and are able to provide their clients with d-euro accounts. The proposed two-dot structure is explained in greater detail in the next section. In fact, there are several sets of different proposed features that could make CBDC an efficient means of payment, a stable unit of account, and a secure store of value. That being said, it all boils down to a policy decision whose adoption depends on the central bank's wish to be involved in the retail payments landscape and on the implications that this decision may have for the safety and the efficiency of retail payments, monetary policy and financial stability. Given the foregoing argumentation, an ideal account-based d-euro would exhibit the following features (see also Bank for International Settlements 2015):

Anonymity: d-euro is semi-anonymous, a property which renders it the ideal alternative anti-money laundering solution and offers an advantage in terms of privacy compared with physical cash[72]. The attractiveness of this semi-anonymous design rests on the fact that anonymity may be only lifted due to AML concerns and/or suspicion of illegal economic activity such as money laundering and terrorist financing. Thus, d-euro satisfies, especially for lower-value payment transactions, the privacy and traceability requirements that help avert the misuse of the financial system to channel illicit transactions that damage its integrity, stability and reputation.

Availability: d-euro is available to all users, providing a 24/7/365 payment experience and immediate transfer of funds. Unlike cash whose availability depends on ATM withdrawals (which are costly and may include withdrawal fees), visits to a bank branch (which operates during banking hours and includes transactional fees) or access to secure storage locations (which bears security costs), d-euro is universally available, without restrictions, and meets the general trend towards digitalisation. Thus, it meets users' need for secure and around-the-clock digital money, irrespective of the underlying payment instrument used, and can execute both online and offline payments.

Convenience: d-euro is convenient, as transactions can be initiated via different devices (e.g. mobile phones, wearables and payment cards), channels and technologies (e.g. NFC, QR-code, AI, AR and IoT). In fact, the proposed d-euro has been designed with convenience in mind and accordingly replicates all the crucial characteristics of physical cash (that have made it the most convenient means of payment so far), while at the same time facilitating the digital transformation of the economy (Selgin 1994; Ruth 2018). In addition, with the exception of web-based services which are energy-consuming and rely on internet access (e.g. smart-

71 Those characteristics were described and presented at length at the 1st and 2nd EUROchain Hackathons (April and November 2018, respectively).

72 The "... CBDC would be acting as an instrument with the liquidity and anonymity of cash, but without the limitations on portability that come with physical cash" (FATF 2020, p. 28).

phones), d-euro can be available to the user via a payment card,[73] thus incorporating the main feature of the most popular electronic payment instrument, i.e. convenience.

Cost: d-euro is a digital means of payment alternative to cash and hence its issuance has zero cost on the public. D-euro accounts are provided, managed and maintained by commercial banks, and do not have opening or maintenance fees. In addition, transferring liquidity from a commercial bank deposit account to a d-euro account is free, while the pricing structure is the same, i.e. there is free usage of e-banking or the ATM. Consequently, the proposed d-euro is conceived as a cost-efficient means of payment that does not suffer from the aforementioned cost of cash.

Interest: d-euro offers zero remuneration and accordingly plays a rather minor role in monetary policy implementation and financial stability. Thus, it is attractive to users without violating the parity rule (see further below) and conflicting with anonymity (if interest is subject to taxation). In addition, it discourages commercial bank account holders from moving liquidity between traditional and d-euro accounts. Again, with users facing maximum holding limits, it becomes highly unlikely that the d-euro would affect the ZLB, since the opportunity for depositors to hold unremunerated d-euro as the best costless alternative (avoiding both possible negative bank deposit rates and the costs generated to holding cash) is offset by its imposed limit (Dyson and Hodgson 2016; Yanagawa and Yamaoka 2019).

Issuance: d-euro is issued by central banks in order to promote convenience, efficiency, transparency, stability and accessibility in retail payments, and to modernise the Eurosystem's TARGET services, keeping up with technological developments and consumers' demands. The main advantages of issuing d-euro for central banks, as analysed in the previous sections, are: (i) to regain trust by promoting a third form of base money; (ii) to respond to the significant decline in the use of cash; (iii) to facilitate the digital transformation of the economy by addressing users' needs and demands for a convenient, secure, global, flexible and instant payment experience; (iv) to contribute to the strategic autonomy and resilience of European payments, thereby supporting the reputation of the Eurosystem and the international role of the euro; (v) to promote the vision for an innovative retail payment solution providing safety, convenience, cost-efficiency, and pan-European (possibly global) reach; and (vi) to offer an attractive alternative to the proliferation of digital currencies.

Quantity: d-euro holders (households) face an amount limit per account (in the next section we analyse further the amount and the limits). Thus, the maximum amount of d-euro per household is constrained by a limit that can be adjusted in order to safeguard the parity rule. This limit could be subject to change depending on the amount of the banknotes in circulation in the euro area (inversely proportional), the financial conditions (in a financial crisis central banks could increase the limit) and certain inequalities across EU countries. In the latter case, wealthier countries may increase the account's ceiling as they face a greater decline in the use of cash. A household can transfer liquidity from its traditional to its d-euro account up to the maximum amount determined by the central bank. In any case, when there would be a change in the limit amount, central banks have to calculate the exact digital money supply which permits d-euro to function as a stable, reliable, and efficient means of payment and to avert a bank run. Under the model proposed here, enterprises are allowed to receive d-euro. Such

73 The ECB's European strategy for retail payments includes a market-led solution that allows users to initiate a payment by using a card with a common European brand and logo. Recently, the ECB has welcomed the decision by 16 European banks to launch the European Payments Initiative (EPI) as a new European payment solution. EPI "seeks to replace national schemes for card, online and mobile payments with a unified card and digital wallet that can be used across Europe, thereby doing away with the existing fragmentation. As it is based on the SCT Inst scheme, it can immediately capitalise on powerful and sophisticated existing infrastructures, such as the Eurosystem's TIPS" (European Central Bank 2020c).

accounts cannot be used for the initiation of d-euro payments. After the receipt of a d-euro payment, the funds are irrevocably transferred to the firm's "traditional" euro bank account. In this way, said digital funds are "subtracted" from circulation and the d-euro money supply is adjusted accordingly.

Two-dot model: d-euro issuance follows the specifications of the two-dot model. Households and enterprises do not hold d-euro accounts directly with central banks in order to get access to central banks' liabilities. At the first dot, central banks open Dedicated Digital Accounts (DDAs) in TIPS to TIPS participants (usually commercial banks already holding DCAs)[74]. Central banks are responsible for the opening and management of the accounts, the setting of liquidity limits, the monitoring of liquidity positions, the performance of local contingency and the provision of help desk functions. At the second dot, commercial banks do provide end customers with d-euro accounts. Commercial banks are responsible for the opening and management of the accounts, ensuring adherence to KYC requirements and providing innovative front-end solutions for the initiation of d-euro payments. In fact, we could say that the two-dot model draws a dividing line between the back-end settlement and the front-end customer services, creating an efficient and promising public-private sector partnership.

Reachability: d-euro transactions are settled in TIPS[75] whose pan-European reachability is ensured by the Eurosystem.[76] TIPS is an extension of TARGET services and enjoys the participation of the overwhelming majority of the Payment Service Providers (PSPs) in the EEA. Additionally, it is in an optimal position to facilitate pan-European reachability since it had been developed[77] to facilitate instant payments becoming the new normal. Therefore, households and enterprises have the possibility to make and receive domestic and cross-border instant payments in d-euro using exclusively their central bank d-euro liquidity pool. Users enhance their convenience and reachability by using IBAN proxies (like mobile phone numbers) based on "trusted hardware"[78] and they experience P2P and P2B mobile payment solutions. Moreover, since a multi-currency facility is a core principle of TIPS,[79] every d-euro account holder could conduct global instant payments via one single account in a fast, safe and efficient manner.

Security: d-euro transactions are settled one by one in central bank money with instant finality. Central banks have the statutory task to secure the smooth operation of payment and settlement systems. Therefore, settlement in central bank money eliminates credit risk and ensures safety, consistency, efficiency, transparency and effectiveness. Since TIPS complies with all relevant legal and oversight requirements, it offers a robust and resilient market infrastructure that adheres to the Eurosystem oversight requirements and the internationally applied CPMI-IOSCO Guidance on cyber resilience. At the front-end, PSPs shall ensure a high level of consumer protection by applying strong customer authentication and common and secure open standards of communication[80]. Thus, strong cryptography and authentication would make d-euro the most secure digital asset, able to initiate anonymous payments in central bank money.

Speed: d-euro payments are settled via the state-of-the-art settlement engine of TIPS that

74 Strictly legally speaking, TIPS accounts in d-euro are opened in TARGET2 by the competent central bank. In addition, central banks, as non-profit organisations, are commercial bank account provider agnostic, i.e. every credit institution established in the European Economic Area (EEA) that holds a RTGS DCA in central bank money may offer d-euro accounts to its customers.

75 The Eurosystem in 2017 offered to settlement banks the connectivity option of ASI6 RT in order to manage their instant payment via their respective ACH. However, this solution, which allows ACHs to offer instant payments in commercial bank money with the final settlement in central bank money, requires cash collateral (which is not included in the calculation of the reserve requirement) in order to remove the counterparty risk associated with instant transactions.

76 "TIPS is in an optimal position to facilitate pan-European reachability, but it cannot guarantee it" (European Central Bank 2018, p. 3).

77 "The value of TIPS service will be increasing accordingly to the percentage of participating PSPs" (Korfiatis 2019, p. 37).

78 Trusted hardware encompasses encryption and data authentication.

79 Riksbank decided to use TIPS for the Swedish krona (Flodén 2019).

80 According to PSD2 and Regulation (EU) 2018/389.

offers final and irrevocable settlement for instant d-euro payments. A d-euro payment is available to the beneficiary in less than ten seconds, simulating a cash payment where both parties are required to be present to settle the transaction. Although speed in retail payments has been recognised as the new normal, recent experience has showed that both time and effort must be spent so that end users start adopting instant payments in their daily transactions (Hartmann et al. 2019). Payments in d-euro would cost much less than TARGET2 customer payments (also suffering from operational time limitations), would not suffer from fragmentation like the various interbank solutions offered by local Automated Clearing Houses (ACH)s[81] (usually also operating only during TARGET2 hours) and would thus comprise one instant, stable, efficient, and user-friendly pan-European payment solution.

The 1:1 parity rule: d-euro supply is perfectly elastic, as d-euro is issued and exchanged at par with the other forms of central bank money (Stournaras 2018). Therefore, converting commercial bank deposits into d-euro should be the same as withdrawing cash (in this context, EUR 100 of commercial bank deposits are exchanged for DEUR 100 instead of banknotes). Thus, the parity rule ensures that a credit risk-free d-euro could be seen as a secure store of value equal to a commercial bank deposit (since they trade at par without entailing any credit risk), as a stable unit of account (since central banks issue the d-euro and commercial banks provide it), and as a low-cost medium of exchange (parity ensures that euro and d-euro purchase the same quantity of goods and services) (Meaning et al. 2018). In other words, d-euro is a stable, secure and easy to use form of money. Additionally, the imposed ceiling on the amount of the d-euro allocated could be seen as adding stability to the financial market, creating fairness to society, and minimising the likelihood of a digital bank run.

Based on these attributes, the next section analyses how the proposed d-euro should be implemented in order to improve the efficiency of the system and promote widespread adoption and usage. In this context, Figure 3 presents the key benefits of d-euro deriving from the aforementioned design features.

Technical design: d-euro issuance follows the structure of the two-dot model shown in Figure 4. The upper layer of the pyramid is occupied by central banks, which are both d-euro issuers and TIPS operators. However, households and enterprises cannot open accounts directly with the central bank and consequently a commercial bank acts as an intermediary to enable their access to central bank money. In order to issue d-euro, central banks have to meet three main objectives: first and foremost, to act as operators, overseers and catalysts of retail payments systems; second, to set limits on d-euro accounts; and, third, to settle d-euro transactions in real time via TIPS. While these three objectives are complementary, they also form three distinct steps of the technical design. Central banks have to convince the public to show confidence and trust in d-euro as a settlement asset. Hence, in their capacity as operators, they provide accounts and settlement-related services; as overseers, they promote and ensure the safety and efficiency of payment systems and instruments; and finally as catalysts, they prevent market fragmentation and ensure a level playing field for both end users and service providers. In short, central banks' aim will be to create a meaningful and secure d-euro ecosystem.

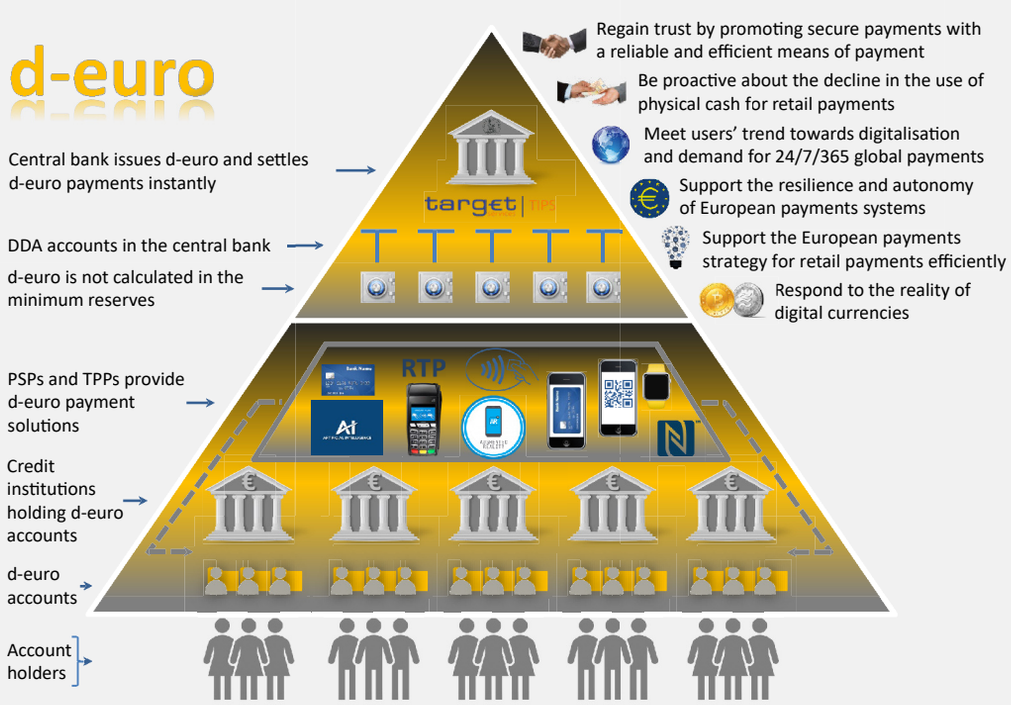
The importance of imposing limits on individual d-euro holdings and the associated policy implications have already been discussed in this paper. Such individual limits have to be determined and adjusted if deemed necessary by the central banks (Chiu et al. 2019; Bindseil 2020). These limits are subject to change according to the amount of banknotes in circulation, financial market conditions, and cer-

81 In Greece, DIAS supports the IRIS Online Payments solution that enables the immediate execution of interbank fund transfers within Greece.

Figure 3 The key benefits of d-euro



Figure 4 The two-dot model



tain indices of inequalities across EU countries. The proposed limit has been set up to DEUR 4,000 per active[82] person and retiree[83]. Assuming a euro area population of 342 million[84] people whereby 228 million are active persons and retirees[85], the total amount of initial d-euro supply is estimated at around EUR 912 billion. Inactive persons younger than 15 years shall not be eligible to hold d-euro accounts. During episodes of financial crisis, enterprises may be allowed to hold d-euro accounts (for monetary policy purposes e.g. helicopter money) but in normal circumstances the default limit is zero since the main objective of the d-euro is to maximise the effectiveness of households' retail payment transactions. The proposed amount of DEUR 4,000 lies between the value of per capita payments with cards issued by resident PSPs (EUR 5,300) and the value of per capita cash withdrawals at ATMs provided in the euro area by resident PSPs (EUR 1,110)[86]. Thus, it is calculated on the basis of the use of cash, which is currently the dominant instrument in proximity retail payments in the euro area, and of cards, which form the most popular electronic means of retail payments at POI in the euro area (46%). In addition, the proposed ceiling of DEUR 4,000 per capita, summing up to EUR 912 billion for the euro area, seems at present an estimated amount that covers the basic retail payment needs of a household when currency in circulation (EUR 1.2 trillion) averages EUR 5,300 per active person and retiree, and the average monthly net income in the euro area after deducting the average monthly saving rate (of 13%)[87] amounts to EUR 1,400. However, the above number should be subject to increase in countries with higher average net income or if currency in circulation is perceived to decline in the euro area (to below DEUR 912 billion), the reason being that some households do not top up their d-euro accounts or some elderly people use d-euro only as a store of value.

TIPS provides a harmonised and standardised pan-European service that settles instant payments in central bank money. It is available 24/7/365 and hosts euro dedicated cash accounts (TIPS DCAs) and (in our model) d-euro dedicated digital accounts (TIPS DDAs)[88]. D-euro would be the second currency settled on the TIPS multi-currency platform.[89] TIPS DDAs, unlike TIPS DCAs, are not linked to the unique payment account of TARGET2 (PM account) responsible for the management of liquidity, and their balance will not count towards the fulfilment of the minimum reserve requirements and excess reserves (Barrdear and Kumhof 2016; Bjerg 2017; Brunnermeier and Niepelt 2019). However, any existing (or future) participant in TARGET2 is seen as an eligible TIPS DDAs holder. Moreover, TIPS allows for three types of participation:[90] (i) participants, i.e. PSPs eligible to open a PM TARGET2 account; (ii) reachable parties, i.e. entities able to access a participant's TIPS DCA in order to settle payments in TIPS; and (iii) instructing parties, i.e. entities or third parties authorised by participants or reachable parties to send/receive instant payments in TIPS on their behalf. Therefore, it becomes obvious that households can only perform the role of reachable party. Thus, a person who opens a d-euro account at a commercial bank,[91] in order to have access to central bank

82 Active population of an economy is the sum of employed and unemployed inhabitants.
83 Population, economic and social conditions data provided by Eurostat. Payment data provided by the Statistical Data Warehouse (ECB).
84 https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=demo_gind&lang=en.
85 The population aged between 15 and 64 is calculated at 160 million, while estimated retirees number 68 million.
86 The distribution of euro banknotes to households is made via ATMs and commercial bank branches.
87 Source: https://ec.europa.eu/eurostat/documents/2995521/10159175/2-14012020-AP-EN.pdf/7d8ef583-6e77-99d5-779e-424de674dd5f.
88 This paper contains an abridged description of how a DDA fits into the TIPS platform. However, the author, having the experience of being both T2S project manager and TIPS project manager for the Bank of Greece, is more than eager to discuss and/or provide any additional information on the technical aspects of issuing d-euro via TIPS.
89 TIPS could support cross-currency instant payment transactions. However, at the moment, legally speaking, TIPS DDAs, just as TIPS DCAs, fall under the legal and operational perimeter of TARGET2 as defined in the revised TARGET2 Guideline.
90 In the future, a fourth type of participation may be added, called "Ancillary System", in order to allow ACHs to interact with TIPS.
91 Participation in TIPS is not mandatory by the Eurosystem. However, participation in TIPS was proposed to be a mandatory application requirement concerning DDA openings by the significant entities directly supervised by the ECB.

money, will automatically become a reachable party to TIPS with a predefined payment capacity limit. Local ACHs[92] could assume an important role in achieving settlement of instant d-euro payments by acting, based on a contractual agreement, as the instructing party of a participant. Thus, TIPS seems the optimum solution for d-euro settlement, as it provides pan-European reachability,[93] settles instant payments in central bank money with high processing capacity, guarantees security and around-the-clock availability, and meets growing consumer demand for secured instant payments with a potential global acceptance[94].

The role of commercial banks in the two-dot model is to provide the new ecosystem with the know-how and best practices that they have accumulated from the existing euro ecosystem, e.g. the client interface, KYC procedures and front-end innovative payment solutions[95]. On the other hand, households substitute their commercial bank deposits with d-euro ones up to the imposed ceiling. We assume that, up to a certain estimated limit (in our model the d-euro supply is a policy choice after assessing the consequences for monetary policy and financial stability), the d-euro will not significantly affect the size of commercial banks' balance sheets but only their composition, as end users substitute euro deposits with d-euro ones. As a result, households' disposable liquidity remains unchanged, while they make an important efficiency gain[96]. With d-euro replacing only a part of physical cash, we do expect a "stolen benefit"[97] effect since, given households' d-euro limit and income constraint, an increase in d-euro will probably only reduce cash withdrawals from ATMs. Citizens wishing to open d-euro accounts in order to initiate instant payments in central bank money will have to address to the commercial banks where they already hold accounts (payroll or savings accounts). Commercial banks, according to the KYC guidelines, will open such accounts and provide d-euro customers and TPPs with innovative onboarding and front-end services. Thus, customers will be able to initiate d-euro payments following modern and innovative solutions thanks to the use of open APIs and user-friendly interfaces even in a post-PSD2 era. In the default version, d-euro accounts will be credited or debited during the processing of a retail payment transaction or liquidity transfer via TIPS, and P2P payments will be processed anonymously. Anonymity, as well as privacy and data protection are provided by commercial banks. As already stated, d-euro is semi-anonymous and therefore payers do not reveal their identity to the intermediaries. Anonymity is achieved by mapping the account holder's personal information to random unique alphanumeric characters that are used in the payment message[98]. Finally, when a d-euro payment is requested, commercial banks debit the ordering customer's account, and transfer the instructed d-euro amount via the central

92 To date, ACHs cannot open a TIPS account since they have to adhere to the SCT Inst scheme, which is restricted only to PSPs (SCT Inst Rulebook). In addition, it was suggested that ACHs cannot open an ASI6 RT technical account for settling d-euro since d-euro instant payments will strictly be processed within the perimeter of TARGET2.

93 TIPS is an extension of TARGET2 and is based on the SCT Inst scheme.

94 TIPS participated in the proof of concept for SWIFT gpi, needing only 0.06 seconds to process a transaction.

95 For enterprises, commercial banks could support electronic invoicing presentment and payment (EIPP) solutions both at the domestic and the European level.

96 Legally, households (acting as reachable parties) own the liquidity of the commercial bank's DDA (in any other DCA in TARGET2, the owner of the liquidity is the commercial bank). Therefore, the total liquidity on the DDA is independent of the main account and cannot be a subject to a change triggered by the TIPS participant (for example to provide a loan).

97 The "stolen benefit" is a term coined by the author in the periodic exhibition of the Bank of Greece's museum ("e-payments: a road map") to describe the inverse relationship between the use of two substitute means of payments. During the Greek crisis, households had to a great extent adapted to conducting electronic payments. However, this relative increase in card payments (from 23,4% in 2015 to 52,6% in 2018 as a percentage of the total number of payments) was not accompanied by a concurrent decrease in cash withdrawals from ATMs but by a decline in the use of other electronic means of payments (mainly credit transfers).

98 A new global messaging standard, known as "ISO 20022", although it contains the identity of the parties involved in the transaction (the names of the initiator and of the beneficiary are mandatory message fields), can facilitate more structured identity fields. Thus, in order to keep anonymity, the sender's field is populated with the special alphanumeric characters provided by the ordering institution. This proxy is only known to the latter and the central bank and remains unknown to the receiver (a cryptographic key is required to open the message). As a result, only central banks can fully trace the transfers of funds in order to prevent, investigate and detect money laundering and terrorist financing. In specific cases such as tax payments, it will be possible to use tax identification codes with the initiator ID instead of the anonymous proxy and hence to remove anonymity.

bank's platform to the recipient's d-euro account[99].

The two-dot model is an efficient approach to conducting d-euro retail payments. It provides pan-European reach, and boosts convenience, safety and efficiency by driving central banks, commercial banks, TPPs, and ACHs to offer a superior payment experience. In this model, the initial use of d-euro as a retail payment medium serves as a stepping stone to become the new cash of a digitalised ecosystem. Additionally, we have faced a number of challenges concerning the aforementioned features[100]. For example, due to policy considerations, central banks may increase the d-euro limit to avoid creating a shortage of minimum reserves[101]. The presented model guarantees a high level of efficiency and ensures the safety and smooth operation of payment systems by defining specific roles for all parties involved in the payment chain and the d-euro ecosystem. However, further research is warranted in order to facilitate its adoption and implementation.

5 CONCLUSION

The widespread use of digital technology has radically reshaped the way we share and exchange information, as well as how we engage in transactions and perceive payments. Accordingly, the ECB has acknowledged that greater attention should be paid to the front-end sector of European retail payment systems, with a view to protecting its strategic autonomy and resilience and to enhancing the international role of the euro. Nowadays, the ECB has started weighing the costs and benefits of issuing a CBDC, as well as analysing its feasibility and merits. In this context, we started our analysis by comparing CBDC with the currently existing forms of money in order to highlight its property of convertibility, which constitutes the crucial building block of our model as it leaves the quantity of central bank money unaffected.

CBDC is the digital cash issued by a central bank for use in payments and settlement. This paper presented a retail account-based CBDC, where the latter is provided indirectly to the public by commercial banks via commercial bank accounts. We argued that this type of CBDC involves a public-private partnership whose effectiveness is enhanced by establishing a separate and distinct role for each stakeholder.

This paper analysed four main motivations: (i) the issue of trust and the digital transformation of the economy; (ii) the decline in the use of cash; (iii) financial stability considerations; and (iv) monetary policy considerations. We have concluded that central banks have to act proactively instead of adopting a defensive stance towards a downward trend in cash use. D-euro is to play a rather minor role in monetary policy implementation and financial stability considerations since it is likely to be irrelevant to

99 Assuming that a DEUR 20 payment is initiated. The commercial bank of the payer (B_p) instructs (via TIPS) the central bank to pay DEUR 20 (debiting its TIPS DDA_p) to the commercial bank of the beneficiary (B_b) (crediting TIPS DDA_b). The central bank debits the B_p's account with DEUR 20 and accordingly the B_p debits the payer's account with DEUR 20. Simultaneously, the central bank credits the B_b's account with DEUR 20 and accordingly the B_b credits the beneficiary's account with DEUR 20. Furthermore, let's assume that a household triggers a liquidity transfer of EUR 40 from its deposit account to its d-euro account. In that case, B_p orders the central bank to debit its RTGS DCA_p (simultaneously reducing the available liquidity in its main account and hence its reserves) with EUR 40 and to credit its TIPS DDA_p with DEUR 40. Therefore, while the household's liquidity remains the same, there are only a change in the composition of central bank money and a decrease in the commercial bank's reserves.

100 Paraphrasing Lancastrian demand theory, the two-dot model has been carefully designed by predicting demand on the basis of certain d-euro features (attributes) in order to make it households' preferable means of payment in a retail payment. Deciding on the desirability of individual d-euro features, our motivation has been to achieve widespread adoption and hence to create strong network effects and boost the effectiveness of the system. One may argue that proposing a low limit is not the most desirable feature, compared with a private issuer (with no imposed limits) or SEPA Inst (with a limit of up to EUR 100,000), since some users may find d-euro restrictive in their desired purchases. However, in our model, limits are subject to change according to the foregoing argumentation. In addition, there is a possibility for a certain limit to the provision of full anonymity (the proposed amount was EUR 500 following the Greek ceiling on cash payments), as presented by the author at the 2nd EUROchain Hackathon.

101 The ECB requires commercial banks established in the euro area to hold minimum reserves. However, when central banks increase the d-euro supply (and assuming that households top up their d-euro account up to the new ceiling), a shortage of liquidity (reserves) is created. This happens because households transfer liquidity from deposits to d-euro accounts (both held with the same commercial bank). This conversion of commercial bank money into central bank money is mapped by a transfer from the TARGET PM account (Main Cash Account – MCA) after the T2-T2S consolidation) to the TIPS DDA. In normal financial conditions, central banks use open market operations (OMO) to supply commercial banks with the necessary liquidity (increasing reserves).

inflation targeting. However, it may be used as a direct channel through which central banks can transmit monetary policy decisions to households and enterprises.

An account-based d-euro has to follow six principles: (i) semi-anonymity (d-euro should be semi-anonymous due to AML concerns); (ii) trust (digital trust is issued directly by central banks); (iii) scalability (it should form the cornerstone of the efforts to respond to modern technological challenges, as well as to enhance the position of the euro as an international currency); (iv) interest rate neutrality (it should be interest rate-free and hence unfitting as a monetary policy tool); (v) acceptance (it should be used by payment solutions that offer pan-European reachability and possible global acceptance); and (vi) convenience (it should be tailor-made according to customers' demands for convenience, speed, and efficiency). We argued that the aforementioned principles also constitute the key benefits of the d-euro.

When issuing d-euro, central banks have to consider how to fulfil their mandate of providing safe, stable, efficient, reliable and secure payment systems. We presented a framework to study the specific attributes of an ideal account-based d-euro and we proposed the technical design of a two-dot model. Additionally, we showed how d-euro should be implemented in order to improve the efficiency of the payment infrastructure and to promote its widespread adoption and usage. That being said, given the introduced technical design, we discussed the importance of imposing limits on individual d-euro holdings, as well as the associated policy implications. Specifically, we proposed a concrete non-binding limit that is subject to change depending on the amount of banknotes in circulation, financial market conditions, and certain regional inequality indices.

We proposed TIPS as the harmonised and standardised pan-European service that settles instant payments in d-euro. TIPS is available 24/7/365 and d-euro would be the second currency settled on its multi-currency platform, where commercial banks would hold d-euro dedicated digital accounts (TIPS DDAs), and households may connect too as reachable parties. We have concluded that, as the present DLT technology is not mature enough, TIPS seems the optimum solution for settlement in d-euro, as it provides pan-European reachability, settlement in central bank money, high processing capacity, security and around-the-clock availability, and meets growing consumer demand for secured instant payments and global acceptance.

Central banks offer the back-end solutions and are the guarantors of anonymity. On the other hand, the role of commercial banks is to provide the new ecosystem with their know-how and best practices. Our model clarifies the provision of anonymity, as well as of privacy and data protection. We have concluded that the two-dot model is an efficient approach to conducting d-euro retail payments. It provides pan-European reach, and boosts convenience and safety by driving all participating stakeholders (central and commercial banks, TPPs, and ACHs) to offer a superior payment experience. According to our understanding, d-euro could be used initially as a retail payment medium and serve as a stepping stone towards becoming the new digital cash.

Central banks have been responding to the fact that digital currencies are part of the global monetary system. Thus it is in their interest to ensure that they are not left behind in the technology race. Whether or not d-euro will be the next step in the evolution of money is subject to further analysis. Issuance of such a currency should contribute towards the autonomy and the resilience of the European payment ecosystem as well as a climate-neutral and digital Europe. This paper argues that d-euro may be the answer to central banks' concerns about the issuance of a digital medium of payment.

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