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CBDC and Cash in the Euro Area: Crowding out or co-circulation?

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CBDC and Cash in the Euro Area: Crowding out or co-circulation?

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Abstract

Cash usage at the point-of-sale decreased perceptibly in the past years. This is mainly due to the ongoing trend towards digitalization, but there are also indications that consumers were somewhat pushed into cashless payments by government regulations and supply-side restrictions by commercial banks. Nonetheless, overall demand for euro cash remained strong and even increased relative to GDP since the financial crisis in 2008. In this process, however, we observe a supply-driven shift towards lower banknote denominations. Central banks all over the world are intensively thinking about the potential issue of a Central Bank Digital Currency as a substitute or complement to cash. Although the characteristics of a possible digital euro have become more perceptible, its fundamental design properties remain unknown. We propose a double pre-paid scheme combining central elements of TARGET Instant Payment Settlement and electronic money features enabling offline and online instant payments. The issuance of a digital euro would be neutral to total money supply as banks act only as intermediaries. Since anonymity is categorically discarded by the ECB and as cash has some special advantages from a consumer perspective, the digital euro will rather co-circulate with cash than replace it in transactions.

Keywords: Cash, banknotes, money, CBDC

JEL Classification: E41, E51, E58

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I. Introduction

This paper intends to provide an overview of the current role of cash and the probable design and functioning of a future Central Bank Digital Currency (CBDC) in the euro area, the digital euro. It explores the prospects of both types of money and asks if there is a possible crowing out of cash by the digital euro or more likely a co-circulation.

Chapter II categorizes different types of money which are currently recognized as official means of payment in the euro area including a possible digital euro. Chapter III starts with surveying current government cash payment restrictions in the EU and analyzes several factors that might have contributed to the declining role of cash at the POS in the euro area in the past decade. However, total euro cash in circulation increased enormously during this period creating the so-called cash paradox (*Zamora-Pérez* 2021). It is well-known, that this puzzle can be solved by taking non-transactional motives for holding cash and foreign demand for euro banknotes into account emphasizing the store-of-value function of cash (see, for instance, Deutsche Bundesbank 2022a). By investigating the denominational structure of cash issued by the Eurosystem, we show that the scope of this store-of-value function of euro banknotes has widened over time towards lower denominations. The declining use of cash for transactional purposes might eventually lead to a dominance of private payment solutions with a possible decrease in the level of competition in the payments market and higher transaction fees for money holders (*Ahnert* et al. 2022; *Bindseil* et al. 2021). This is one reason why monetary authorities around the globe are currently considering the issuance of CBDC (*Kosse*/*Mattei* 2022). The CBDC of the Eurosystem is still in its planning phase, but the principal shape of a future digital euro has become more perceptible. In section IV, our paper provides an overview of the current situation and shows how a digital euro might be put in circulation based on a suggested two-pillar approach consisting of the TARGET Instant Payment Settlement (TIPS) infrastructure for interbank payments complemented by e(lectronic)-money-type features to allow also for instant offline payments by nonbanks. Such a scheme would rest upon a double pre-paid system ensuring that the creation of the digital euro is neutral to total money supply but enables 24/7/365 instant online and offline payments. In addition, the paper raises the question of potential demand for a digital euro to outcompete cash as a transactional means of payment. Chapter V summarizes and concludes.

II. Categorization of different types of money in the euro area

Table 1 shows the different types of money which are currently circulating in the euro area as officially recognized means of payment and how a future CBDC can be incorporated in such a scheme.

Table 1: Official types of money in the euro area

Category of money	Public-issued money				Private-issued money	
Type of money	Central bank money			Government money	Commercial bank money	E-money
Kind of money	Accounts at the central bank	Central Bank Digital Currency	Banknotes	Coins	Transferable accounts with commercial banks	E-money
Issuer	Eurosystem	Eurosystem	Eurosystem	Euro area governments	Commercial banks of the euro area	E-money institutions of the euro area
Money holders	Commercial banks	Commercial banks/nonbanks	Nonbanks, banks	Nonbanks	Nonbanks	Nonbanks
Control of money supply by Eurosystem	Yes	Yes	Yes	Yes	Only indirectly	Only indirectly
Resemblance to cash	No, but convertible into cash	Central bank issued „digital cash“	Physical cash	Physical cash	No, but convertible into cash	Private-issued „digital cash“
Volume (June 2022)	€4,046bn	-	€1,603bn	€32bn	€10,037bn	€32bn (End of 2021)

Notes: Data from ECB statistical data warehouse (SDW).

Source: Own table.

In the euro area, public-issued money in its various forms of central bank money and "government money" in the form of coins co-circulate with private-issued money comprising transferable accounts held by nonbanks with commercial banks and e-money. Central bank money in the euro area is issued by the Eurosystem, i.e., the European Central Bank (ECB) and the national central banks (NCBs) of all member states of the euro area. It provides book money in form of demand deposits (reserves) to commercials banks[1] and has the monopoly on the issuance of euro banknotes.[2] The legal basis to issue CBDC by the Eurosystem depends on the design of the digital euro and the purpose for which it is issued, i.e., as wholesale CBDC for commercial banks only or as retail CBDC for the general public (ECB 2020a, 24). By contrast, the issuance of euro coins lies within the competence of the national governments of the euro area countries, but its volume is subject to approval by

[1] Some NCBs also provide accounts to nonbanks such as private households and enterprises, but only to a very limited extent.

[2] Since the introduction of euro banknotes in January 2002, all euro banknotes are brought into circulation solely by the NCBs. The ECB also has the right to issue banknotes but refrains from doing so. The item "banknotes in circulation" in the ECB's balance sheet does therefore not reflect the actual net issuance of banknotes by the ECB. For details see (ECB 2022a, 28ff.) and the Decision of the European Central Bank on 13 December 2010 on the issue of euro banknotes (ECB/2010/29; 2011/67/EU).

the ECB.[3] Commercial banks, are free to produce book money at their will as long as it is in line with general supervisory regulations.[4] The issuance of private e-money in the euro area is regulated in the European e-money directive (2009/110/EC). It requires that e-money is issued only on a pre-paid basis by regulated institutions[5] and can be used for payments only. Those schemes try to somewhat mimic cash as they promise instant payment without using commercial bank accounts (private-issued "digital cash"). E-payment schemes are currently only operational on a country level and cannot be used for cross-border payments in the euro area. The latest available figures on the outstanding volume of e-money in the euro area (€32 bn) show, however, that the stored amounts are low and similar to total coins in circulation (see table 1).

III. Cash supply and demand in the euro area

1. Anti-cash-cartel in the EU?

Since 2005, when MasterCard declared its "war on cash" (*Adams* 2006), also other major players of the FinTech industry, representatives from "law-and-order" and few economists ("alchemists") started allegedly what the former board member of the ECB *Yves Mersch* once called an "anti-cash-cartel" (*Mersch* 2016). Its supposed members made suggestions to restrict the use of cash including upper limits and reporting obligations for cash payments, withdrawal of high banknote denominations from circulation or even the complete abolishment of cash. By such measures, it would be reportedly much easier to fight against corruption, tax evasion, drug trade, and financing terrorism (e.g., *Rogoff* 2016; *Sands* 2016). In addition, it should also be possible to break through the "effective lower bound" of the risk-free interest rate (*Buiter*/*Rahbari* 2015). Although these measures would come with disproportionate high economic and social costs (*Rösl* et al. 2019; *Krüger*/*Seitz* 2017), the EU Commission changed its former attitude and put forward proposals to limit the use of cash to €10,000 per transaction (EU-Commission 2017). After the commissioning of a study on the effects of a harmonization of EU cash payments limits on illicit activities and the internal market, and a public consultation, the EU Commission stopped the

[3] In addition, there are also agreements between the "micro-states" of Andorra, Monaco, Vatican City and San Marino with the ECB to issue euro coins. These countries are legally neither part of the EU nor the euro area.

[4] In practice, the Eurosystem controls the private money supply indirectly through its monetary policy instruments.

[5] Although the overriding majority of e-money in the euro area is issued by institutions owned by commercial banks, also non-financial institutions are allowed to put this type of money in circulation. Common ways of storing e-money for offline-payments are chips integrated in mobile phones or plastic cards and for online-payments also distant servers.

beforementioned initiative (EU Commission 2018). However, in 2021, it again tried to back a possible harmonization of these limits under cover of the 6th Anti-Money-Laundering Directive. Although this harmonization is not yet in effect, national cash payment restrictions are already in place in 16 EU member states and the latest available data show a quite heterogenous picture (see table 2): Cash payment limits range from countries with no limitations (e.g., Austria) to quite low upper limits for cash usage of just €500 per transaction (Greece).

Table 2: National cash payment limits in the EU

Euro area countries			
No cash payment restrictions		**Cash payment restrictions (upper limits)**	
Austria	No limits	**Belgium**	€3,000, for precious metals €500
Cyprus	No limits	**Greece**	€500, no limits for buying cars
Estonia	No limits	**Italy**	€ 1,000
Finland	No limits	**Latvia**	€ 7,200
France	€ 1,000 for domestic taxpayers, € 3,000 for real estate purchases; € 10,000 for non-resident taxpayers acting as consumers; Taxes can be paid in cash up to a maximum of 300 euros	**Lithuania**	€ 3,000
Germany	No limits (except for anonymous gold purchases €2,000). Report of origin mandatory for cash payment > €10,000	**Portugal**	€ 3,000
Ireland	No limits	**Slovakia**	For private persons €15,000, for enterprises €5,000
Luxemburg	No limits	**Slovenia**	No limits for private persons, for enterprises €5,000
Malta	No limits, except for precious metals and others metals, antiques, real estate etc. (limit of € 10,000)	**Spain**	For private persons €10,000, for enterprises €1,000
Netherlands	No limits		

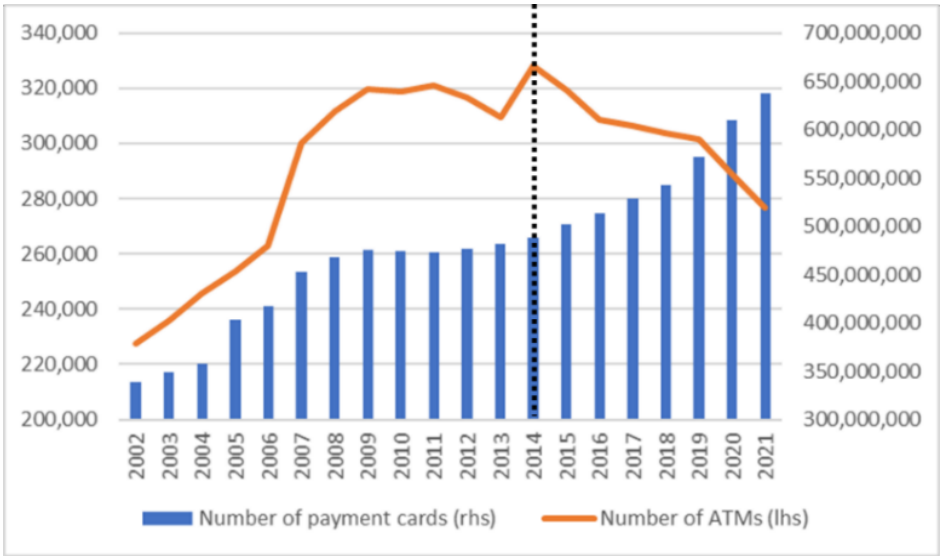
Non euro area EU countries			
No cash payment restrictions		**Cash payment restrictions**	
Sweden	No limits	**Bulgaria**	LEW 10,000 (≈ €5,100)
		Croatia	HRK 75,000 (≈ €10,000)
		Czech Republic	CZK 270,000 (≈ € 10,500)
		Denmark	No limits for private persons, for enterprises DEK 20,000 (≈ €2,700)
		Hungary	No limits for private persons, for enterprises HUF 1,500,000 (≈ €5,000)
		Poland	No limits for private persons, for enterprises PLN 15,000 (≈ €3,300)
		Romania	LEI 5,000 (≈ €1,000)

Source: European Consumer Centres Network (ECC-Net), various national websites.

Cash usage can also be limited by supply-side restrictions imposed by commercial banks which put banknotes in circulation on behalf of the central bank, nowadays mainly via Automated Teller Machines (ATMs). As shown in figure 1, the number of ATMs in the euro area decreased over the past 7 years by around 15% from its peak of 328,000 in 2014 to 277,000 in 2021 making the access to cash for the public increasingly more difficult.[6] Exactly at the same time, however, the issuance of payment cards by Payment Service

[6] Initiatives like Cash Back or Cash-in-Shop could only partly compensate the decrease in ATMs.

Providers (PSPs) in the euro area went up immensely by 30% from 489 million in 2014 to 638 million units in 2021, equipping euro area residents with 1.9 cards per person in 2021.



Notes: Data for 2017 estimated by linear interpolation due to lack of data. Payment cards without e-money function.

Source: ECB SDW.

Figure 1: Numbers of payment cards and ATMs in the euro area

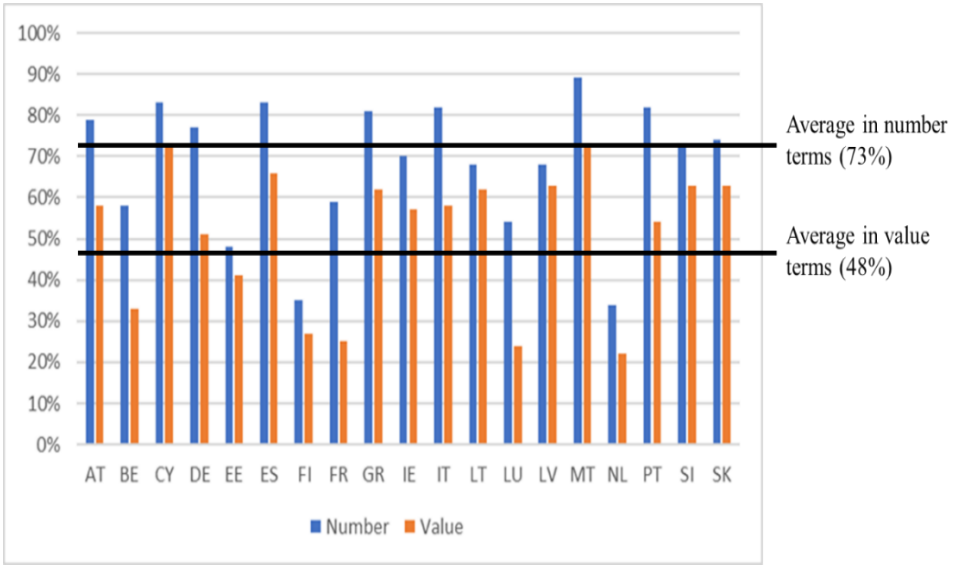
This development might be supply- and/or demand-driven. As indicated by the dotted line in figure 1, the sudden break in both time series after an astounding phase of parallel movements from 2002 until 2014, however, seems to show that consumers were at least to some extent pushed into cashless payments by banks as these not only made cards and mobile payments more attractive but also actively limited the access to cash by removing ATMs and closing branches. At any rate, the card payment infrastructure in the euro area has significantly improved over the past years as the number of POS terminals increased from 8.1 million in 2015 to 13.5 million in 2021. Moreover, the number of card payments at the point of sale in the euro area increased in that period from 29.7 billion to 56.3 billion transactions showing a clear trend towards more intensive use of cashless payments in the euro area.[7]

2. Cash usage at the point of sale

Despite government limitations on cash usage, possible supply-side restrictions for cash by commercial banks, and the provision of a better digital payment infrastructure, cash remains the most popular means of payment at the POS and for P2P transactions in the euro area. The results of the latest comprehensive household survey (SPACE) on the use of cash

[7] See ECB SDW, payment statistics.

in the euro area (ECB 2020b) show that consumers still prefer to pay in cash over card payments in 2019: 73% of the volume of POS and P2P transactions was carried out using cash as a payment instrument. In value terms, cash transactions in 2019 accounted for 48% of all transactions. On average, euro area residents made 1.6 transactions (at the POS and P2P) per day, with a corresponding transaction value of €25.6. However, figure 2 demonstrates a considerable heterogeneity in the payment habits among the different euro area countries.



Notes: Data refer to 2019, except for Germany (2017). Recent German data for 2021 show a number share of 58% and a value share of 30% (Bundesbank, 2022b).

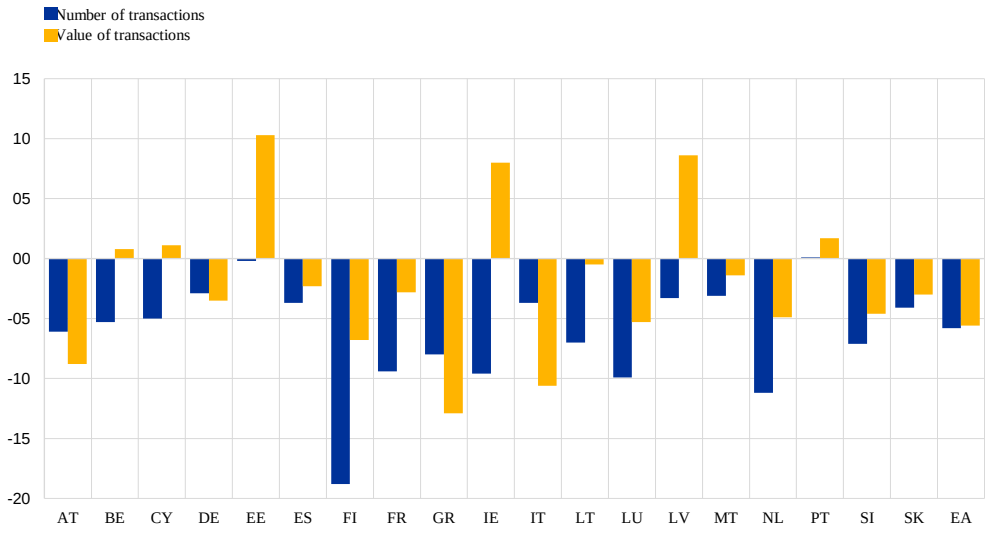
Source: Own figure, based on data from ECB, 2020b, 20.

Figure 2: Cash payments – share in number and value of transactions

In tendency, southern European countries (see, for instance, Malta, Spain, and Italy) are using cash more often for payments than northern countries (see, for instance, Netherlands, Finland and Belgium). Germany – often cited for its alleged special preference for cash – is just in between.[8] In July 2020, the ECB initiated a further survey (IMPACT) in all euro area countries to analyze (inter alia) how the Covid pandemic affected cash demand: 40% of the respondents replied that they have used less cash since the start of the pandemic, and almost 90% of them stated that they would continue to pay less with cash (46% certainly and 41% probably) after the pandemic (ECB 2020b, 7). Indeed, studies on individual euro area member states clearly confirm the accelerated use of cashless payments since the start of the Covid pandemic (see, for instance, *Ardizzi* et al. 2020; Deutsche Bundesbank 2022b; *Jonker* et al. 2022).

[8] In effect, Germany ranked 7 in value terms and 12 in number terms of all 19 euro area countries in 2019.

However, there was already a tendency towards cashless payments in most European countries long before the pandemic (ECB 2020b). Due to lack of consistent survey data, however, a complete time series on cash usage for payments at the POS (and P2P) in the euro area is not available. Nonetheless, a comparison of the SUCH study in 2016 (*Esselink/Hernandez* 2017) with the SPACE survey in 2019 reveals that the declining use of cash as a transaction medium can be broadly confirmed. On average, cash usage for payments in the euro area (EA) decreased between 2016 and 2019 in value and in number terms by just over 5 percentage points (see figure 3).[9]



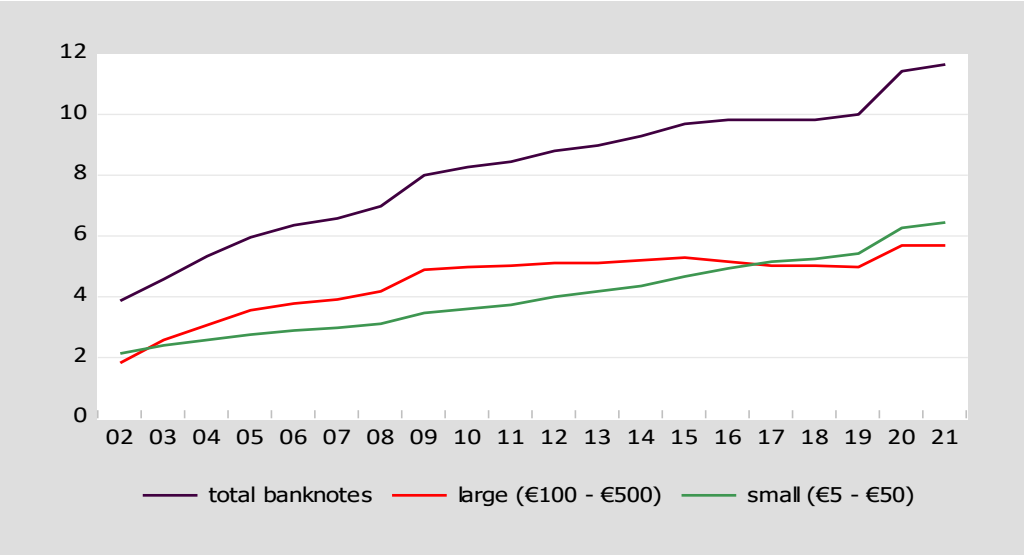
Notes: Differences between SUCH (2016) and SPACE (2019) results in percentage points.
Source: European Central Bank, 2020b, 21.

Figure 3: The evolution of cash transactions in euro area countries

3. Total cash in circulation

Nevertheless, euro cash remains still heavily in demand since its introduction in 2002. Of the total value of euro cash in circulation in June 2022 (€1,634.5 bn), 98% are banknotes (€1,602.6 bn) and only 2% coins (€31.9 bn). Figure 4 shows how total banknotes in circulation as well as its "small" (€5 - €50) and "large" (€100 - €500) denominational sub-groups evolve over time. Note that the time series are presented in percent of nominal GDP to implicitly account for inflation.

[9] In volume terms there is a decrease in cash usage in every country (except for a very slight increase in Portugal) whereas in value terms this is generally not the case indicating that cash is substituted more and more by cashless payment media for low value payments



Notes: Small: €5 - €50, large: €100 - €500.

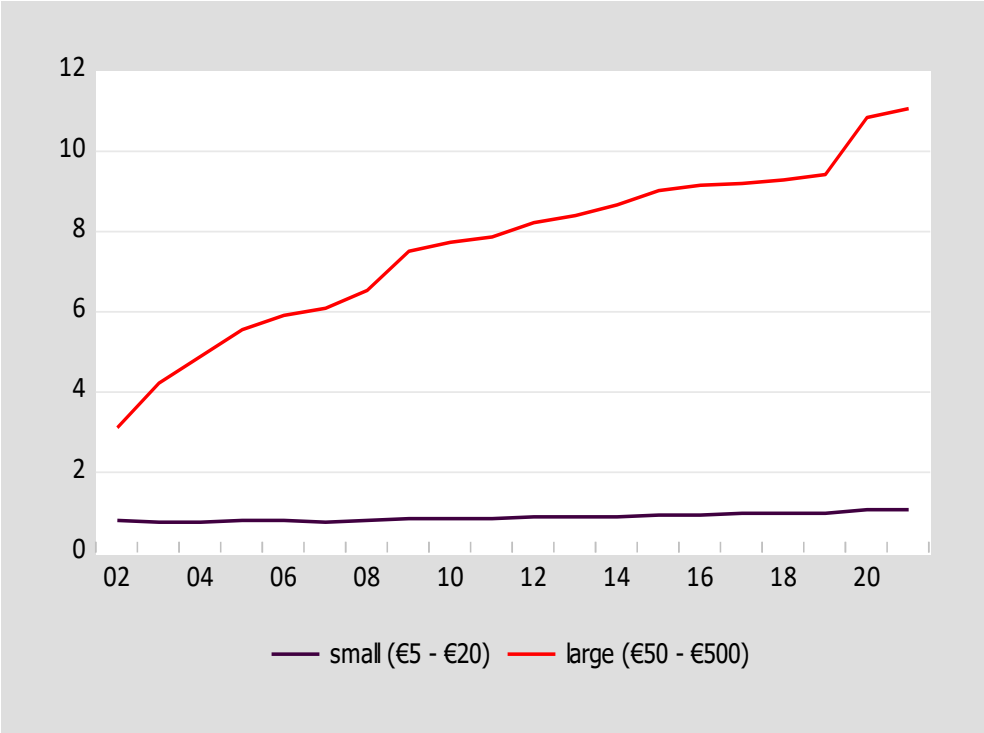
Source: Own figure. Data: ECB.

Figure 4: Total banknotes in circulation, small and large denominations in % of nominal GDP

Total cash issued by the Eurosystem not only continued to increase strongly even after the effective end of the cash changeover phase around 2004,[10] it was also in high demand in times of crisis (*Rösl*/*Seitz* 2022a). Since central banks provide banknotes and coins in a perfectly elastic way, cash developments are predominantly demand driven. The underlying motives of holding cash can be principally separated into two categories: demand for transaction balances and non-transactional demand such as precautionary and savings motives emphasizing the store-of-value function of cash. Unfortunately, the relative importance of the different motives cannot be measured directly in practice. One indication, however, is the denominational structure of issued banknotes since "small" denominations (for instance €5 - €50) are usually used for payments and "large" ones (€100 - €500) for other purposes (*Amromin*/*Chakravorti* 2009; Deutsche Bundesbank 2022a). At least on a global scale, there seems to be a clear tendency towards non-transactional use of cash over the past 30 years indicated by a comparatively higher growth of large banknote denominations than small ones even if accounted for a possible inflationary bias towards higher face values (see *Rösl*/*Seitz* 2022a). The denominational structure of the banknotes issued by the Eurosystem, however, might – at first glance – suggest that the supposed relationship may not hold for the euro area (see figure 4). In Figure 4 the definition of small euro banknote denominations follows the usual convention of those a bank customer typically gets from ATMs. Consequently, they comprise for most euro area countries the

[10] The issuance of euro banknotes by the Deutsche Bundesbank reached its projected level of hypothetical DEM issuance end of 2003 (see *Bartzsch* et al. 2011, 2).

range from €5 to €50 and the remaining large denominations consist of the €100 and the €500 notes. The small denominations grew at a slightly higher pace than the large ones. In 2021, both are around 6% of GDP (see figure 4). However, the €50 banknote has a special role as it is usually the smallest denomination that is used as a store-of-value in addition to its transactional purpose (Deutsche Bundesbank 2022a). Since 2002, it increased more than tenfold. If we change our classification scheme and restrict small denominations from €5 to €20 notes only, the picture changes drastically (see figure 5).



Notes: Own calculations.

Source: ECB.

Figure 5: Small (€5 – €20) and large (€50 - €500) euro banknote denominations in circulation in % of nominal GDP (2002 – 2021)

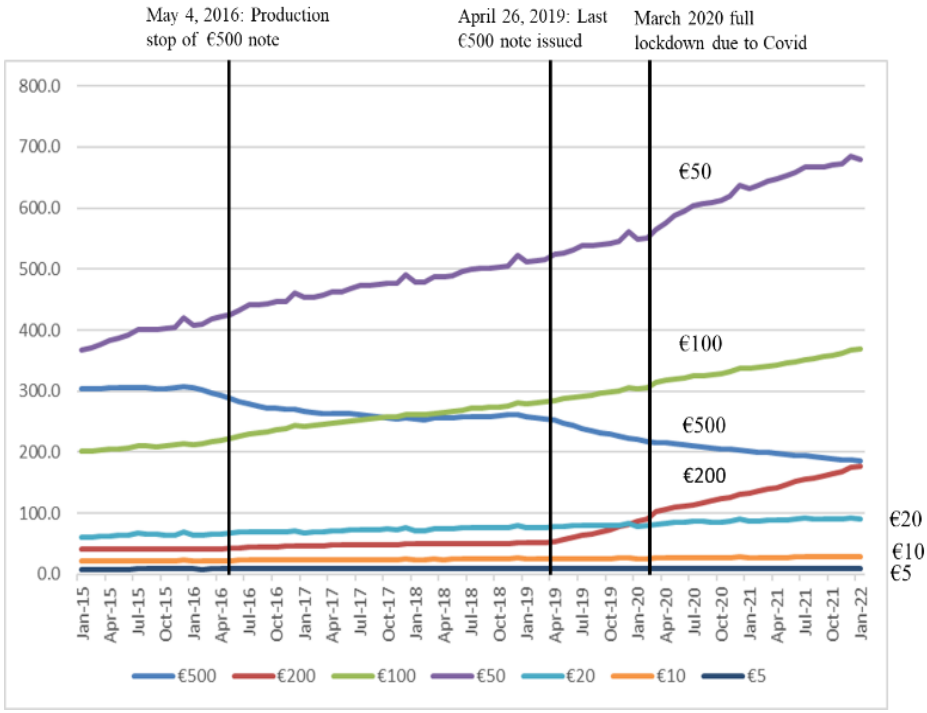
In this case, the ratio of small denominations to nominal GDP in the euro area is extraordinarily stable around an average of around 0.9% (2002 – 2021) indicating its steady transactional use (*Lalouette*/*Esselink* 2018). By contrast, the larger denominations grew stronger than GDP and also reacted to macroeconomic crises like the outbreak of the financial crisis (2008) and the Covid-pandemic (2020) perceptibly. Both facts seem to emphasize the store-of-value function of the so-defined larger denominations (€50 - €500). It is also safe to assume that the higher the denomination within this spectrum,[11] the more dominant the store-of-value component in the demand for these banknotes becomes. Indeed,

[11] Lalouette & Esselink (2018) even find some evidence of a non-transactional demand for €20 banknote, but only to a comparatively minor extent.

the payment survey (SPACE) on cash holdings in the euro area indicates that high-value payments (above €100) accounted for only 3% of all cash-based transactions (ECB 2020b, 30). Hence, it comes with no surprise that in an econometric analysis the demand for the two highest euro denominations reacts significantly during crisis periods (*Rösl*/*Seitz* 2022a). However, the same study also finds such evidence for small denominations if defined as the sum of €5 - €100. But the variance in this time series is driven by the €50 and the €100 notes (compare figures 4 and 5). As mentioned, the €50 denomination can be interpreted as "hybrid" banknote which is used both for transaction purposes and as a store of value (*Lalouette*/*Esselink* 2018).

4. Demand shift towards lower denominations

Indeed, an analysis of the denominational structure of euro banknotes indicates that the scope of the store-of-value function has shifted over time towards lower denominations. Note, however, that this development is supply-driven: On May 4, 2016, the Governing Council of the ECB decided (ECB 2016) to discontinue the production of the €500 banknote, although it keeps its legal tender status and the remaining €500 bills in the vaults of the NCBs were still to be issued (see figure 6).



Note: Own figure.

Sourc: ECB.

Figure 6: Development of single euro banknote denominations from 1/2015 – 1/2022 in € bn.

Figure 6 exhibits that the denominational demand shifted away from the €500 note to the

€50 and €100 "hybrid" notes even slightly before the official announcement of the €500 production stop when first rumours of this measure reached the public. Since the demand for the next lower large denomination, the €200 bill, did not react at all in 2016, it seems that market participants viewed the ECB announcement only as a first step to withdraw also the €200 note from circulation in the foreseeable future. This changed, however, after the last €500 banknote was issued on April 26, 2019. The demand for the €200 bill increased strongly afterwards as did both "hybrid" denominations (€50, €100) before, especially when the economies of the euro area went into full lockdown in March 2020. Due to the lockdowns and shutdowns, the increased demand for the hybrid denominations cannot be attributed to transactional demand. As criminal activities also declined at that time (*Nivette* et al. 2021), there is also no reason to assume that there was an increase in transactional demand for those hybrid notes by the shadow economy.

5. Foreign demand for euro banknotes

The enormous increase in the demand for the €200 note since the last €500 note was issued in spring 2019 was mainly from residents outside the euro area (*Lalouette* et al. 2021, 9). Consequently, an analysis of cash issued by the Eurosystem must take also foreign demand into account. Estimates show that the share of euro banknotes outside the euro area is between 30% and 50% of the total value of euro banknote circulation (*Zamora-Pérez* 2021). This implies that at the end of 2021 roughly between €460bn and €730bn of €1,554bn total banknotes issued are held by foreigners. Regarding the demand for single euro denominations, foreign demand concentrates mainly on the high denominations €100 - €500 (*Rua* 2021) although euro cash is also used partly as a medium of exchange in south-eastern European countries (*Scheiber*/*Stern* 2016; *Scheiber*/*Stix* 2009). In the euro area itself, only around 20% of total cash in circulation is used for payments. Another 30% – 50% is used as a store-of-value by euro area residents (*Zamora-Pérez* 2021).

4. The digital euro: supply and demand side considerations

1. Characteristics of the digital euro

CBDC is a new type of digital money issued by central banks, denominated in the national unit of account which represents a genuine liability of the central bank (*Boar*/*Wehrli* 2021). It can be classified into two categories (*Barontini*/*Holden* 2019): "General purpose" or "retail CBDC" for the public (private households, firms, and even the government) and "wholesale CBDC" for commercial banks or other financial institutions only. In principle,

both variants can be "token-based" using a Distributed Ledger Technology (DLT) to store information on a blockchain or "account-based" giving money holders access to ordinary central bank accounts. According to the latest survey by the Bank for International Settlement, 90% of 80 surveyed central banks are currently engaged in CBDC work, mainly focusing on retail CBDC as a cash-like claim on the central bank, but where the private sector handles all customer-facing activities (*Kosse*/*Mattei* 2022).[12] In July 2021, the Governing Council of the ECB decided to formally launch a project for the possible issuance of a digital euro (ECB 2021b). After initially exploring the possible anonymity of CBDC (ECB 2019), an official report on a digital euro (ECB 2020a) was published and later supplemented by a summary on key learnings from the discussion so far (ECB 2021a). Together with a variety of up-to-date speeches from ECB Board Members and additional information from the ECB website[13] the principal shape of a future digital euro has become more perceptible.

Although the ECB explicitly keeps all options open (including the termination of the whole project), the digital euro is likely to be issued only as retail CBDC and its use is therefore restricted to nonbanks such as households and firms. Its purpose is to provide the public with some sort of "digital cash" with an instant payment function. It should not be used as a saving instrument (*Panetta* 2022b). For that reason and to avoid systemic risks that might occur from a possible flight into CBDC in times of financial crisis (*Brunnermeier*/*Niepelt* 2019), individual holdings of digital euros will be either limited or indirectly restricted by tiered remuneration (*Bindseil* et al. 2021). From a legal perspective, the Eurosystem will probably issue the digital euro as a genuine central bank liability against nonbanks.[14] So-called indirect CBDC solutions (*Auer*/*Böhme* 2020, 89), in which financial intermediaries are the owners of CBDC accounts and handle retail payments for the central bank on their own accounts are obviously not being pursued any further. Nonetheless, financial intermediaries will be given a crucial role in distributing the digital euro on behalf of the Eurosystem just like commercial banks currently provide the public with cash (*Panetta* 2022a). In addition, the digital euro shall get legal tender status and it will be convertible on a one-to-one basis to cash and other official means of payments in the euro area. The final decision to introduce the digital euro will not be taken before autumn

[12] The first CBDC was issued as the "digital Sand Dollar" from the Bahamas in October 2020, and Nigeria followed with its eNaira in September 2021. For update information see https://www.atlanticcouncil.org/cbdctracker/.

[13] See, for instance, the FAQ section on the digital euro on the ECB website, https://www.ecb.europa.eu/paym/digital_euro/faqs/html/ecb.faq_digital_euro.en.html.

[14] See https://www.ecb.europa.eu/paym/digital_euro/html/index.en.html.

2023 (*Panetta* 2022c). Regarding the payment infrastructure of the digital euro, it is still unclear what solution (token- or account-based or even hybrid) the ECB might prefer. In a recent survey of stakeholders on what they might expect from a digital euro, the respondents emphasized the ability to "pay anywhere" and payments should also be instant, easy, and contactless (*Kantar Public* 2022) and the ECB is willing to meet those demands (*Panetta* 2022c). About the desired protection of personal data, however, the ECB unambiguously stated (see, for instance, *Panetta* 2022c) that complete anonymity regarding the digital euro will not be feasible due to legal requirements regarding anti-money laundering (AML) and combating the financing of terrorism (CFT). Hence, money holders will have to identify themselves when they start using the digital euro ("onboarding") preferably at a supervised intermediary such as a commercial bank. With respect to the recording of transactional data, the Eurosystem seems to be satisfied with the minimum of data that is needed to perform the payment, but financial intermediaries would have full access to ensure compliance with AML/CFT requirements (*Panetta* 2022c).

2. A suggested double pre-paid design for the digital euro

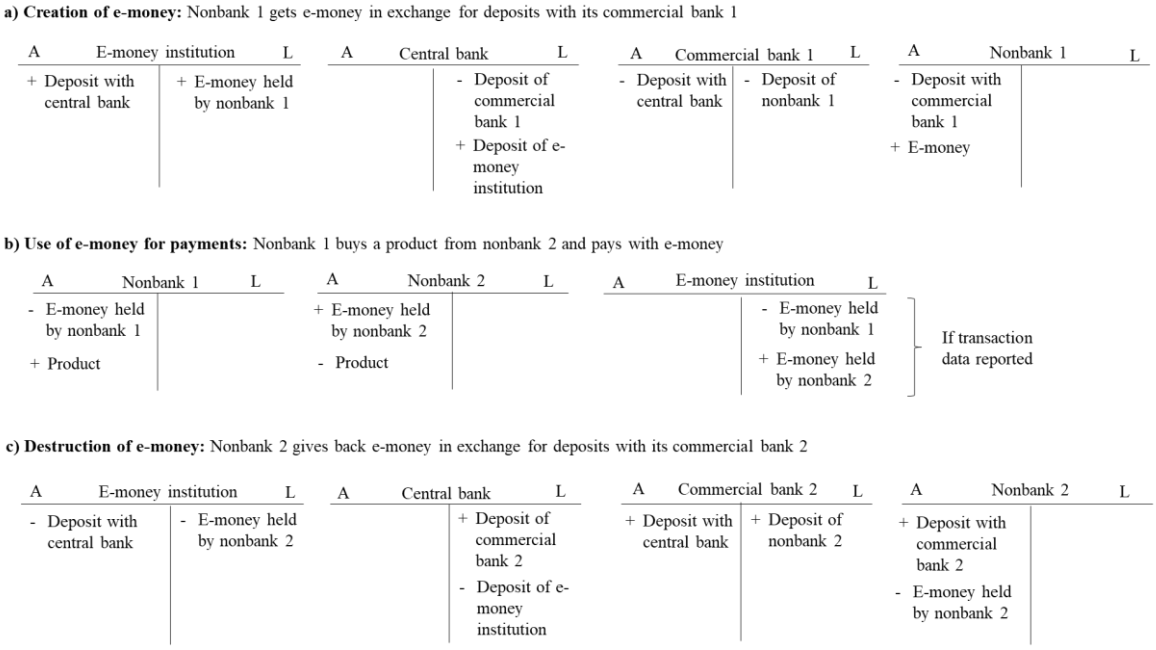
Note, that the decision by the ECB not to guarantee full anonymity in the use of the digital euro has severe strategic consequences. It effectively disbands the idea of creating a true digital equivalent to cash since anonymity is one of its fundamental characteristics (*Rösl*/*Seitz* 2022b). And this also implies that the digital euro does not necessarily have to be built on a DLT technology. Therefore, the ECB will probably choose an account-based payment scheme which has already shown its robustness in practice. *Bechtel*/*Otto-Schleicher* (2021) plead for using the TARGET Instant Payment Settlement (TIPS) infrastructure of the Eurosystem. But due to its design characteristics, TIPS per se cannot process instant offline payments, which is an important feature for a broad acceptance of the digital euro (*Kantar Public* 2022). Consequently, TIPS should be combined with a second payment scheme that enables the transfer of monetary value without being connected to a remote server in real-time.[15] Indeed, such a system already exists in the euro area in the form of e-money. In what follows, we show that such a two-pillar structure of a digital euro relying on TIPS and e-money features would also allow to integrate private financial institutions in a way envisaged by the ECB: Commercial banks and eligible PSPs should only act as intermediaries regarding the issuance of the digital euro but would play

[15] The ECB already stated in its press release on the launch of the digital euro project on July 14, 2021, that architectures (including TIPS) "combining centralized and decentralized elements are (…) possible." (ECB 2021b).

a crucial role in "know your customer" (KYC) and customer due diligence (CDD) checks as well as AML/CFT (*Panetta* 2022a).

a.) E-money in the euro area

To demonstrate the basic functionality of such a payment scheme for the digital euro, we first recall – by example of e-money stored directly on chips embedded in decentral devices designed for offline-payments[16] – how this type of digital money is currently created in the euro area. As shown in figure 7a, four separate entities are involved hereby: e-money users (nonbanks), commercial banks, the central bank (system) and e-money issuing institutions.[17]



Source: Own figure.

Figure 7: Creation, use, and destruction of e-money

Assume, that nonbank 1 wants to store e-money on (a chip integrated in) a mobile phone, a plastic card, or any other data storage device for offline payments. In practice, the desired e-money is created at a designated terminal in form of a data set (representing a specific monetary value) which is directly stored on the corresponding chip (for instance, by magnetizing or other types of data transmission). Commercial bank 1 debits the deposit

[16] The ECB speaks of a "hardware-based" e-money scheme since both devices communicate offline with each other. By contrast, "software-based" e-money schemes need by definition a connection to a remote server that controls the use of the purchasing power (ECB 2000, 50).

[17] Note, that e-money systems can in principle also be created without the involvement of central banks. In the euro area, however, monetary authorities have to be included in the analysis since settlements between commercial banks and e-money institutions must be conducted in central bank money (*Kovacs* et al. 2014).

account of its customer accordingly[18] and makes a corresponding credit transfer in favor of the e-money institution using its funds with the central bank. As is obvious from figure 7a, commercial banks are actively involved in the process of e-money creation but act only as financial intermediaries. E-money itself, however, is created by a separate e-money institution which in turn receives central bank deposits from those commercial banks to which the e-money terminal is connected. The central bank operates only as a clearing house and settles the respective funds on its own accounts provided to both types of financial institutions (commercial banks and e-money institutions). Note, that e-money in the euro area is only allowed to be issued on a pre-paid basis (as required by the directive, 2009/110/EC). This implies that although more e-money is in circulation, the total money stock in the hands of the public (nonbank liquidity) does not change, only its composition is altered (less deposits with commercial banks and more e-money). From a monetary policy perspective, this is highly desirable, and we can confidently assume that the issuance of a digital euro might also be neutral to money supply in the euro area.

Figure 7b shows in accounting terms what happens to the participants of the e-money scheme if e-money is spent offline by nonbanks assuming that nonbank 1 purchases a good from nonbank 2. E-money is transferred electronically by means of a device reader or via Bluetooth from the chip stored in the payment device of nonbank 1 to the chip in the payment device of nonbank 2. From the viewpoint of both nonbanks the payment is instantly and finally settled. However, as there is no real-time network connectivity to the server of the e-money institution, it cannot keep track of the e-money spending directly. In this regard, "hardware-based" e-money resembles very much cash. But since every data transaction leaves a trace, it would be at least technically possible to create a system where the e-money institution could identify every single payment once its server is connected to the storage devices (for instance at loading terminals or via a mandatory data transmission once a day). Hence, e-money – even if stored decentral – does not necessarily ensure anonymity. If tracked, the payment would lead to an accounting exchange on the liability side of the balance sheet of the e-money institution. Of course, e-money schemes can also be "software-based". In that case, e-money is still stored in a decentral way, for instance on personal computers or smartphones, but transferring requires a special software ("client") and – by definition of the ECB – connectivity to a remote server (ECB 2000, 50). Note that this remote server does not necessarily have to be the one of the e-money institution. If so, however, e-money payments in this case are very similar to credit transfers of commercial

[18] E-money could, of course, also be created in exchange for cash at special terminals.

bank book money.

If an e-money holder, for instance nonbank 2 in figure 7c, prefers to give back its e-money in exchange for commercial bank deposits, e-money will be taken out of circulation and all the steps of e-money creation will be simply reversed. Again, this transaction leaves the total money stock in the economy constant.

b.) TARGET Instant Payment Settlement

The next step of our analysis demonstrates the basic features of the TARGET Instant Payment Settlement (TIPS) infrastructure of the Eurosystem. TIPS itself is part of the wider TARGET2 family comprising TARGET2, TARGET2-Secutities, TARGET2/T2S consolidation and TIPS – building blocks of a euro area-wide payment and settlement system operated by the Eurosystem.[19] From a pure payment perspective, TARGET2 and TIPS are especially relevant. TARGET2 is the second generation of the Trans-European Automated Real-time Gross settlement Express Transfer system and is, roughly speaking, the "work horse" for standard payments based on central bank money in the euro area. The settlement in the TARGET scheme usually takes one day and the money used is stored at the corresponding Payments Module (PM). Consequently, we refer to this category of central bank book money as TARGET-PM deposits. By contrast, TIPS is reserved for instant payments only and is run on a separate platform. The associated accounts are officially called "Dedicated Cash Accounts" (DCA) although this term is somewhat misleading since there is no cash involved. The funds stored here are just another category of central bank book money (TIPS-money) and we denote the corresponding accounts as TIPS-DCA. Note, that TIPS currently works – just like e-money in the euro area – only on a pre-paid basis.

[19] For more information see https://www.bundesbank.de/en/tasks/payment-systems.

a) Creation of TIPS-money: Commercial bank 1 transfers central bank money from its account in the TARGET Payments Modul (TARGET-PM) to its TIPS Dedicated Cash Account (TIPS-DCA)

Central bank	
A	L
	- TARGET-PM$_1$
	+ TIPS-DCA$_1$

Commercial bank 1	
A	L
- TARGET-PM$_1$	
+ TIPS-DCA$_1$	

b) Use of TIPS-money for instant interbank payments: Nonbank 1 buys a product from nonbank 2 and pays by instant credit transfer of commercial bank book money

Central bank	
A	L
	- TIPS-DCA$_1$
	+ TIPS-DCA$_2$

Commercial bank 1	
A	L
- TIPS-DCA$_1$	- Deposit held by nonbank 1

Commercial bank 2	
A	L
+ TIPS-DCA$_2$	+ Deposit held by nonbank 2

Nonbank 1	
A	L
- Deposit with commercial bank 1	
+ Product	

Nonbank 2	
A	L
+ Deposit with commercial bank 2	
- Product	

c) Destruction of TIPS-money: Commercial bank 2 transfers central bank money from its TIPS Dedicated Cash Account (TIPS-DCA) to its account in the TARGET Payments Modul (TARGET-PM)

Central bank	
A	L
	+ TARGET-PM$_2$
	- TIPS-DCA$_2$

Commercial bank 2	
A	L
+ TARGET-PM$_2$	
- TIPS-DCA$_2$	

Source: Own figure.

Figure 8: Creation, use and destruction of TIPS-money

This means that commercial banks first have to transfer money from their TARGET-PM accounts to their TIPS-DCA before they can use it for instant payments (see figure 8a). The time to transfer funds from TARGET-PM accounts to TIPS-DCA is restricted to the opening hours of TARGET2, i.e., from 7 am to 9 pm CET, but instant payments using TIPS-money are then possible 24/7/365. Assume again that nonbank 1 purchases a good from nonbank 2, this time, however, the payment shall be conducted by instant credit transfer of regular accounts at commercial banks – a possibility which is quite new to European consumers but gains momentum recently. Figure 8b shows how funds are now transferred in an almost instant fashion.[20] Interbank payments are conducted in TIPS-money, whereby the receiving bank credits and the sending bank debits its customer's account accordingly.

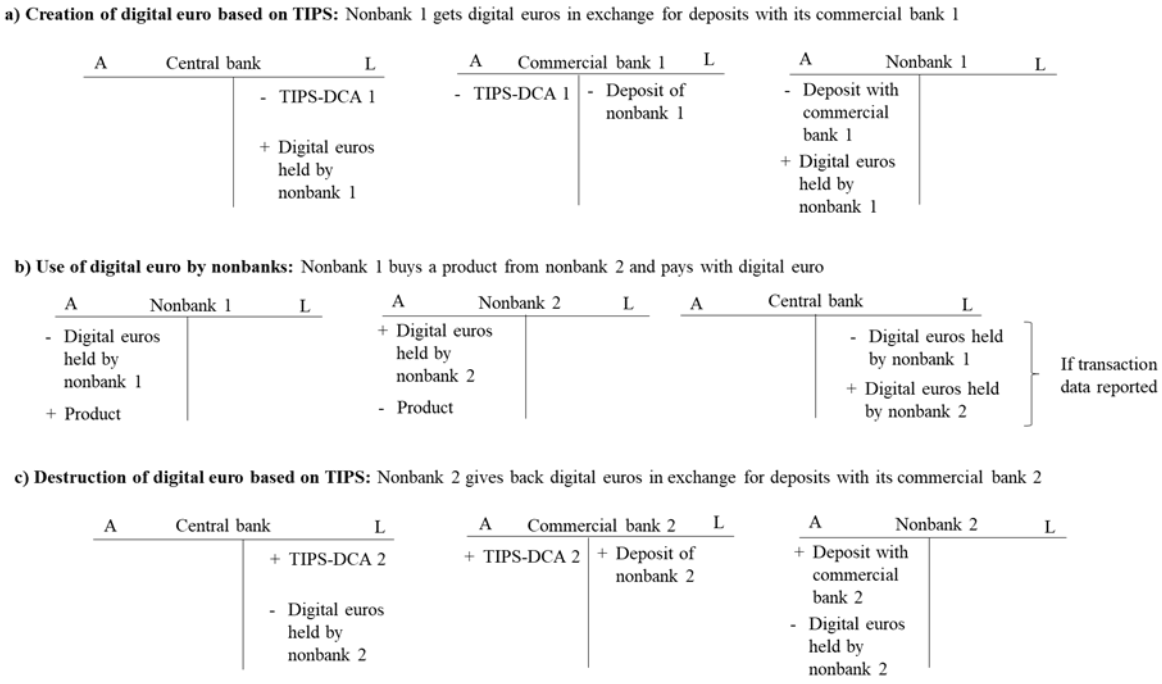
If the TIPS-money receiving bank 2 wants to reduce its TIPS balance afterwards (for instance, because of intended cash withdrawals which need to be settled with PM-accounts), it transfers money from its TIPS-DCA to its TARGET-PM account and "TIPS-money" is

[20] In practice, such a TIPS-based transaction takes only 10 seconds at most. In comparison, "normal" SEPA credit transfers working on the TARGET2 platform and therefore using TARGET-PM accounts need one working day until final settlement.

destroyed although total bank liquidity does, of course, not change (see figure 8c).

c.) TIPS-based accounting system with e-money elements for the digital euro

Since its introduction in late 2018, TIPS operates smoothly and reliably. It is therefore a natural candidate for the implementation of an account-based payment scheme for the digital euro. Figure 9a illustrates how a digital euro could be created within the TIPS infrastructure constituting a genuine CBDC.[21]



Source: Own figure.

Figure 9: Creation, use and destruction of digital euro based on TIPS infrastructure

Analogous to the e-money scheme (compare figures 7a and 9a), two necessary preconditions for the creation of digital euro must be met: First, nonbanks need book money with their commercial banks in advance, and second, commercial banks need beforehand sufficient deposits with the central bank (stored on TIPS-DCA) to fully cover the digital euro issued. In this double pre-paid system, commercial banks act indeed only as intermediaries in the process of digital euro issuance. As in the case of e-money, the issuance of a digital euro leaves the total money stock in the hands of nonbanks unchanged but increases the demand of commercial banks for additional central bank reserves. On top, payments in digital euro by nonbanks also take place outside the commercial banking system, as it was true for e-money. This comes with no surprise, however, since both types

[21] It is an open question, how central banks' balance sheets in general have to and will adjust (on the liability and asset side) once CBDC is issued. See on this issue, for instance, *Hauser* (2022).

of money are in their nature digital currencies, only the issuer is different – either private or public (see table 1). Figure 9b also shows that payments in digital euro will be principally reflected in an accounting exchange on the liability side of the central bank if tracked accordingly. What would happen if the digital euro is only stored on mutually communicating storage devices used for offline payments (for instance, mobile phones connected via Bluetooth in the moment of payment at the POS or P2P), no history of transaction data are created at the time of spending, and no data transmission from these decentral devices to the TIPS server takes place except when the digital euro is either taken from or given back to the Eurosystem? Such a hypothetical scenario for a digital euro is comparable to banknotes (see chapter III): the Eurosystem knows exactly the volume issued, but it is not able to track single spending and does not know who holds which amounts and in which country. But since full anonymity for the digital euro is negated by the ECB, we can safely assume that there will be some form of data tracking implemented in its payment scheme.

As in the case of e-money, the destruction of digital euro will be handled by commercial banks which take digital euro back on behalf of the Eurosystem at any time and pay by crediting its customers' accounts leaving nonbank liquidity again unchanged (see figure 9c). But with it comes an inflow of central bank money on TIPS-DCA increasing the liquidity of the commercial bank instantly.

3. Cash and the digital euro: coexistence or crowding-out?

Due to its intended lack of full anonymity, a digital euro will never be a perfect substitute to cash even if the underlying technology would change from an account-based system to a DLT/Blockchain technology. This raises the general question whether there will be sufficient demand for the digital euro. Obviously, this will depend strongly on its future design and is therefore hard to predict. But given the information currently available, there seems to be little interest in the new digital money by consumers who want to pay in an anonymous way. These people are very likely to continue using cash at least as long as supply-side restrictions by commercial banks and government limitations on cash usage (see chapter II) will not intensify. The Eurosystem as the central provider of cash in the euro area repeatedly emphasized that the digital euro shall not replace but complement cash.[22] And indeed, the expected design of a trackable digital euro seems to be the best way

[22] See, for instance, the ECB's hub page on the digital euro, https://www.ecb.europa.eu/paym/digital_euro/html/index.en.html

of protecting cash as long as the Eurosystem is willing to provide it in sufficient quantities. For those consumers, however, who prefer to pay cashless, the digital euro might be a principal alternative to private digital payment solutions. Recent surveys, however, indicate that there is currently little need for a European CBDC, as respondents are generally satisfied with the existing (cash and cashless) payment options (see, for instance *Abramova* et al. 2022; Deutsche Bundesbank 2021).[23]

This might explain why the ECB recently changed its communication strategy from emphasizing the need for a digital euro because cash will allegedly lose importance at the POS anyhow to a more systemic approach. The digital euro is officially supported as it safeguards the European payment infrastructure from influences of foreign card and private BigTech payment solutions (ECB 2022b; *Panetta* 2022a;b). Such an approach makes sense if it aims at increasing the level of competitiveness in the European payments market. But finally, it will always be the cost-benefit-ratio for users that decides if a certain means of payment will be successful or not. Although the ECB could outcompete private payment solutions very easily, for instance by making access to TARGET2 and TIPS more expensive for interbank settlements or increasing regulatory requirements, the European monetary authority remains somewhat opaque in this respect: On the one hand, the digital euro should be attractive enough to be widely used but on the other hand it should not drive out private payment solutions and endanger financial market stability (*Panetta* 2022a). The reasoning behind this position is to provide with the digital euro a new form of central bank money that functions as a fallback solution in case confidence in private payment providers deteriorates and cash is not sufficiently in circulation anyway due to the overall trend towards digitalization.[24]

IV. Summary and conclusions

To sum up, the declining role of cash as a medium of exchange in the euro area will probably continue in the foreseeable future due to cash payment limitations, further possible supply-side restrictions by the banking system and the lasting trend towards digitalization. But it will presumably take decades (if ever) that cash will be nearly obsolete at the POS in

[23] In countries with one well-functioning private payment app (like Swish in Sweden or Twint in Switzerland), this reasoning is even more convincing.

[24] Possible scenarios for bank intermediation are discussed in *Adalid* et al. (2022). In this respect, *Keister/Monnet* (2022) offer two interesting arguments in favour of CBDC. First, as banks do less maturity transformation when depositors have access to CBDC, they are less exposed to depositor runs. Second, monitoring the flow of funds into CBDC allows regulators to more quickly identify weak banks and take appropriate action.

the euro area given the fact that (in volume terms) most retail purchases are currently still paid in cash. In addition, cash is far from being outdated as domestic and foreign residents continuously seek for euro banknotes as a highly liquid store of value. In fact, around 80% of total euro cash in circulation is not used for domestic transactional purposes. In this regard, however, the observed demand shift towards lower banknote denominations over the past years will not likely be reversed as the ECB has decided not to include a €500 note into its new banknote series.

The declining use of cash at the POS was initially one justification by the ECB for the possible issuance of a retail CBDC for the euro area – the digital euro. Since the official launch of the digital euro project in July 2021, its future shape gets more and more perceptible although no final decision has been taken yet: The digital euro is intended to be a genuine retail CBDC, it should be accepted and used widely at POS in the euro area but not as a saving instrument. Its use will not be fully anonymous. And financial institutions such as commercial banks will act as intermediaries in the issuance and withdrawal of the digital euro from circulation.

But little is known about the technical functionality of the digital euro. Will it be account-based or based on the distributed ledger technology? We follow a suggestion to use a payment scheme based on the well-established TIPS infrastructure of the Eurosystem. But since this account-based system cannot process offline payments, it should be complemented by elements form e-money schemes. Our suggested approach results in a double pre-paid payment scheme, where nonbanks pay in advance for digital euro as do commercial banks for funds used in TIPS to conduct payments to finally settle transactions in real-time within the financial sector initiated by the spending of digital euro.

It is very hard to predict what role a digital euro will play in the future payment markets. Our guess, however, is that there will be a co-circulation with cash in the coming decades. And if the trend towards cashless payments at the POS continues in the euro area, banknotes and coins will probably be substituted by already existing private payment solutions, such as mobile payments as well as debit and credit cards with increased limits for contactless payments, and not by the digital euro. Recall that the digital euro is very likely to be issued on a pre-paid basis in order to be neutral to total money supply in the euro area. But this makes the digital euro cumbersome and costly. The argument that the digital euro could have an advantage of credibility versus private money (ECB 2020a) seems, at least at the moment, not very relevant for ordinary citizens. From their point of view, there are

obviously only two types of payments: cash and cashless – without reflection on the issuer (Deutsche Bundesbank 2021). Why change to another new type of cashless payment (i.e., the digital euro), if there are already convenient and well-proven alternatives such as payment cards or mobile payment schemes? In the e-commerce markets, however, there might be a case for the digital euro at least as long as the currently evolving instant payment schemes stay well behind their huge potential.

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