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THE EVOLUTION OF MONEY: THE DIGITAL EURO CASE

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ABSTRACT

Money's multifunctionality has sustained its widespread diffusion; today the new frontier is constituted by central bank digital currencies (CBDCs), and the ECB is considering introducing a European version: the digital Euro. Three stakeholders' groups will drive its success, the ECB, commercial banks and households due to its implications for monetary policy, the banking sector, and the public. Using available qualitative and quantitative studies, this paper found that the ECB will benefit the most from the foreseeable digital Euro by narrowing the gap with private digital forms of money and strengthening the passthrough of monetary policy rates. Commercial banks will not suffer much in terms of lower profitability and compliance with regulatory requirements due to limited deposit substitution. Households will enjoy full acceptability granted by the legal tender status, as well as privacy and safety of transactions. Thus, the foreseeable digital Euro is set to take a hold in the European payment industry, but the ECB shall strive to favour the conditions for its diffusion to successfully issue the first digital central bank money.

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ABBREVIATIONS

AML: Anti money laundering

ATM: Automatic teller machine

B2I: Business to individual

CFT: Combating the financing of terrorism

DEAN: Digital Euro account number

DLT: Decentralised ledger technology

ECB: European Central Bank

ECDSA: Elliptic curve digital signature algorithm

ESCB: European system of central banks

ETF: Exchange traded fund

FREL: Floor required excess liquidity

HQLA: High quality liquid assets

KYC: Know your customer

LCR: Liquidity coverage ratio

LSI: Least significant institution

NFC: Near field communication

NSFR: Net stable funding ratio

P2P: Person to person

POS: Point of sale

PSD: Payment service Directive

PSP: Payment service provider

QR: Quick response

RDG: Rulebook Development Group

RoE: Return on Equity

RTGS: Real-time gross settlements

SAP: Single access point

TFEU: Treaty on the functioning of the European Union

I. INTRODUCTION

Money is tightly bound with human development as the three fundamental characteristics of means of payment, store of value and unit of account, together with the ancillary role as standard of deferred payment, have fostered growth enabling to pay, preserve value, count and stipulate contracts. In this continually evolving process, central bank digital currencies which are digital forms of money issued by central banks that cannot be refused by anyone to settle a debt (i.e, they are legal tender) are the novelty. Almost all central banks have launched projects on digital currencies and are carrying out experiments to modernise central bank money available to the public. Specifically, monetary institutions would be able to complement their supply of physical coins and banknotes with a digital form of money reducing the gap with private sector moneys and means of payments. Restricting the scope of the analysis to the European case, starting from November 2023 the ECB has entered the preparation phase that could potentially lead to the introduction of the digital currency. This paper investigates the reasons for potential success, based on the foreseeable features of the digital Euro. This chapter will introduce the topic, state the research objective and limitations, and provide a summary of the subsequent parts.

CBDCs can be classified according to two parameters: the intended users and the system employed. The first comprises wholesale CBDCs (that aim to smooth payments between the central bank and commercial banks) and retail CBDCs (intended as digital extensions of cash). Retail CBDCs can be subdivided into deposit-like and cash-like groups based on the intended usage by the monetary institution. Instead, the two conceivable systems are token-based (centred on the token part rather than on the holder's identity and suitable to grant anonymity) and account-based (more akin to a bank account held at the monetary insitution). Speeches of ECB executives, official reports and the proposal for a regulation, point at a cash-like account-based retail CBDC.

More specifically, the ECB initiated the digital Euro project with the publication of a report in October 2020 that set the core principles and requirements for the prospective digital currency. Consequently, it initiated a consultation phase to collect the views of citizens (users) and retailers on a digital Euro. The positive feedback received paved the way for the investigation phase that started in October 2021 and lasted two

years until October 2023. In the said period, the ECB addressed its main features, the roles of PSPs and the Eurosystem, and the compensation model to ensure a smooth adoption, as well as, the limits for its use as a mean of investment and the privacy and data protection schemes. Then it has entered the preparation phase, that is subdivided into two stages, and could lead to the introduction of the digital currency, upon approval of the Governing Council of the ECB. The central bank will focus on testing and experimenting, interacting with all stakeholders to realise a safe and usable digital currency.

Studying the main consequences of the project is critical to release a competitive digital currency. Numerous studies investigated the possible implications for commercial banks, and the effects on monetary policy (e.g. Infante *et al.* (2022) and Das *et al.* (2023)), but few deepened on households' incentives: indispensable to stimulate the demand. Moreover, whilst a consistent strand of literature focused on deposit-like digital currencies due to the more pronounced implications for the banking sector, few researchers considered cash-like CBDCs. As a result, existing literature does not provide a complete framework for the introduction of the digital Euro as those pivotal factors have rarely been considered. Consequently, this paper will investigate whether a digital Euro presenting the features laid down in the proposal for a regulation would be successful, identifying and evaluating the effects on three stakeholders' groups: the ECB, commercial banks, and European households. The qualitative and quantitative approaches adopted provide a European perspective on the digital Euro, leaving the implications on foreign countries and citizens aside. Moreover, the reasonings presented rely on the currently discussed features, but subsequent adjustments may limit the applicability of the research.

This paper will contribute to the body of knowledge on the digital Euro, offering a holistic perspective on the consequences for the three main stakeholders' groups that will determine the supply, distribution, and demand for the CBDC. This will help pinpoint the focal aspects of the project, enabling the ECB to individuate the strengths and weaknesses of the proposed digital Euro and plan the necessary steps to release a competitive digital money.

Chapter II delves into the three main characteristics of money, together with the fourth debated role as standard of deferred payment, then takes a historical perspective

from barter until the more recent digital forms, deepening on the most successful innovations. Chapter III will insist on CBDCs, describing the different types and architectures. Subsequently, it will zoom on the digital Euro reviewing the progresses made. Chapter IV will provide a three-fold examination of the implications for European monetary policy, the banking sector, and households.

II. FUNCTIONS AND HISTORY OF MONEY

II.1. Definition of money

Any attempt to define "money" would be vain; at most it would produce a new interpretation that would lengthen the never-ending list of definitions laid down throughout the years. The main reason is that money is continually evolving, and any new interpretation would become outdated sooner or later. In fact, money has changed alongside and adapted to human developments and inventions; as an example, its consistency evolved from physical metallic money (such as gold, copper and silver coins) to paper money, from cattle to electronic forms of money etc. Additionally, any possible interpretation does not move beyond the problem of classification of "money"; namely what phenomena should be included in the definition (Pryor 1977). Nevertheless, before delving into a comprehensive and detailed analysis of the different types of money and its evolution, it seems reasonable to identify its main purposes, given that the two concepts are intertwined. Those functions may help to identify the rationale behind any innovation introduced in the evolution of money. The traditional view holds that money serves three main purposes: unit of account, mean of payment and medium of exchange[1]. However, it could be argued that money actually serves four main purposes – exchange, counting, store of value and long term exchange standard leading to a four-factor functional topology: money as a medium of exchange, unit of account, store of value and

[1] According to Meikle (1994, p. 26), the said theory can be traced back to Aristotle who identified money as "medium of exchange, as measure of value and as store of value".

standard for deferred payments[2]. For the purpose of the paper, the latter classification provided by Paul Einzig (1966) will be used.

II.1.1. Money as medium of exchange

The medium of exchange theory posits that money is an object that can be quantifiable: a payee will accept it because he believes that others will not refuse it. In Einzig's words "A medium of exchange is an object conforming to certain standards of uniformity that is widely accepted in payment for goods and services, because the recipient can easily use it for making similar payments" (Einzig 1966, p. 431). Therefore, money needs to possess specific features which render it suitable to be used in the payment system i.e. it needs to have desirable physical features in terms of ease of use, durability, low carrying costs, etc. These characteristics have changed throughout the years as a direct consequence of the evolution of the payers and payee's needs. As an example, in primitive communities, uniformity was not pivotal: it is documented that exchanges occurred through various means ranging from cattle to precious metals (Einzig 1966, p. 431). Divisibility is key too: money needs to be easily divisible to be used even for small exchanges of goods. Finally, it needs to be standardised. This characteristic is crucial for its diffusion because the higher the degree of standardisation, the higher the chances of being accepted, the higher the money velocity[3].

Considering the four functions from a historical perspective, money as a mean of exchange seems to be the *condicio sine qua non* the other three would not have developed. In fact, according to Pryor (1977), any kind of inventory can serve as a store of value (e.g. gold, cattle...) therefore this feature does not seem to be the initial function of primitive money. Secondly, for what concerns money as a unit of account or standard of value, it can be argued that in archaic societies, people could have remembered the exchange rates between different goods without reverting to its value in terms of money[4]. Finally, the

[2] Meikle (1994, p. 26) reports that Aristotle limited its classification to three purposes, given that deferred payments did not exist at that time.
[3] Defined as "the rate of turnover of money supply" or, more specifically, as "the number of times one currency is used to purchase final goods and services" by the FED.
[4] As an example, payers and payees could have remembered that the value of 3 oxen was equal to 2 horses, irrespectively of their conversions to some form of primitive money, to execute transactions.

concept of mean of payment is tightly connected to what has been previously stated for the unit of account feature; again, money was unnecessary to make payments in small, closed economies, so this function too is subordinated to that of mean of exchange.

The view presented above with respect to the causal relationship amongst the four functional forms of money reflects the metallists'[5], while nominalists[6] sustain the "standard of value/unit of account supremacy" (Einzig 1966, p. 356). They believe that money as a medium of exchange does not represent the turning point from barter to the primitive forms of money; rather they are convinced that it originated only in terms of "money of account". Consequently, despite being different from one another, the four functional goals of money are interconnected, especially in primitive communities where payers and payees used the same goods both as media of exchange and standards of value. Namely, this occurred in Greece where oxen were used as a mean of exchange by the wealthy individuals and as a standard of value by the poor, who did not have access to the aforementioned form of "money" (Einzig 1966, p. 434).

For what concerns the development of the mean of exchange theory, in primitive communities, payees were interested in salt or grain (money of the past) *non solum* for exchange purposes, *sed etiam* for consumption purposes, according to Einzig (1966, p. 345). Money had a double role at that time, while today it will be impossible to consume (i.e. eat) a banknote, coin or a digital number. This divergence signals how the functional form of money as a medium of exchange has evolved; the novelty stands in the widely recognised acceptance enjoyed today where payers use and payees accept it by tale, due to its interchangeability and convertibility. Obviously, those features did not pertain to primitive money (Einzig 1966, p. 346).

[5] Joseph Schumpeter gave a double interpretation of metallism in his masterpiece *History of Economic Analysis*: "By Theoretical Metallism we denote the theory that it is logically essential for money to consist of, or to be 'covered' by, some commodity so that the logical source of the exchange value or purchasing power of money is the exchange value or purchasing power of that commodity considered independently of its monetary role. . . By Practical Metallism we shall denote sponsorship of a principle of monetary policy, namely, the principle that the monetary unit 'should' be kept firmly linked to, and freely interchangeable with, a given quantity of some commodity" (Schumpeter 1954, p. 288).

[6] John Maynard Keynes was an exponent of this theory. Again, Schumpeter (1954, p. 297) presents the nominalist view defining money as "any commodity which purely in itself is of no material use to man hut which acquires such an estimation from his opinion of it as to become the universal measure of what is called value".

Leaving primitive communities aside, many intellectuals deeply investigated the drivers affecting money circulation which hinges on its acceptancy rate. They found a tight relationship between money velocity, the overall money supply, volume of transactions in the economy and price level. Those ideas were later formalised in the so called "quantity theory of money", whose first proponent was Martin de Azpilcueta (Navarrus) from Salamanca in the 1550s (Dimand 2019, p. 46). It mainly posits that, in the long run, changes in the quantity of money would affect the price level in the same proportion – keeping constant money velocity and the volume of transactions in the economy. In layman's terms, the theory explains how increases of money supply lead to increases in the price levels i.e. inflation. As mentioned above, the theory was first introduced in the 16th Century, it was further developed by David Hume in the 18th Century and by Simon Newcomb in 1885 (Dimand 2019, p. 47), but the most prominent forms are Fisher's and Keynes'.

The most known form can be summarised as follows: $M \times V = P \times T$ where M stands for Money supply, V stands for money velocity, P for price level and T for volume of transactions in the economy. Another form was proposed by the Cambridge monetary theorists Marshall, Pigou and Keynes who came up with a slightly modified version of the formula, stressing on the relationship between desired cash balances M and nominal income Y. The Cambridge version is the following: $M = k \times P \times \mathrm{Y}$ where k is the cash balance coefficient i.e. "a parameter reflecting economic structure and monetary habits, namely the ratio of total transactions to income and the ratio of desired money balances to total transactions" (Black, Hashimzade, and Myles 2009). The two formulations are equivalent with the parameter k being defined as $k = \frac{T}{VY}$, namely the quotient between the level of transactions in the economy and he product between the volume of transactions and the nominal income.

II.1.2. Money as unit of account

Another fundamental function of money is related to the possibility to use it for counting purposes; namely the so-called "money as a unit of account". As stated by Einzig

(1966, p. 436), a standard of value[7] is a "unit in which prices are apt to be quoted also independently of any actual exchange transaction". Regardless of the possible physical goods that can serve as units of account, deepening in the monetary aspects, the definition stresses that it is not needed for a currency to effectively circulate and be used in settlements to be the unit of reference. This marks the difference between the functions of "medium of exchange" and "unit of account".

Nowadays, the divergence is not easily identifiable given that payments are settled and accounted in the same unit; however, in the past the situation was strikingly different, and payers and payees were accustomed to complete transactions using a different medium of exchange than the accounting unit[8]. A quite recent example, however, concerns the ECU[9] (European currency unit) introduced initially in the European Economic Community in 1979 and later extended to the European Union until its replacement at par with the Euro in 1999. The currency was used for conversion purposes; therefore, it served only the function of "standard of value" with Europeans executing transactions in their home currency.

It could be argued that the functions of "medium of exchange" and "standard of value" appear to be closely intertwined. Einzig (1966, p. 438) takes a more extreme view reporting that for "unit of account" and "medium of exchange", one function implies the other, unless a different unit is specifically chosen. The interconnection has sparked a long-lasting debate for supremacy, with the two sides being the metallists[10] and the nominalists[11]. The first sustain that the prevalent feature is the "medium of exchange"; conversely the latter favours the other function. Delving into the debate, metallists point out that money was born when communities grew large and exchanges by means of barter had become infeasible. More in detail, some contended it was pointless to even

[7] "Standard of value" or "unit of account" are used interchangeably in the paper.
[8] See Cipolla (1957) where he reported that a payment of 20 *solidi* was settled with a horse.
[9] "The ECU was composed of a basket of currencies of the European Communities Member States and it served as the standard monetary unit of measurement of the market value/cost of goods, services, or assets in the European Communities, thus constituting the cornerstone of the European Monetary System (EMS)" (Eurostat 2016).
[10] The metallists' most righteous view can be summarised with money being "a standard of value that must have an intrinsic value of its own", while a less extreme theory supports that "if an object serves as a standard of value it must be valuable, but it need not to have intrinsic value" (Einzig 1966, p. 437).
[11] They believe that "money comes into existence only when it becomes money of account" (Einzig 1966, p. 356).

hypothesize a primary function for money different from the "medium of exchange"[12], others took a more extreme approach arguing that "there is only one fundamental function" of money[13], finally economists also formulated a more hybrid approach sustaining the metallists view, yet recognising how the need for a common denominator materialised soon after the barter was introduced[14].

It is hard to oppose the metallists thesis on an evolutionary basis; however, nominalists took a more ideological viewpoint focusing on the primordial need to compare wealth and prices rather than on the historical transition from barter-based to money-based economy. The rationale behind the "standard of value" theory is that when an object begun to be used as a medium of exchange, by its nature it was already serving the purpose of "unit of account". Indeed, payers and payees resorted to the said object whenever they needed to compare relative values. On the other side, the use of a standard of value did not imply the use of a medium of exchange[15] (Einzig 1966, p. 356). What can be concluded (and what intellectuals mostly agree upon) is that the two said functions of money are fundamental and, no matter which came first, they enjoy a supremacy over the rest.

Having defined the second feature of money, it is now time to deepen on its key advantages. According to Doepke and Schneider (2017, p. 3), the four characteristic elements of money as a "unit of account" are its feasibility to be used in contracts which are costly to break or renegotiate, the reduction of the relative price and balance sheet risk it implies, and finally the network of credit and borrowing for which a standard of account is needed. Concerning the first and the second reasons, the assumption of contracts which are costly to break means that, should a contract not be observed, debtors will incur in costly penalties; therefore, borrowers should be in favour of using the same unit of account for both their income and their debt. In fact, in principle many objects are suited to serve as units of account (e.g. gold ingots, cattle, etc...), but money is the simplest to

[12] Karl Theodore Helfferich, according to Einzig (1966, p. 346).
[13] Carl Menger, according to Einzig (1966, p. 347).
[14] James Laurence Laughlin, according to Einzig (1966). Laughlin sustained: "so natural is this operation of the human mind, that the evolution of the standard concept must have proceeded the concept of the medium of exchange".
[15] As pointed out earlier, in medieval age debts were expressed in currencies (*solidi* in the example provided) while it was later settled with a horse. See Cipolla *supra* note 5.

use. Moreover, by using the same money as unit of account, the borrower is hedged from the relative price risk; namely the risk that the relative value of its debts and incomes changes, resulting in an eventual default on its debts. As an example, in case a borrower receives an income expressed in gold ingots and should a new gold mine be found, the income would diminish only due to the increased availability of gold. This could consequently lead to a default due to the reduced value of its income.

Turning to the third and fourth elements, money serves perfectly the "standard of value" function due to the formation of credit chains (Doepke and Schneider 2017, p.4). Indeed, the system of payments evolved alongside human development, transaction numbers ballooned, and agents were both lenders and borrowers in different transactions; consequently, the need to express contracts in the same unit became preponderant and money, due to its ease of convertibility, was then adopted. Further, money became more suitable to be used in exchanges because it allowed to uniformly express relative values. More in detail, the introduction of money as a standard of value eased exchanges dramatically: agents did not have to keep in mind the relative values and conversion ratios between goods to understand whether they gained or lost value in a transaction[16], and money, working as a common denominator reduced the number of prices per transaction from two to one. This is the novelty of money as "unit of account": the "common denominator" feature. Regardless of the number of transactions involved, an agent can always easily compare the relative value of many goods and rapidly understand whether he gained or lost value, once the credit chain has terminated.

In modern times, a certain currency can lose purchasing power mainly due to inflation and, sometimes due to debasement. This phenomenon was common in the Middle Ages when governments unquestionably decided to debase currencies from time to time (Cipolla 1957, p.43). The key difference however lies in the fact that, despite not all forms and denominations of money circulate with the same speed[17], nowadays the inter-denomination relation is fixed. This was not the case in the Middle Ages where a florin was worth 240 pennies, then 250 and 255 at different periods (Cipolla 1957, p.44).

[16] Imagine that an agent initially exchanged 3 oxen for 5 horses and later exchanged those 5 horses for 4 oxen. This simple example already implies cumbersome calculations to compare the two relative prices. As human communities progressed, the picture worsened as exchanges proliferated.

[17] As an example, the 500 Euro banknote circulation is limited to some specific cases, and it is very uncommon to use it in retail transactions.

In modern times instead, regardless of the purchasing power of the currency in question, the system in place equates a 500 Euro denominated banknote to 500 coins worth 1 Euro. This is one manifestation of the so-called "ghost money". The problem started with the Carolingian reform of the monetary system which introduced the *libra* (pound) and it mandated that 240 pennies had to be struck from one coin implying an equivalence in terms of weight. Moreover, an old measure from the Roman system started to be used to express debts: the *solidus* (shelling). The system was then created with the following inter-denomination relationship:

1 POUND = 20 SHELLINGS = 240 PENNIES

However, the only real money in circulation was the penny and people began to express prices, debts and payments in terms of pounds or shillings to simplify calculations. Clearly, the system was very convoluted, and the conversion ratio surely did not help[18]: while agents of Medieval Europe circumnavigated the system resorting to the barter or employing foreign currencies to settle payments, the accounting problem was left unsolved, and cumbersome calculation were needed to record payments of hundreds or thousands of a penny (Cipolla 1957, p. 41).

Additionally, a typical phenomenon governments were accustomed to was to issue new currencies, thereby introducing new conversion ratios amongst the different denominations[19]; the lack of clarity in the specification of the inter-denomination relation led to the materialisation of the "ghost money". In fact, it occurred that the conversion ratio for the only real money, the penny, was initially 1:240, it later became 1:250 and was further debased when 1 pound could be exchanged for 255 pennies (Cipolla 1957, p. 44). Obviously, this caused uncertainty in the payment and accounting systems with a heightened burden on accountants. To conclude, what could be inferred from the monetary system of the Middle Ages is that for accounting purposes *non solum* different denominations are needed[20] *sed etiam* a fixed relationship among the difference denominations.

[18] A decimal system would have simplified calculations.
[19] In 1266, a gold coin was introduced in Medieval France under the reign of Louis IX, according to Cipolla (1957, p. 42).
[20] To allow payments of different magnitude to be completed.

II.1.3. Money as store of value

The third function money fulfils is that of "store of value"; however, a long list of objects kept as store of value, ranging from precious ornaments to warehouse elements such as wheat, can be compiled. Regardless of their sparking differences, a key feature they all possess when serving as store of value is the ability for the owner to "hold wealth exclusively, or at any rate primarily, for the purpose of preserving the value they represent" (Einzig 1966, p. 440). As previously stated, any definition of money is open to interpretation, and probably not fully explanatory; the borderline is blurred when attempting to discern one function from the other, but the one provided above seems a good starting point to isolate the "store of value" function. Indeed, it could be improperly inferred that every medium of exchange could serve also as a store of value, the moment payees accept it, because it can preserve its value until later exchanged; however, the definition above rules out this scenario because it expressly considers stores of value only those objects "held primarily for the purpose of preserving the value they represent". Moreover, the same applies to objects kept for future consumption[21]: they do not serve as store of value simply because they are stored.

Einzig (1966) identifies two main characteristics for an object to qualify as a "store of value": a stable value and stable physical properties. The latter, however, is not mandatory: the author reports that in primitive communities, cheese was used as store of value despite being perishable, and agents simply kept replacing it before it spoiled. Despite being in contrast with most of the capitalistic theories for being considered "unproductive capital"[22], in primordial communities keeping primitive money and objects as store of value led to tangible benefits: it allowed to accumulate and carry stocks beyond their immediate requirement, it constituted liquid reserves to use as buffers, and it allowed agents not to be forced to sell at inadequate prices (Einzig 1966, p. 443). On the other side, the tendency to overstocking negatively affected economic development two-fold:

[21] E.g. food.
[22] The critiques moved against objects held as store of values are treated later in the paper.

it first slowed economic growth because those objects remained out of the economic cycle, and it sparked inter-tribe conflicts.

A prominent intellectual who investigated the function of store of value, was Jean-Baptiste Say. The French economist deeply analysed the said aspect of money; he at the same time defined hoarded money as "unproductive capital", but also provided a rationale for keeping it in form of cash[23]. He firmly sustained that money represented a value to hold and that could be used not only for circulation purposes. He added that money was preferable than holding merchandise and justified it on a transactional level reporting that, should an agent need to convert an object from a pure store of value function to a medium of exchange, money was best placed given its liquid form (Numa 2020, p. 932).

In Say's opinion, the quantity of money holdings depended on the number of sales and purchases expected by an individual. Further, he provided three main reasons to hold money as store of value which can be summarised as follows: the precautionary motive, lack of investment opportunity and lack of information. Concerning the first rationale, he argued that investors had to consider the opportunity cost of keeping money idle, thereby losing interest. In this perspective, identifying the trade-off in terms of interest foregone between money demanded or invested, he was a precursor of the liquidity theory formulated by John Maynard Keynes in his masterpiece *The General Theory of Employment, Interest, and Money*[24]. Say defined "unproductive capital" any object that could be "kept without being used for consumption and without being used to create other products" (Say [1803] 2006, p. 208). In his opinion however, hoarding was temporary, and, under the assumption of rationality, he justified it as a way to avoid undesired losses in a risky environment. He further identified a positive relationship between hoarding for a precautionary motive and political and economic turmoil[25], recognising that this could

[23] Firstly, he presented how agents keep objects "incapable of satisfying a want" as stores of value (e.g. indigo, silver in the shape of crown pieces, etc...). Secondly, he sustained that also money could be used for the same purpose. Finally, he also stressed how money enjoyed a convertibility advantage with respect to other objects (Say 1826, p. 475).

[24] The precautionary motive was identified by the English economist as one of the causes for money demand (Davidson 1990, p .11).

[25] More specifically, hoarding is a consequence of the uncertainty caused by economic turmoil.

in turn slow economic growth due to the aforementioned "unproductive capital" (Say ([1803] 2006, pp. 267–68)[26].

For what concerns the second reason for keeping money, his justification was that rational agents shall wait until profitable opportunities materialised so that the expected profit was greater than the amount of cash hoarded. Obviously, this behaviour would not sustain the economic development of poor countries mainly for two reasons: it first reduces the quantity of available capital to employ in the production process and it implicitly sets a threshold below which rational agents would not invest. In brief, this conundrum resulted in a paradox, being investments necessary for the development of poor communities. Finally, deviating from the classical assumption of rationality and equal access to information, Say also hinted at lack of information as a cause for money demand pointing out that even when more remunerative alternatives are present, ill-informed investors will choose not to invest, leading to a boost in money demand (Numa 2020, p. 936).

Passing from the XIX to the XX Century, a major economist was John Maynard Keynes. As anticipated, Say's ideas are intertwined with Keynes', yet the British was able to theorise an economic scheme that revolutionised the history of economic thought: the so called "liquidity preference theory" where he stressed the importance of money as a store of value. Condensing his enlightening theory, he sustained that, when facing uncertainty, agents prefer to keep money as a store of value, thereby foregoing any gain from investment[27]. In his analysis of Keynes' liquidity theory, Modigliani (1944) reported that people can essentially keep money in two forms: cash and securities[28]. The former is a riskless, very liquid item which is assumed not to yield any interest, while the latter is riskier yet more rewarding.

[26] In short, he referred to the Ottoman Empire and recognised its influence and power could be enlarged, should its wealthy not have hoarded and hidden their treasuries.

[27] The interest rate is the opportunity cost of keeping money in form of cash rather than investing it or, in Modigliani's terms: "the ruling rate of interest measures the remuneration to be obtained by accepting the drawbacks and assuming the risks that are characteristic of securities as compared with money" (Modigliani 1945, p. 52).

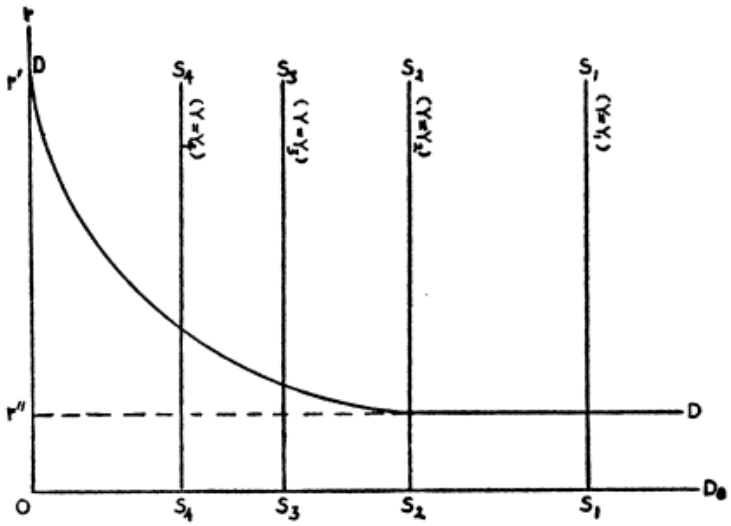
[28] The third form of money (physical assets) does not play a pivotal role (Modigliani 1944, pp. 49-50).

Now that the framework has been clarified, the mathematical aspects upon which the theory builds are the following: the demand for money as an asset as a decreasing function of interest rate[29]

$$D_a = D_a(r)$$

This function is downward sloping as it can be observed from the graph below. Two important features are to be noted: on one side, there will be a certain level of interest rate (r') for which agents will invest all their income in securities and, on the other side, a plateau level (r'') that will result in an infinite demand of money. This implies that when the interest rate offered reaches that level, agents will not react to any further decrease, and the classical monetary policy will be useless. This is the well-known "liquidity trap"[30].

Figure 1: The demand for money and the liquidity trap



Source: Modigliani, M. (1944) *Liquidity Preference and the Theory of Interest and Money*

[29] The lower the rate of interest, the larger the number of owners who prefer to hold money in forms of cash, given a small opportunity cost.

[30] A concept for which, any further decrease of the interest level will not result in an increase of the demand for money in form of cash.

II.1.4. Money as standard for deferred payment

The last function of money is that of standard of deferred payment, which refers to its use in long term contracts involving an exchange of goods or services in the future. As it could be inferred from the previous paragraphs, also this purpose is intertwined with the other three; namely, it is strongly connected to the functions of medium of exchange and standard of value. Concerning the first relationship, nowadays money is generally used both as medium of exchange and standard of deferred payment, but it was not always the case: Einzig (1966, p. 446) reports that rent used to be payable in terms of grains, or the cultivated land in terms of the agricultural produces. The rationale for having only one good serving two functions is to avoid conversions and have a clear understanding of the burden a debtor will undertake (or benefit a creditor will be entitled to); however, they could in principle be different. Money is well suited for the task as it enables both parties to know in advance the value of future settlements. It could be argued that inflation or deflation may alter or at least influence the settlement value in terms of purchasing power[31], nevertheless money enjoys an edge over competing goods in terms of convertibility as it can be readily used by the creditor and is at debtor's disposal. Consequently, not only it facilitates settlements, but it also reduces the transaction and price discovery costs, improving the efficiency of the payment system.

Comparing the standard of deferred payment and unit of account functions, Einzig (1966, p. 498) stresses that a heightened "confidence" is needed to perform the first, compared to the latter. Indeed, parties expect a standard of deferred payment to keep its value at least until the end of the contract, thereby expecting a long-term stability of the good. It is in the best interest of both payers and payees to know in advance the financial flows that will occur at settlement, and in principle, while a unit of account can rapidly change, the value of the payment usually is left unchanged (standard of deferred payment). In today's terms, a quick example could be any type of international payment which is settled in dollars: being considered the safest and more stable currency in

[31] Under an inflationary scenario, creditors will lose purchasing power, and the opposite occurs amid deflationary pressures. However, uncertainty could be mitigated indexing the payment to inflationary changes.

circulation, the American currency is well suited to serve as standard for deferred payments.

II.2. The evolution of money

The four functional forms described have highlighted the versatility of money. These helpful features were well known in the past and people tried to find proper ways to condense them in one or few objects, if not all, at least the three main ones: mean of exchange, unit of account and store of value. Then, the situation evolved and the search for novel solutions to serve those four purposes originated plenty of prototypes that were introduced in the market, reached their peak and then declined. After all, money is tightly bonded with human history and just like inventions are soon or later replaced by newer ones, money too has evolved throughout human history. Therefore, to investigate how money reshaped from everyday objects such as flour to digital numbers in mobile devices, an analysis of the most important types is necessary.

II.2.1. Barter

Due to globalization that has resulted in more interconnected economies, money is indispensable, in fact, also as a consequence of the new inventions that generally improve the payment system, it is basically impossible to switch back from a money economy to a barter economy. However, barter represented a viable way to sustain progress for a long time; and still today it has not been completely displaced in certain scenarios[32]. Einzig (1966, pp. 330-334) produced a comprehensive list of communities that were generally moneyless that used barter to conclude exchanges. Besides some extreme cases of primitive communities that either did not have a general sense of the value of goods and services or were not used to exchanges in a systematic way, some groups were not familiar with the concept of money, yet they still thrived. The pre-Colombian populations, as an example, used to share their produces amongst the tribe

[32] As an example, Arslanian (2023, p. 4) reports that countries like Zimbabwe, Venezuela, or Argentina which all experienced continuous episodes of inflation and hyperinflation, mainly due to bad government policies, have recently resorted to barter in such scenarios.

and thrived ignoring the concept of money[33]. Another peculiar example is represented by closed economies such as monasteries. Also in this case, they were self-sufficient, and everyone contributed actively to the welfare of the community. The two cited communities, despite the differences, share one fundamental characteristic: the authoritarianism. Indeed, both for the pre-Colombian communities and monasteries of the Middle Age, the life of every individual was planned from the beginning and there were few, if any, ways to climb the social ladder. In a modern capitalistic world, there would be no place for those type of social organizations as the equilibrium established inside the community would be quickly broken by some ambitious individuals.

Delving into the development of barter, it all started in primitive communities, but historical findings offer only a partial idea of the role that barter played in human development. In fact, the human history goes hand in hand with its progress and, extending the scope of applicability of barter to intra-tribe exchanges of goods, it could be stated that barter originated at the early stages of humanity. The uniqueness of it is the immediate use of the goods exchanged for consumption or industrial purposes[34] - not even money possesses this peculiarity - in fact, whenever money is transferred, it is not readily usable: another transaction is needed. This occurs because any object exchanged possesses an intrinsic value due to its physical properties; money does not, in principle, and any agent accepts money believing it will be usable in another transaction; whenever this chain of faith is broken, individuals realise how worthless a coin, banknote or digital numbers on a bank account are.

On the other side, barter carries some downsides too. The main one is the so-called "double coincidence of wants" (Arslanian 2023, p. 2) which implies that for barter to occur, the two parties must satisfy their needs at settlement. This double coincidence of wants is not a prerequisite for money exchanges, as the money received is suitable to satisfy numerous needs. An alternative idea was proposed by Angeles (2022, p. 19) where he harshly criticised the preponderant view that barter was the precursor of money until the latter stole the show for reasons of efficiency. He sustained that exchanges took place by means of mutual credit, while barter was residual. In his view, a creditor and a debtor

[33] Arslanian (2023, pp. 10-11) reports that they used gold and silver only for ornamental purposes.
[34] The term "industrial" meaning that any good obtained through barter can readily be used to produce a new good or service, irrespectively of the actual size and complexity of the production process.

resulted from each transaction, later recorded by the two parties[35]. However, the author stresses that those debts recorded were not proper money as one party could not use the credit from one transaction in a new one. In brief, this system was inefficient as it mandated a precise record of debts and credits that could not be used as media of exchanges. Barter entails another drawback too: inconsistency in the units of account which leads to a myriad of prices, once the goods exchanged increase. The rationale lies in the fundamental nature of barter with two prices stemming from each transaction[36]. The problem could be mitigated employing a preferred mean of barter in terms of which all the other goods are expressed, still barter remains less efficient than money for what concerns the unit of account and medium of exchange functions.

When examining barter, one could erroneously assume that it only consisted of two parties meeting in a physical place and bargaining until they reach an agreement; however this is not the full story and barter has evolved through time starting from a "silent" form, where parties agreed to leave the good they wanted to trade in a predetermined place and continued adding more units until an agreement was reached, to a newer form of barter where agents interacted verbally to strike a deal. Excluding the religious exchanges and gifts[37] from the definition of barter, Einzig (1966, pp. 338-339) reported that barter came to light when communities engaged in the division of labours. People (not necessarily in distinct tribes) started to specialise in the production of certain goods and experimented the famous concept of "economies of scale". They realised they could be better off through specialisation and subsequent transfer of surpluses, and the easiest way to do so was by means of barter. Needless to say, in primitive communities not accustomed to the specialisation of labour where all the produces were gathered and redistributed based on each family's need, barter was superfluous and therefore never

[35] The author proposes a simile with the modern banking system where, whenever an agent deposits money on a bank account, a new debt for the bank is originated and the depositor becomes creditor.

[36] Arslanian (2023, p. 2) reports: "For example, an economy with 1000 goods (in practice, a poor economy) would require 499500 different prices!".

[37] A well-known tradition is the "potlach" that was common amongst North American Indians. It consisted in a mixture of both private and public gatherings. The former involved initiation into tribal secret societies, while the latter consisted in cultural activities including public speaking, drama, and elaborate dances. The main purpose of these exchange ceremonies was to validate the social ranking of the leading participants as a person's prestige depended largely on his power to influence others through the impressive size of the gifts offered (Arslanian 2023, p. 3). Potlach does not constitute barter, for the purpose of the paper, as the main goal of the offeror was to impress and influence the elderly to earn a social status, rather than improving the economic condition.

implemented. Transfers in the aforementioned "silent barter" occurred in the following way: a party left its good to trade in a spot agreed with the counterparty who would have taken it – if interested – and would have deposited its offer. In case the first agent had accepted the offer, it would have taken it, and the deal would have been concluded; however, in case the offer had been considered insufficient, the second party would have needed to increase it until they reached an agreement (Arslanian 2023, p. 3). Clearly, this system implied long delays in the exchanges, still it was adopted as the standard to conduct inter-tribe exchanges. The pillar of this system is the deliberate intention to not interact with the other – possibly rival – tribe.

Many historians in the XIX Century reported examples of communities still engaging in barter transactions in their logbooks[38] of the expeditions in remote islands; quite frequently, they ironically criticised those tribes, thereby shedding a negative light on barter transactions. A well-known case is that of a French singer receiving cattle as a fee for her performance[39]: an inestimable gift for the local population, an unusual payment (in terms of carrying cost) for the performer. Equally, another striking example of a European scientist documenting the inefficiencies of barter is referred to Sir A.R. Wallace's trip to the Malay islands where he reported how hard bargaining was key in those moneyless territories, and it was not uncommon to skip dinner should negotiations turn unsuccessful (Arslanian 2023, pp. 3-4). The fallacy of these reports is the viewpoint taken by the author. In the first case, a European reader would concentrate on the ironic vicissitudes, rather than putting himself in the islanders' shoes. Those works received a lot of attention and influenced the predominant thinking on barter which was discarded rather than recognised for its importance in the human development.

Nowadays, barter is not in vogue anymore as most of the economies are dependent on money; however, there are some residual cases when individuals still resort back to this outdated yet functional mean of exchange. This occurs in specific scenarios when money circulation is impaired and/or individuals lose faith in the purchasing power of their currency. Einzig (1966, p. 346) cites the so-called "butter standard" during the 1920s hyperinflation period in Germany. To conclude, barter, despite its inefficiencies and time-

[38] An example is Jevons' book on *Money and the Mechanism of Exchange* in 1875.
[39] Einzig (1966, p. 342) treats the matter extensively.

consuming aspects, remains a viable way of exchange populations may go back to under scenarios of uncertainty.

II.2.2. Coins

Leaving the exchanges by means of barter aside, the first form of money that still exists today is represented by coins. In fact, especially for those following the monetarists' view, communities were practically moneyless until its introduction. Del Mar (1885, p. 40) reported: "money has always consisted, tangibly, of a number of pieces of some material, marked by public authority and named or understood in the laws or customs: that its palpable characteristic was its mark of authority; its essential characteristic, the possession of value, defined by law; and its function, the legal power to pay debts and taxes and the mechanical power to facilitate the exchange of other objects possessing value". Coins started to be massively used since their introduction as they were fit to serve alle the four functions previously listed, and they still circulate today. The definition provided already presents several key elements that coins typically present: a physical consistency, the mark of the issuing authority, the possession of value and fitness to be used as mean of exchange. For what concerns the physical consistency, metals were normally used to mint coins due to their ductility, malleability, and low carriage cost, but porcelain or clay coins were found too. Metals in fact keep their chemical composition and do not spoil compared to agricultural produces or any other mean of exchange and store of value used before.

Angeles (2022, p. 24) sustains that coins were primarily introduced to pay the soldiers' wages - it was much easier to count the number of coins, rather than weighing the quantities of precious metals. However, their uses broadened, and governments started to collect taxes in form of coins, with an implied substitution effect of other means of exchanges. Few decades after their introduction, agents realised that coins served not only the unit of account function; archaeological findings show it was not unusual to hoard coins, due to the physical reasons listed above which turned them into a preferred store of value. Their metallic nature gave rise to a double price or value attributed to each coin and required issuing authorities to ascertain that the value of the currency was higher than the intrinsic value of the metal; should this not have occurred, agents could have profited

by simply melting coins. Generally, governments kept the monetary value slightly above the intrinsic value[40]. Nonetheless, in times of urgent needs, governments resorted to debasement[41] to keep the monetary level afloat and disincentivise melting. If on one side this proved necessary, on the other it incentivised shady debasements with governments collecting taxes in the old currency and paying with lighter ones. In certain cases, they even went further by issuing worthless currencies made of base metal or leather[42] as it occurred in ancient Greece. Consequently, the philosopher Plato went on to formulate a radical theory in the *Laws* where he purported the use of metallic coins for external trades and of a worthless token (the *symbolon*) for internal uses (Angeles 2022, p. 26).

The oldest prototypes of coins were found in China and are dated at around the second millennium B.C. (Arslanian 2023, p. 12). However, as it often occurs with inventions, China was not able to fully exploit this novelty as its coins presented numerous drawbacks that limited the scope of application to small payments. Namely, they were made of base metal; therefore, they were easily counterfeited at a low cost. This in turn led agents to weight precious metals, instead of counting them, as coins did not contain gold, nor silver. Differently from any other currency, Chinese coins had a hole in the middle, supposedly to carry them using a rod, and never exhibited any face of the emperors. Being aware of the drawbacks listed, China solved the problem of currency circulation by specialising on paper money that was extensively used by its people.

Moving towards West, Lydians (a people located in the West part of modern Turkey) invented coinage in the VII Century B.C. This people was able to mint high quality coins and introduced many novelties that represented the *non plus ultra* for a quite a long time. Firstly, they used an alloy of gold and silver (electrum), in place of base metal, and impressed the king's symbol on any coin. The insignia was the "mark of authority" and guaranteed the coin was made of 75% of gold and 25 % of silver mix. By doing so, they certified their coins and made it harder for counterfeiters to mint false

[40] Angeles (2022, p. 24) reports the study conducted by the academic Christine A. Desan where the wedge was found to be 5-10% in England in the Middle Ages.
[41] It consists in minting coins of the same value with reduced quantity of metal.
[42] Angeles (2022, p.24) reports an early episode occurred during the final years of the Peloponnesian war (431–404 BC), when the Greek city-state of Athens issued an emergency coinage of bronze with a thin silver coating worth the same as the famous Athenian drachmas of pure silver. Surprisingly, the Athenian public accepted the coins, and the city was able to continue the war, not for long though.

coins. Another ingenious idea was to introduce coins of various weights which became useful for payments of different size: this boosted the payment system as common people were also granted access to this mean of payment and switched from barter or reciprocal debt creation[43] to the use of coins. Lydians also introduced seignorage[44] realising that the issuing authority could profit from the mint; in fact, the value of the coins produced outweighed the cost of production and they gained on the wedge. On a more technical level, their metallurgists were able to separate the electrum's components, thereby allowing the king to create standardised coins of pure gold or silver which drastically eased commerce as time-consuming weighting of coins became superfluous. Consequently, the volume of transactions ballooned, and permanent retail shops proliferated, due to reduced uncertainty in the means of payment.

A country that benefited from the Lydian invention was Greece. The Greeks exploited the Lydian coinage system but preferred to mint pure silver coins for strategical reasons: namely Athens was close to the silver mines of Laurion, its metallurgists were able to isolate silver from the lead ores and they had numerous slaves to employ in the silver extraction process, resulting in a lower cost of production. The Greeks used those silver coins mainly to finance the navy and develop a financial system. The circulation and availability of silver coins substituted barter and other means of payments (similarly to what happened in Lydia) and allowed wealthy individuals to take part in the political life of the city, regardless of their social origins. Coins however were not only used to serve the classical functions of money, but also as strong instruments of propaganda as they exhibit the mark of authority. Phillip II of Macedonia and his son Alexander the Great impressed their faces on the coins and utilised this tool for the first time.

For what concerns the greatest power of that period, Rome, the introduction of coins occurred long after its foundation in 753 B.C. Romans traded by means of cattle for quite a long time but, as it was the case for the Greeks, they introduced silver coins to fund their military campaigns; namely the Punic wars. The Roman system consisted of three main coins: the *denarius*, *sestertius* and *aureus*. The first was the initial coin, the second was the most used (especially to pay for the military expenses) and the third was

[43] Depending on the view of primitive means of exchanges followed.
[44] "The difference between the face value of the money and the cost to issue" (Arslanian 2023, p.14).

later introduced as a consequence of overspending. It could then be inferred that the financial statements of the Roman Empire would probably not have passed any audit inspection[45], and they heavily relied on wealthy lenders and on the resources of the conquered territories to avoid default. Arslanian (2023, p. 18) reports that Romans never stopped minting coins in the temple of Juno Moneta; consequently, their currency was subject to inflationary pressures and the kings and Emperors periodically debased the lower denomination currencies[46]. A smart investor of the period could have exploited these periodical rebalances by keeping the *aureus* rather than the other two currencies. More specifically, riskless profits could have been obtained simply due to the changes in the conversion ratios. The effects on the general population were catastrophic and, unsurprisingly, the wealthiest who were able to keep *aurei* grew even richer, while the remaining population lost its possessions due to frequent debasements. This resulted in a disparate and unequal society. Despite those events, the Roman monetary system held on until the III Century A.D., when a series of monetary crises struck down the overall payment infrastructure aggravating the precarious condition that eventually led to the collapse of the Roman Empire in 476 A.D.

Skipping the early Middle Ages when the West world economies set back and populations resorted to the means of barter, coins played a crucial role in the rise and fall of the Templars. They were formed in Jerusalem in 1120 (Arslanian 2023, p. 21) and were employed in the Crusades. It is well known that wars require financing to cover the numerous costs (e.g. arms, shipments, food, etc.) and this Order, which was initially employed to cure and assist soldiers, grew rich when it started to provide "financial" services. Templars were granted the power to mint their coins and they used this authority, in conjunction with their naval fleet, to set a florid business that connected the West world to the territories of the Crusades. They were able to leverage a Muslim financial innovation: the bill of exchange, not too dissimilar from the modern letter of credit, and shipped the required goods upon request, charging a commission. An example reported by Arslanian (2023, p. 21) was the shipment of 460 bezants to repay an initial debt in

[45] Arslanian (2023, p. 18) reports that the Empire had to frequently borrow from senators and wealthy individuals. More in detail, they were able to hoard money, given their apical hierarchical position, and finance the Empire.

[46] The *aureus* value compared to the other two sharply increased and, while in 307 A.D. one pound of gold was worth 100000 *denarii*, by 324 A.D. it was worth 300000 (Arslanian 2023, p.18)

Genoese pounds. Once they monopolized this business, they went on to become the King of France and Pope's financiers and were regarded as go-to bankers; however, their path to downfall was even steeper than their surge. Their riches made of coins, castles and ships were dismantled in the XIV Century when the Pope abolished the Order, but their intuition was remarkable and just as they disappeared, a new financial player entered the scene: the Italian bankers.

Right after the fall of the Templars, the cities of Genoa, Pisa, Florence and Venice became the financial centers of the last two centuries of the Middle Ages. Three of them were maritime Republics and exerted their dominion on the Mediterranean Sea for three Centuries. Venice especially, due to its tight relationship with the Arabic world, became a superpower and established profitable trade routes. However, a great contribution was given also by their banking system that sustained the merchants' activities. The source of success was again the bill of exchange mainly for three reasons: firstly, the Italian bankers utilised it to circumvent the usury regulation that forbade to charge interests on loans[47], secondly, they were able to considerably reduce the time required for shipments, and thirdly they hedged the patrimonial risk. More specifically, should a bill of exchange have been stolen, it could not have been claimed by the thief due to specific clauses embedded in the contract. Despite this system appeared seamless, history repeated itself, and when Italian bankers started to finance kings in the military campaigns, their hegemony came to an end[48]. After the collapse of the Italian bankers, coins retained a major role and were still the preferred mean of payment. The European colonization of South America boosted the coinage as most of the gold and silver to be employed in the production was taken from there; in fact, pre-Colombian civilizations used those precious metals only for ornaments, and the Europeans looted those people to enrich their countries. At the same time however, a new mean of payment gained momentum and gradually eroded the dominance of coins: paper money.

[47] Italian bankers were able to earn an interest for the loan provided by implying a favourable conversion ratio between the two currencies exchanged. By doing so, the interests earned were hidden in the contract and Italian bankers could not be held liable.

[48] Namely, they financed King Edward III in the Hundred years war, and he eventually defaulted on his debts.

II.2.3. Paper money

Analogously to what occurred for coins, it was China that introduced paper banknotes for the first time. During the XIII Century, China was under the dominion of the Mongolians which took power after Genghis Khan's conquests. Marco Polo, an Italian merchant and explorer, wrote that the reigning dynasty had started producing paper banknotes ("cards") already in the 1200s. He reported not only that payments in China were made by means of paper banknotes, but also that any foreigner entering China had to exchange his bullions or coins for those banknotes: the only accepted currencies in XIII Century China (Arslanian 2023, p. 26). The rationales behind the novel system are to be found in the scarcity of precious metals the Chinese had to cope with and the gradual expansion of their economy that needed a stable supply of currency to thrive. Moreover, the confiscation of all the available coins and metallic bullions and a frightening and extremely authoritative judicial system that resorted to the death penalty to contrast counterfeiters[49], contributed to the diffusion of the paper banknotes. Finally, in 1287 Genghis Khan's son, Kublai Khan, issued a paper note called the *zhiyuan chao*, which was the first note not nominally linked to silver or any other metal: again, another example of the declared intention to give birth to a new monetary system, detached from any precious metal. However, as it usually occurs to any unexplored invention, they were not aware of the risks stemming from an overproduction of banknotes: inflation. The Chinese market was flooded by those banknotes that quicky became worthless, thereby ending the Yuan dynasty and the experiment in 1350 (Arslanian 2023, p. 27). After a few decades, another dynasty tried to bring back to life the banknotes, but the attempt turned unsuccessful causing another inflationary crisis in China.

Before moving to the European history of banknotes, an overview of the nature of the paper currency and of the circulation process is necessary. Banknotes are "debts recorded on a piece of paper, issued by a bank, and payable not to a named individual but to the bearer of the note" (Angeles 2022, p. 52). The definition already points out the key characteristic of this type of currency: its paper nature[50], the debt component and its peculiarity to be paid to any agent in possession of it. In principle, adopting the central

[49] Arslanian (2023, p. 26) exhibited a 1287 banknote reporting that "(this note) can be circulated in various provinces without expiration dates. Counterfeiters would be put to death".
[50] Nowadays other materials are used (e.g. cotton fibres for Euros).

bank's perspective, banknotes are not too dissimilar from a deposit. They both are liabilities for a bank that entitle the creditor to be paid back upon request; however, it is common practice to have one issuing authority per state[51], while retail deposits cannot be held at the central bank but rather at any commercial bank.

The classical banking business is based on deposit collection and loan issuance. Banks engage in maturity and liquidity transformation converting money received in the form of cash, setting a deposit (a very liquid instrument immediately callable by the owner upon request) and lending to individuals and firms (in the form of loans and mortgages). The system works until banks' creditors (depositors) trust the bank, thereby leaving their sums in the form of bank deposits; however, should a bank run occur, not even the solidest bank could survive and would not be able to pay its depositors in full. In fact, the loan origination process is intertwined with the deposit creation and the safety buffer to keep as bank reserves (in the form of precious metals, domestic and foreign currency, etc...). Nevertheless, bank runs occurred and still occur in the modern world, despite being more infrequent. The problem was well known also in previous historical periods and Angeles (2022, p. 50) reports a passage from a XVI Century Senator of Venice that signals how banks collapses can occur due to numerous causes, implying that the equilibrium is narrow, and irrationality is detrimental to any bank:

"A suspicion born, a voice heard, that there is no cash or that the banker has suffered some loss, a person seen at that time withdrawing money, is enough to incite everyone to take his money and the bank, unable to meet the demand, is condemned to fail. The failure of a debtor, a disaster in some venture, the fear of war is enough to destroy this enterprise, because all creditors, fearing the loss of their money, will want to insure themselves by withdrawing it and will bring about its complete destruction. It is too difficult, indeed impossible that in the space of a few years one of these events fail to occur that bring about the ruin of the bank".

Already in the late Middle Ages, economists started to investigate how to prevent banks defaults and realised that a preponderant problem was to meet the depositors

[51] The United Kingdom attributed the monopoly of the issuance of banknotes to its central bank in 1844, more than a hundred years after the introduction of banknotes (Arslanian 2023, p. 30), while the Swedish central bank in 1904. To deepen on the reasons leading to a single banknotes issuer, please see Söderberg (2018).

demand in short time. Economies were expanding and the supply of coins did not meet the demand; therefore, in conjunction to the creation of the public bank, they decided to introduce a new form of currency: the banknote. The early public banks were created at the beginning of the XV Century and their scope was to maintain the functioning of the payment system, as they realised how a bank collapse was able to disrupt the credit system expanding to the whole economy. These special banks did not engage in the classical banking business and their *raison d'etre* was to hold deposits. They were very safe, and profited from the provision of other services for which they enjoyed monopoly powers[52]. Some of them were even prohibited to issue loans (e.g the Venice's Banco di Rialto), but the norm was to lend only to safe and established institutions: the biggest being the State. The experiment of the public bank was successful, and they proliferated all over Europe.

Deepening on the most known and innovative public banks, the Wisselbank of Amsterdam must be mentioned. It was founded in 1609 and offered clearinghouse services for merchants, a vital need at that time as maritime commerce was flourishing and currencies differ greatly from one another. The bank was overseen by the municipality of Amsterdam, and it bonded itself to return deposits whole and not in a debased manner (Arslanian 2022, p. 29). This peculiarity was innovative and encouraged depositors not to withdraw their sums for a long period, thereby ensuring a great solidity for the bank. The most innovative however was the Bank of England. Founded in 1694 by two entrepreneurs, it was chartered by King William and his wife, Queen Mary[53], who were in desperate need of money to finance the military campaigns. The novelty was to combine the provision of loans to the Crown with the issuance of banknotes, given that the two services had not been previously integrated[54].

The main business was the provision of loans to the English Crown through the issuance of banknotes that the government spent to finance its war efforts; but it also received deposits from the public enlarged. The turning point occurred when the Crown allowed the citizens to pay their taxes in the form of banknotes. By doing so, banknotes were implicitly granted legal tender and became valuable to pay taxes. This innovation

[52] The term public is misleading as they were privately owned, generated profits for their shareholders and were not legally bonded to the state, at least in the first place.
[53] The two were the original shareholders.
[54] Banknotes were already circulating since the middle of the XVII Century, but no other bank took the role as the "government's bank" (Angeles 2022, p. 53).

hinged on the prestige of the State and was the solution to the problem presented above: the imbalance between supply and demand. In fact, conversely from metal, paper was not so rare, and the supply of paper banknotes is in principle infinite. In the XVIII Century, the Bank of England was not the only issuer, yet surely the most trusted: paper banknotes of other private banks were still used in commerce but only at a local level. Starting from1844, the Crown gradually prohibited the issuance of banknotes other than the Bank of England's: the modern central bank was created. The British innovation caught on in Europe and, by the end of the XIX Century, major countries[55] had instituted their central banks on the British model.

On the other side of the Atlantic, paper banknotes were introduced not long after the British innovation, but a mix of bans, overprint (and consequent inflation) and counterfeit limited their use and negatively conditioned the predominant thought on paper money. Namely, they were first stamped in 1690 in Massachusetts, circulated freely for half a century when the Crown outlawed them in 1751. Despite the prohibition, the Congress printed money to finance the American revolution, but was not able to control its supply, create a solid banking system nor contrast counterfeiters, and agents soon lost faith in the Continental[56].

By the late nineteenth Century, banknotes had become the most used form of legal currency, practically constraining coins to small transactions; however, a limit on its issuance was still in place: the convertibility with gold. The Gold Standard doctrine permeated the banking sector and paper money was in principle convertible in gold upon request. As mentioned before, gold and precious metals are scarce, and the idea of non-convertible banknotes got a foothold. Moreover, economies already had experimented this kind of paper money at time of wars when governments sharply increased the supply, regardless of the bank reserves of its central bank. The final push towards non-convertible banknotes was given by the Great Depression as central banks increased the production to contrast the deflationary pressures. A revised form of gold standard was revived after World War Two with the currencies adhering to the Bretton Woods system being

[55] Namely, Bank of Spain (1856), the Reichsbank in Germany (1876), the Bank of Japan (1882), the Bank of Italy (1893), the Swiss National Bank (1907) and the Federal Reserve (1913), according to (Angeles 2022, p. 55).

[56] The name of the paper banknote printed at that time (Arslanian 2023, p.31).

convertible to the dollar, that remained convertible to gold. However, the system lasted for a few years and was dismissed in 1971. With the fall of the Bretton Woods system, currency had become the aforementioned token idealized by Plato in the *Laws* as agents exchange central bank debts (coins and banknotes) without being entitled to the conversion with precious metal[57].

II.2.4. Credit cards

The types of money analysed so far, are both issued by central banks in the present times; however, the payment system also includes forms of commercial bank money that permit agents to execute transactions[58]. One of the most revolutionary is the credit card, introduced in the United States of America in the second half of the XX Century: the first to exploit the great novelty of the past Century, which is the internet. Modern credit cards are very different from the initial models as issuers and fin tech companies introduced physical features to improve users experience[59] and ensure safety, as well as fidelity programs to incentivize customers to adopt them. In general terms, a credit card is an unsecured loan that does not require a collateral; therefore, it is a risky instrument, from an issuer's perspective, as it is subject to a risk of default and does not permit the bank to seize any possession of the debtor, should he fail to repay the debt. Due to their risky nature, interests paid are high and are inversely related with the credit score[60] of the credit card owner: the higher the score, the lower the interest rate as the perceived risk is lower. A common characteristic is the revolving credit feature that consists in a line of credit

[57] The token nature of current banknotes can be illustrated with a quick example that highlights the main steps of the circulation process. Once a banknote is issued by the central bank, agents (individuals and banks) start to use it to make payments; anyone accepts it due to its legal tender nature, meaning that a creditor cannot refuse it for the payment of debts (Angeles 2022, p. 57). Should an agent decide to give it back to the central bank it will receive a new banknote (a new central bank debt). Obviously, this last transaction is pointless, therefore once agents deposit currency at their banks (only banks are allowed to have deposits at the central banks, individuals can deposit at their commercial bank), their account balance will surge.

[58] Both types of money currently circulate and allow payers and payees to transact. The main differences are the legal tender status and the riskless feature of central bank money with respect to commercial bank money. For an in-depth analysis of these two types of money, please see *The role of central bank money in payment systems* (BIS 2003).

[59] The dimension and materials of credit cards changed radically in response to consumer needs.

[60] In the United States, "the FICO score was introduced by the Fair Isaac Corporation in 1989 as a tool to help assess whether card applicants were creditworthy" (Bennett 2023).

extended to the owner for repeated transactions; more specifically, the available credit changes once debs are repaid.

The said features are common to any credit card, but none of them were initially present. The idea of extension of credit to *habitué* led to the antecedents of credit cards: in 1885, chains of hotels and department stores gave paper cards to their most loyal customers to use in one specific location, generally. Then it was Western Union that introduced the "metal money" right before the First World War, in 1914. This time, it consisted in a signed metallic plate that allowed the few owners to defer payment to a later date. It was a breakthrough innovation and was followed suit by oil companies ten years later. Thirdly, the Charga-Plate more akin to a military plate rather than a modern credit card. It was made of metal too and it could fit in a wallet and reported the name of the owner on the back. This innovation eased the checking process of salesclerks as the required information were summarized there. Charga-Plate was very popular amongst large merchants in their stores between 1930-1950s[61]. Another milestone in the credit card history is represented by the Diners Club[62], introduced in 1949, according to Wolters (2000, p. 321). It was the first device to be extended to a broader area being widely accepted by many American retailers in the major cities. However, it was not a proper credit card, rather a charge card requiring owners to repay their debt in full at the end of each month[63]. The main difference lays in the interest payments; in fact, this type of card was usually issued to high credit-worthy individuals and did not establish any interest repayment nor limit, as the owner needed to extinguish its debt each month.

Then was the turn of the major players still operating today: American Express entered the business in 1958, according to Mandell (1990, p. xiv), and was later followed

[61] According to Wolters (2000, p. 321), those "charga-plates" were widespread amongst several department stores in New York City and were a sort of extensive cooperative credit plan. Although similar to modern credit cards, as they introduced the "revolving credit account" feature enabling customers to continue making charges as long as they met the minimum required monthly payment, their purpose was different. Indeed, retailers participated in cooperative card agreements primarily to aid sales and increase customer loyalty, rather than acting as profit-making enterprises.

[62] According to Simmons (1995, p. 25) that contributed to the issuance of the card, his partner MacNamara had an ingenious idea to offer businessmen the opportunity to pay their business entertainments (mainly restaurants) with one monthly check, without the need to carry a lot of cash.

[63] Moreover, at the beginning they levied a 7 per cent fee on their customers while the card was offered for free. After substantial losses in the first year, however they started to also charge an annual fee for the privilege of owning a Diners Club (Wolters 2000, pp. 321-322).

by Bank of America. According to Wolters (2000, p. 333), in 1959 the California-based bank introduced its BankAmericard in the Sacramento, Los Angeles and San Francisco metropolitan areas. Analogously to the Diners Club, the bank struggled at the beginning with delinquent accounts running higher than expected; however, after some adjustments such as the introduction of an anti-fraud department and the reduction of the fees applied to merchants, the card spread, its volumes increased and it turned out to be a very profitable business (Wolters 2000, p. 334). To grow nationally, Bank of America licensed its card to be used by other credit institutions and joined a consortium of banks, later renamed Visa. The 1960s saw a struggle for supremacy amongst many competing banks that was resolved in 1966 when Bank of America decided to licence its card across the USA: the first bank to do so. The East coast responded with the creation of another credit card programme, the Interbank Card Association, later renamed Master Charge and known today as MasterCard. During the 1970s, the two companies competed head to head and the number of banks issuing both credit cards increased sharply[64]. In the travel and expense card industry instead American Express took the lead as it quickly overtook Diners Club (Mandell 1990, p. xvi). Contemporaneously, IBM introduced the magnetic stripe, thereby speeding the transaction process. Finally, the 1980s was the golden age for the credit card business as banks' profits soared also due to the hawkish monetary policy by central bankers that resulted in higher fees. Moreover, many features still in place today were introduced such as fidelity programs in the form of sign-up bonuses, cash backs, etc...

This form of payment is still widely used today, due to its versatility and ease of use; at the same time, it embeds certain risks that need to be carefully considered. The first to mention is the risk of default that occurs when a card owner fails to repay its debt. There are safeguards and incentives (such as the said FICO score or renegotiation of the debts) to prevent, or at least reduce, the phenomenon; anyway, issuing banks need to be prepared to suffer losses from credit cards defaults. The interest received is a compensation mechanism for the risk borne, but they need to properly manage the trade-off between higher market share and safer credit card business. A striking example is

[64] According to Mandell (1990, p. xvi), they went from 4461 to 12504 for MasterCard and from 3751 to 12518 for Visa.

represented by the recent record $1 trillion of credit card debt[65] in the US that, despite the safeguards and consumer protection regulations, still looms over the industry.

II.2.5. Digital forms of money

The last subsection of this first chapter is dedicated to the new kinds of private money or "wannabe" money that have developed in the last twenty-thirty years. Telecommunications and the internet have speeded the transmission processes, and the rate of introduction sparked originating digital forms of money that largely differ from credit cards, banks cheques or other outdated means of payments. Innovations went hand in hand with consumers' needs as they started asking for faster, more efficient, disintermediated and secure means of payments. The types of innovations that will be analysed are e-moneys, cryptocurrencies and stablecoins.

II.2.5.1. E-moneys

The paper by Dodgson *et al.* (2015, p. 325) regards e-money "any means of payment that has cash equivalence but is stored in a purely digital form"; however, as it happened for money, laying down a punctual, detailed classification would be pointless as new methods of payments frequently enter the scene and it would be hard to keep up with new inventions. The rationales behind the introduction of e-moneys are an easier access to finance, disintermediation and cost reduction for individuals, and revenue growth and diversification for established organizations. In fact, telecommunications have the power to "democratize" finance granting access to money to developing countries too. Before investigating the most common types of e-money, it is worth citing the ECB definition that, differently from the one previously provided, highlights the hardware part of digital payments. In the ECB website, e-moneys are defined as: "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. The device acts as a prepaid

[65] According to Bennett (2023), the US credit card debt reached $1 trillion in the second quarter of 2023, after a sudden drop due to Covid.

bearer instrument which does not necessarily involve bank accounts in transactions" (ECB 2024a). Moreover, the European Parliament and Council Directive No 110/2009 of 16 September 2009 defines it as: "electronically, including magnetically, stored monetary value as represented by a claim on the issuer which is issued on receipt of funds for the purpose of making payment transactions, and which is accepted by a natural or legal person other than the electronic money issue". Reporting these definitions is crucial because they help to discern which services are to be considered in the classification and those to be excluded: in the reader's perspective, they serve a clarification function in the convoluted digital money world, in the issuers', a classification function as they draw the line between regulation and lawlessness, supervised areas and grey areas.

E-moneys emerged in the 1990s, they are now issued both by banks and authorised e-money institutes and are accepted as means of payments. They initially consisted of bank debit cards with a top-up feature, while today they mainly include payment methods such as Paypal or Amazon pay. Since their introduction, their use spiked and the number of EU transactions peaked at 8.4 billion in 2022, according to de Best (2023). For what concerns their implementation, e-moneys are issued with a 1:1 ratio with commercial bank money, thus their overall supply is limited. Issuers have two possibilities: they could keep the amount issued in liquid form (e.g. in prepaid cards) or purchase an insurance for the same amount. The following measures are needed to meet the 100 % coverage requirement that renders e-money fully covered currency.

The most known example of e-money is M-Pesa (meaning "mobile cash") that was set up in Kenya in 2007, and later extended to other countries. Many M-Pesa agents, mostly small retailers, usually convert cash received by their customers in the accounting units of their mobile phone. Those telecoms then keep the money in a bank account (in return for a fee paid by the user) and offer P2P services in real time. Regardless of the fees awarded, agents still prefer the M-Pesa to a costlier bank account. Taking a closer look, the said type of e-money serves the main functions of money being used as a medium of exchange, store of value and unit of account. Moreover, while customers increasingly opt to convert currency into M-Pesa, the same cannot be said for M-Pesa into coins or banknotes; according to Huber (2023, p.23) this hints at a change in the payment and storage habits. The reasons are to be found in the lower cost and higher safety offered by this type of money as the e-currency is a viable hedge against the risk

of stealth, being at the same time widely accepted by the public, analogously to coins and banknotes. M-Pesa is a good example of the said democratization of finance as mobile devices (phones, smartwatches, etc...) are much more diffused than banking services, especially in those developing countries where the percentage of banked people oscillates between 15 to 70 per cent, as reported by Huber (2023, p. 23). At the same time, the diffusion of these types of e-moneys necessitates proper regulation and cybersecurity; indeed, there are many examples of scams and data breaches that could undermine the overall trust of the payment system.

II.2.5.2. Cryptocurrencies

The second type of "digital money" requires a much deeper investigation due to its breakthrough technology and wide diffusion. For the purpose of the paper, an overview of Bitcoin, the first cryptocurrency to be introduced, will be presented, without delving into the peculiar types of cryptocurrencies and digital assets enlarged, that would require a dedicated chapter, if not an entire book[66].

Bitcoin is a form of decentralized cryptocurrency, which are defined by the Merriam-Webster dictionary as "any form of currency that only exists digitally, that usually has no central issuing or regulating authority but instead uses a decentralized system to record transactions and manage the issuance of new units, and that relies on cryptography to prevent counterfeiting and fraudulent transactions". Also in this case, the definition helps to pinpoint the key aspects of this cryptoasset which only exists in the digital world, despite being convertible into more classical forms of money. Cryptoassets are commonly, but not always, issued by a decentralised authority[67], differently from the usual forms of central bank (paper, banknotes and reserves) and commercial bank moneys (e.g. deposits or cheques, etc...). Bitcoin, a subcategory, also lacks a central regulatory authority and a central storage system, with all the participants playing a bookkeeping role. Finally, one of the pillars of this form of cryptoassets is the cryptography that hinges

[66] If interested in cryptocurrencies, please read Arslanian, H. (2023) *The book of Crypto*.

[67] Most of the cryptocurrencies are decentralised (e.g. Bitcoin, Ethereum, etc...) while others are considered centralised as they either are issued by a central authority or are not peer to peer distributed or limit the access to certain specific users (e.g. the EOS token).

on a double-key system that proved very useful and innovative. There is some debate over the possibility to embed Bitcoin under the umbrella of money, but the right terminology shall be carefully picked; what can be stated with certainty is that it is not legal tender (exception made for El Salvador that passed a bill to grant Bitcoin the legal tender status) and therefore agents are not obliged to accept payments in the said form. At the same time, Bitcoin attempts to serve certain functions of money under specific scenarios. Indeed, it is used as a mean of payment[68], it even serves as unit of account in smart contracts[69], thereby serving also as a standard of deferred payment[70], and, under certain circumstances, it can be used as a store of value under specific scenarios[71]. Nevertheless, the intrinsic volatility of the cryptocurrency rules out the classification as a form of money.

The history of Bitcoin starts in 2008, two months after the bankruptcy of Lehman Brothers, that caused many to lose faith in the traditional banking and financial system. Satoshi Nakamoto, whose identity is still unknown, wrote the Bitcoin Whitepaper to list the main characteristics: a "peer-to-peer version of electronic cash" with "online payments to be sent directly from one party to another without going through a financial institution" and "digital signatures" (Nakamoto 2008, p. 1) to ensure safety and hedge the double spend risk. Satoshi Nakamoto recognised the main downside with online currencies to be the double-spend problem, whose solution before the introduction of Bitcoin had been found in a third-party authority that validates the transaction (a financial intermediary). However, there is no room for an intermediary in Nakamoto's innovation, and the drastic break with conventional forms of money is blatant.

The said problem arises in digital payments as there is not a physical transfer of money (in paper or coins or any other mean of payment for which the amount exchanged can be checked by the parties) but rather an increase or decrease in the balance. In principle, without an intermediary it would be impossible to impede the payer to send the

[68] The first payment consisted of two pizzas for 10000 Bitcoins, in 2010, according to Arslanian (2023, p. 58), but Bitcoin's acceptance rate is booming as physical and online retailers are gradually introducing this form of payment.

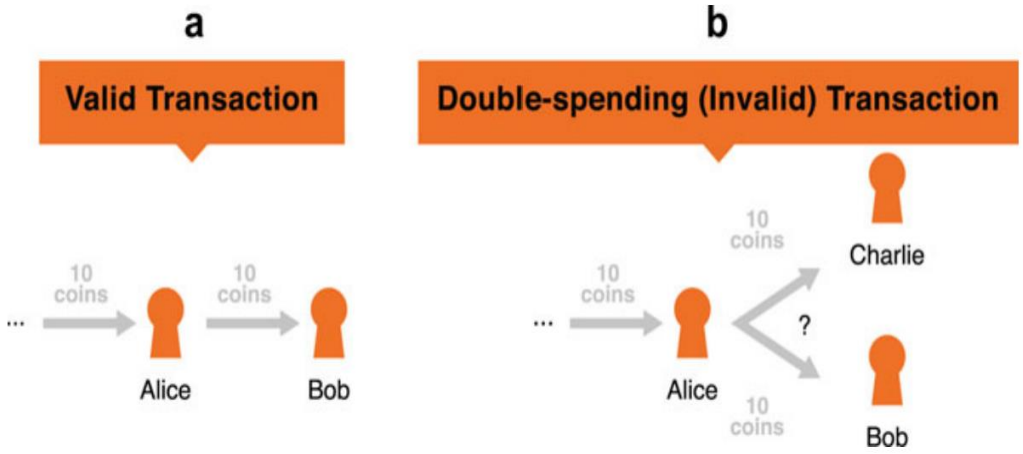
[69] They are "self-executing contracts with the terms of agreement written directly in the line of code". However, according to Arslanian (2023, p. 121), Ethereum is more suitable for the purpose due to some specificities.

[70] A constituting feature for those sustaining the quadruple nature of money.

[71] As an example, at times of uncertainty where people lose faith in conventional monetary authorities.

same token to two distinct people, as it occurs with forwarded e-mails. However, whilst different copies of the same e-mail would not cause any trouble, the same does not hold for currencies as patrimonial risks could limit the diffusion of a form of money. The graph below represents the double spending scenario presenting two transactions with a different outcome.

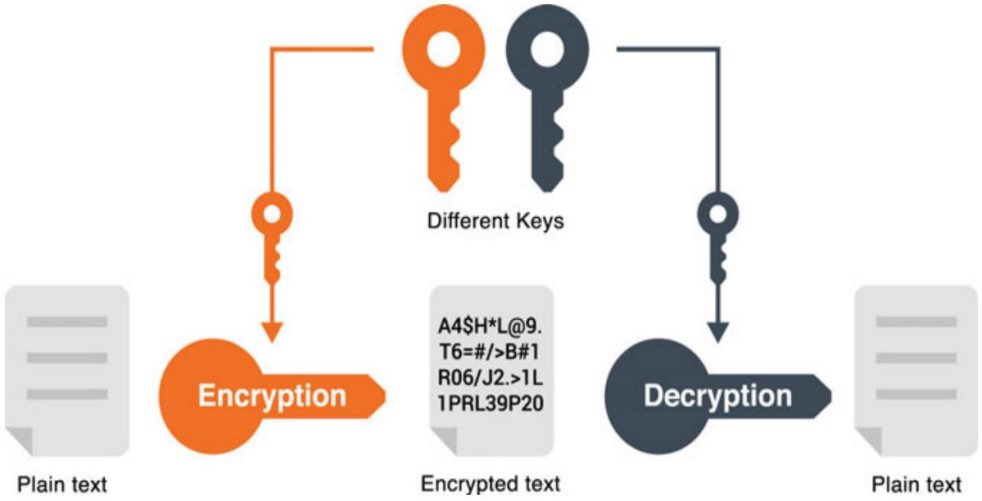
Figure 2: The double spending problem



Source: Arslanian, H. (2023) *The Book of Crypto*

The solution individuated was to use a double key (one public and one private) for each transaction, exploiting the asymmetric cryptography. It is a system that hinges on a public key available to other participants and a private key that is not. Should the message or transaction be intercepted, nobody would be able to decrypt it only using the public key. As reported by Arslanian (2023, p. 47), Bitcoin uses a secure system called ECDSA (Elliptic Curve Digital Signature Algorithm) that allows users to originate a public key from their private one, yet still preventing anyone to steal the private, knowing a public key. Also in this case, the graph provided below offers a clearer picture of this asymmetric cryptography system.

Figure 3: the asymmetric key cryptography



Source: Arslanian, H. (2023) *The Book of Crypto*

More in detail, Nakamoto (2008, p. 2) defined an electronic coin as a chain of "digital signatures", with agents using their private keys to sign the hash[72] of the transaction, not the transaction itself. Hashes allow to transform information of different lengths into fixed size strings, thereby enabling users to demonstrate ownership of the coin through small signatures, regardless of the size of the underlying data. A quick and efficient way that does not rely on any third-party validator.

The proof of ownership is key, but still payees cannot verify whether a coin was double spent. Here comes the innovation of Bitcoin which hinges on the sensitivity of hashes to generate a completely different code even for minor changes. The Bitcoin network functions through blocks and, rather than vesting one user (individual agent or company) with the role of main bookkeper (that would have resulted in a centralised system), any node was assigned this power. In layman's terms, any user can see the transaction and they all need to agree for the transaction to be completed and a new block to be added to the chain. To those arguing that an agent could then change the previous block and then double-spend the coin, doing so would not suffice because any block contains the information of the preceding blocks; therefore, the whole sequence would

[72] A hash is an algorithm that cryptographs any message into a fixed length code, according to Arslanian (2023, p. 50). It is a valuable security feature as any small change in the message causes a completely different hash.

have to be modified. Needless to say, any modification would require the approval of the whole network: a quite hard task. The said peculiarity of hashes comes handy as they allow to store extensive information (the record of previous transactions) in a fixed size string.

Finally, once ownership can be verified and the double spending risk is hedged, the last pillar of the Bitcoin infrastructure is the proof of work. In fact, despite the system being already suitable to grant ownership and avoid frauds in already existing blocks, the creation of new Bitcoins has not been addressed yet. And now the proof of work enters the scene. It involves the creation of a new Bitcoin as a compensation for the "miner" (the user who has found the golden hash to extend the chain) and consists of "scanning for a value that, when hashed, it begins with a number of zero bits", according to Nakamoto (2008, p. 3). As summarised by Arslanian (2023, p. 55) any miner must find the right combination of hashes, and nonces[73], to mine a new coin. As transaction numbers increase, it becomes more difficult to mine a new coin, as hashes will store more information, golden hashes must be compatible with them, and a higher computing power is needed. To conclude the technical description of the Bitcoin process, Nakamoto' summary of the necessary steps clarifies the whole picture. In the whitepaper, it is reported that once a transaction enters the network, it is broadcasted to all nodes, then each of them collects it in a block and tries to find a proof of work for its block (Nakamoto 2008, p. 3). When a proof of work is found, a node broadcasts it to the whole network that accepts it only if valid and if the coin has not already been spent. Finally, once the checks on ownership and double spending have been executed, a new block is created and the process repeats.

Besides the technical aspects that have been presented, still an important question needs to be addressed which is: "why users got interested in this new form of money?". Regardless of the initial time when only technology enthusiasts and libertarian cyber users demanded Bitcoin, it grew popular also due to its ability to grant quick, safe and cost-effective money transfers: an edge over the available means of exchange. According to Tambe and Jain (2024), Bitcoin transactions are settled in a matter of minutes, regardless of the two parties' location, while common bank transfers require days for international

[73] In cryptography a nonce is a number.

transfers. Moreover, costs are lower too as there is no need for a third-party verification. Lastly, it is easy to access as a smartphone is sufficient to send or receive money. At the same time, Bitcoin also embeds risks that need to be considered when deciding to join the network. Firstly, the private key is fundamental and cannot be recovered if a user loses it, thereby resulting in a patrimonial loss due to the impossibility to access the Bitcoin wallet. Secondly, the risks of annulment and double spend which can occur if the majority of the network colludes and takes control of the mining hash rate, thereby approving a fraudulent behaviour. Thirdly, the no refund or cancellation policy in case of human error. This last drawback occurs due to the core nature of the blockchain technology that would require the whole network to change the hash to grant the refund. The most common solution in such cases is a reverse transaction of the same size, that requires the approval of both parties.

Turning to the twisting points in the development of this 16-year-old cryptocurrency, as previously stated it was introduced in 2008, and the first real world transaction was the purchase of two pizzas in 2010. The first boom occurred in 2013, when the price rose above $ 1000, then Bitcoin started a downward path until it reached the $ 200 value to be attributed to both a physiological fall that usually follows a record and some technical problems occurred due to a hack of a crypto exchange[74]. The new record was set in December 2017 when Bitcoin was trading at $ 20000. In 2018, during the so called "crypto winter", Bitcoin dropped drastically, but it also witnessed the entrance of investment firms into the system with the American Fidelity introducing Fidelity Digital Asset Services to provide crypto custody and execution, and the Japanese Nomura offering custody services to its institutional clients. Once the gate was opened, other players started to populate the market such as JP Morgan introducing its digital coin: JPM coin. Another rally in Bitcoin value occurred in 2020; this time, it enjoyed a positive externality, differently from 2017. The Covid pandemic diffused, and central banks engaged in quantitative easing; this resulted in an unprecedented demand of Bitcoins as store of value. Also, hedge funds decided to get exposure to it and future contracts on Bitcoin spiked in value, as reported by Arslanian (2023, p. 68). Bitcoin's fame grew also in 2021 for mainly three reasons: for what concerns its conversion with the dollar, it

[74] The Mt. Gox scandal, according to Arslanian (2023, p. 61).

almost reached $ 65000 in November, as reported by Yahoo Finance. On the institutional side, El Salvador was the first to introduce it as legal tender, and the first Bitcoin ETF was launched in the U.S. To conclude, 2022 and 2023 saw a U-shaped path in terms of price and were characterised by the thunderous conviction of the owner of FTX, a crypto exchange.

II.2.5.3. Stablecoins

Having analysed e-moneys and cryptocurrencies, it is now the turn of stablecoins. They are issued by means of an ICO (initial coin offer)[75] in exchange for a cryptocurrency like Bitcoin or a classical currency as the Dollar, according to Huber (2023, p. 24). They are a special form of cryptocurrencies but, as the name suggests, their intent is to maintain a relatively stable value over time, analogously to most of the currencies. The idea behind stablecoins is to maintain a fixed peg with the underlying currency, but that does not mean having a constant value. In fact, being a currency backed fully or partly by its reference asset, it maintains a 1:1 peg with it but, should the underlying be a volatile (crypto)currency, then its value in terms of a stable currency would fluctuate. What differentiates stablecoins from Bitcoins or similar cryptos is the promise to redeem any token upon request at parity with the reference asset. An improper yet clarifying analogy would be paper banknotes that were initially convertible in gold upon request. This feature renders stablecoins useful for international exchanges, as a substitute for Bitcoin, or to transfer wealth from one crypto asset to another without leaving the crypto environment. At the same time, this 1:1 peg, especially when the reference asset is a classical currency, limits its use and exposes stablecoins to many critiques on the effective benefits they entail: simply looking at this feature, they do not differ much from e-moneys.

Stablecoins entered the scene in 2019 when Facebook announced the launch of its Libra. Initially it was pegged to the Dollar and a basket of currencies such as the Euro, Pound and Yen. The project shocked the world and, being a supra national non-monetary (yet influential) authority, it received a fierce opposition, as it could have been relied upon

[75] The digital version of an IPO (initial public offering).

as a currency index, thereby substituting the existing ones. The initial prototype of Libra was too ambitious, and, despite its power, Mark Zuckerberg had to desist. Many central bankers were worried about the future of their currencies, and the inventor of Facebook had to reshape its stablecoin creating different types of crypto assets for each currency (e.g. Libra USD, Libra EUR...). Also, the backing of Libra stablecoins changed as it switched to cash or cash equivalents, as well as short-term government securities denominated in that currency: a flight towards liquidity. Still, policymakers remained unhappy with the modifications presented, and Zuckerberg, after a late tentative to rebrand its stablecoin into Diem, had to abort the project. Despite being unsuccessful however, the introduction acted as a catalyst for the development of CBDCs, among which the Digital Euro.

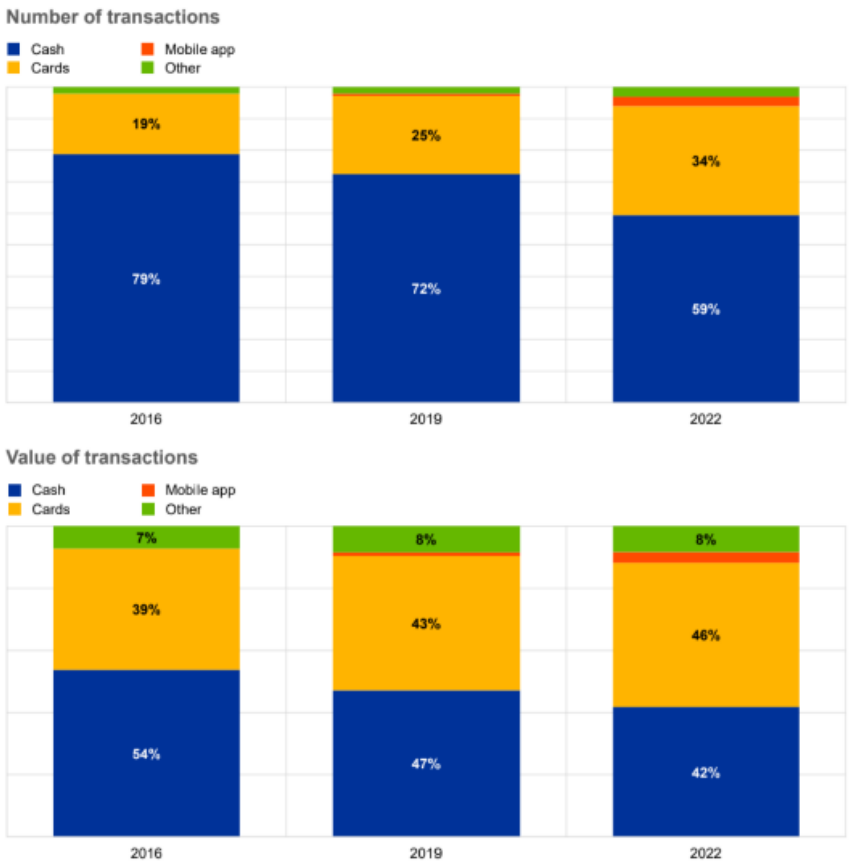
III. CBDCs

The previous chapter has provided an overview of the evolution of money starting with its precursor (barter), continuing with two forms of central bank money (coins and banknotes) and a type of commercial bank money (credit card), and concluding with the most recent developments (e-moneys, cryptocurrencies and stablecoins). For what concerns central bank money, it can be noticed that monetary institutions (or governments before the formal establishment of the central banks) have been very careful when introducing a new form of money, due to their status and preservative attitude towards risk. Indeed, it is no surprise that, in any industry, innovations come from the private sector; and the payment system is not excluded either. After thoughtful analyses, also central banks are considering the introduction of their own digital currencies[76]. There are numerous benefits, that will be examined later in the paper, stemming from the development of a digital currency, but the rationale for its introduction is to be found in the gradual substitution of central bank money with commercial bank money or private sector instruments. The said erosion of central banks' share in the payment system is supported by striking data coming from exhaustive analyses of the payment habits. The

[76] Three countries already have launched their CBDCs; namely Bahamas, Jamaica and Nigeria and 134 countries and currency unions are exploring a CBDC (Atlantic Council 2024).

Study on the payment attitudes of consumers in the euro area[77] (ECB 2022a) provides support as differently from the past, payments by cards have outnumbered cash transactions in terms of volume[78]. Moreover, card payments are closing the gap with cash, in terms of number of transactions, despite being still behind. The figure below, provides a clear-cut representation of the actual payment habits and hints at a downward trend in the number and value of cash transactions.

Figure 4: Payment habits in the Euro Area



Source: ECB (2022) *Study on the Payment Attitudes of Consumers in the Euro Area*

The results are shocking and underline an energic shift from cash towards card payments; the pandemic further accelerated this process. Moreover, the histograms portrait a rapidly evolving situation for payments via phones or smartwatches. More in

[77] Also referred to as SPACE.
[78] Namely, 46 % of the overall value of transactions was paid by card while 42 % in cash (ECB 2022a, p.3).

detail, the survey reports that the share of number and value of payments through mobile apps tripled, respectively from 1% to 3 % and from 1% to 4% (ECB 2022a, p. 12).

The said data are specific to the Euro area; however, the substitution effect of cash payments is common amongst major countries and, if on side traceable means of payment permit to better fulfil the duties of contrasting the financing of terrorism and money laundering, on the other side they signal a shift in the payment habits that needs to be addressed by central banks by virtue of their statutory responsibilities. Indeed, as stated by Article 3 of the Statute of the European system of central banks, one of the key tasks is to "promote the smooth operation of payment system" (ECB 2016), and all major central banks have a similar duty; therefore, considered that there are only three forms of central bank money (coins, banknotes and reserves), it seems reasonable to expect a response of the monetary institutions to a change in the payment habits. The intervention of central banks through the issuance of their own digital currencies is not for competition purposes with commercial banks, as they are not striving for market shares and the related revenues, rather they need to provide a safer alternative to the riskier private sector digital currencies. In fact, cards or cryptocurrencies are not under the direct control of central banks and, should an intermediary or private sector issuer fail, depositors will not be able to recover their money. Amongst the two, cryptocurrencies are the riskiest due to their nature, as they are not usually backed by safe assets, have a volatile price and are weakly regulated. In particular, policymakers at the ECB are aware of the sudden changes in the payment system and are worried the Euro could be marginalised and substituted by unsafe alternatives: in a 2022 interview to the President of the ECB, Christine Lagarde and former member of the ECB's executive board, Fabio Panetta, they declared that "a digital payments ecosystem without a strong monetary anchor would create confusion about what qualifies as money".

III.1. Incentives from the central bank's perspective

Introducing a digital currency however is not an easy task as it would require central banks to venture in a new field[79] and would call for an in-depth investigation of

[79] Currently, central bank money is used in physical form (banknotes and coins) or held as store of value and safety buffer by the banking sector (reserves).

the most suitable characteristics to enjoy benefits. Namely, they can be grouped into three main categories: CFT and AML, monetary policy transmission and market related purposes. For what concerns the first category, it seems obvious that the introduction of a digital currency would increase the share of digital payments even more, thereby serving the AML and CFT goals in terms of traceability of financial flows. Namely, digital payments help policymakers and regulators to better quantify economic activity and intervene more effectively with their measures. Nowadays, in fact, estimation, cleansing and reorganization of data are necessary to analyse economic trends, as digital payments are managed by commercial banks; conversely CBDCs will help to get live data on transactions and, therefore, on the general economy. As a cascade effect, tax evasion will be reduced leading to tangible fiscal benefits. It can be argued that cash will still be used for illicit activities, but at the same time CBDCs will help to curtail this phenomenon. Also, the incentive to counterfeit false banknotes will diminish as their usage will drop. Comparing CBDCs and cryptos, the authentication processes required, exception made for purely token-based CBDCs, that are more like digital forms of banknotes, will mark the difference as cryptocurrencies lay their foundation on anonymity. Indeed, central banks shall not attempt to convert libertarian crypto users to CBDCs as they will still prefer cryptocurrencies to central bank money for ethical reasons; but rather those who want to enjoy both the benefits of digital currencies and the safety of central bank money.

The second family of benefits is referred to the implications that CBDCs will have on the transmission mechanisms as monetary institutions will add digital currencies to their set of instruments to be deployed. Firstly, in case of expansionary monetary policy, central banks could intervene directly on the cash balances of their users, in addition to the classical commercial banks channel. This would help limiting the problem of cash hoarding in bank deposits that practically does not help to stimulate the economy. The COVID pandemic has highlighted the said problem with governments handing out money to their citizens without effectively inducing them to spend it (Arslanian 2023, p. 176). Secondly, it allows central banks to transmit their negative interest rate policy regardless of the commercial bank decisions. In fact, the transmission of negative rates starts with central banks declaring the key interest rate applied to commercial banks deposits and continues with these private institutions charging a negative rate on their depositors. However, there is still some discretion as to the actual rate applied, and some banks may

opt to offer more favourable rates to attract depositors, resulting in an imperfect monetary policy transmission. Central banks could bypass them by directly imposing negative rates on their digital currencies[80]. By doing so, however, the CBDC introduced would be more akin to deposits rather than cash with consequent different implications; therefore, the decision to choose between a remunerated or interest free CBDC shall be taken consciously by central banks.

The third group of benefits is related to the implications CBDCs will have in terms of market power. As mentioned before, stablecoins have been widely criticised for different reasons ranging from the insufficiently safe backing to the privacy implications with the collection of data; however, those critiques hide central banks' worries that large companies such as Meta could leverage their wide user base[81] to disrupt the market and enjoy an edge over competitors. More in detail, as mentioned before Facebook (before being renamed Meta) launched its stablecoin Libra in 2019, long before any introduction of central bank digital currencies. The critiques certainly induced Meta to interrupt the project, but the risk of a stablecoin issued by another tech company is still alive. Consequently, the introduction of CBDCs may help central banks to hedge the said risk and erode big tech's market share in the payment industry[82]. Another key aspect in the development of CBDCs will be their interoperability, to be interpreted as the possibility to use and transfer currencies in different countries or monetary unions (e.g. using digital Euros in the USA). The said characteristic is pivotal to limit the role of cryptocurrencies for international transfers, due to the reduced fees compared to commercial banks[83]. By doing so, the scenario could change drastically; however central banks have not addressed said interoperability as their major priority, so far and it could be expected that the first releases of CBDCs will work only internally.

III.2. Wholesale and Retail CBDCs

Developing and launching a digital currency is a timely process, especially because a thoughtful analysis of the possible architectures is necessary to enjoy the

[80] It is impossible for central banks to impose a negative rate on banknotes and coins; CBDCs allow to do so, conversely.
[81] Meta owns Facebook, Instagram and WhatsApp.
[82] As an example, Amazon pay or PayPal.
[83] Arslanian (2023, p. 195) reports the average fee for cross border payment being around 7 %.

benefits listed before. The two macro categories of CBDCs are wholesale and retail with the majority of monetary institutions inclined towards the latter. As the name suggests, wholesale CBDCs would be used to "facilitate payments between the central bank and other banks with accounts at the central bank itself" whilst retail CBDC would be used by the public for retail payments; as an example between individuals and businesses, according to Arslanian (2023, p. 184).

Wholesale CBDCs are the least disruptive as their application is limited to the banking sector, while retailers will not be entitled to use them. They can be subdivided into three groups analysed in increasing order of interoperability between different agents: the national, the cross border and cross border multi CBDC model. The first category embeds those projects introducing digital currencies to settle interbank transfers at a national level but has received little attention as only few central banks have investigated the feasibility of the said model in the past years. The main reasoning is that national interbank markets are already very efficient from a cost and time perspective (many states and monetary unions have in place RTGS systems that operate 24/7); therefore, the costs in terms of verification and infrastructure management related to the introduction of a digital currency serving only this purpose could overwhelm the benefits.

The second group refers to cross border payments that today are fragmented and call for the introduction of smoother systems. The main frictions in those inter-state payments are due to the high fees that pertain to the heavily intermediated system in place, the speed and time of settlement and regulatory and compliance costs. Auer, Haene and Holden (2021, p. 1) stress how inefficient cross border payments are. They report that those payments occur by means of corresponding bank agreements with settlement and exchange rate risks arising from currency conversion. Moreover, rules are set to favour domestic transfers, and this could result in delays and inefficiencies due to the time differences. Finally, diverging regulatory and compliance standards complete an already convoluted environment. CBDCs of this type would favour inter-state payments but would still be limited to exchanges between two parties: this would result in lower compliance costs that would not drastically change the overall system, given the conspicuous number of currencies. To truly compete with cryptocurrencies, the third system needs to be implemented: the multi CBDC model.

This last architecture of CBDCs would be the most beneficial, but also the most complex to implement. Following the classification provided by Auer, Haene and Holden (2021, p. 4), there are three micro categories that offer different levels of interoperability but also imply varying costs: the compatible system, the interlinked system and the single system for multi CBDCs. The compatible approach implies agreed common standards, such as message formats, security, and data requirements to be aligned on the legal, regulatory, and supervisory planes. The benefits it would bring are undisputed; at the same time, it would still require a multitude of privately offered correspondents and clearing services, similar to the cross-border models already in place. Therefore, it is unclear whether the advantages would justify the required investments. More specifically, each CBDC system would have its own rulebook, governance and infrastructure while transfers would be managed by private companies: those that would mostly benefit from the reduction in compliance costs. On the negative side, it takes time to come up with and implement common standards; therefore, large banks that already have built their own system would not be willing to switch. The interlinked system is an evolution of the former. The two main differences are the clearing and settlement services, and the interfaces. The CBDC systems would still be separate, but rather than having many private companies managing the interlinks, those services will be concentrated. The benefits will be more pronounced, but each central bank would have to set a different link with any CBDC, thereby leading to a myriad of interlinked systems; according to Arslanian (2023, p. 196) connecting 200 currencies would require 20000 bilateral agreements.

The last and more complex model involves the highest level of coordination resulting in an integrated multi CBDC system. Central banks would issue their digital currency on a shared platform and participants of the network could directly transact. It could generate economies of scale in the development and management of the platform and reduce frictions but would require some compromises to come up with a single rulebook, infrastructure and participation requirements. The most difficult task would be to find a shared system of governance as every central bank would prefer to have a direct hold on its own currency. For what concerns this type of system, various projects have been launched to study its feasibility. A possible development would consist in a vertically integrated system allowing each central bank to issue its own currency on a

decentralised platform. Instead, the governance of the application providing the different functionalities and the platform for the currency applications would be shared among the different participating monetary institutions. Another solution, proposed by the BIS Innovation Hub and reported by Auer, Haene and Holden (2021, p. 13), is the mBridge infrastructure that consists of a core layer, using a decentralised ledger technology where each central bank acts as validator, and two additional layers: the user interface (front end) where commercial banks can operate and the management services (back end). This system is very innovative as it consists of a single platform that leaves ample rooms for the central banks to innovate.

Differently from wholesale, retail CBDCs are "digital payment tokens issued by a central bank that would be used as a digital extension of cash by the public and companies" (Arslanian 2023, p. 184). As the definition underlines, the idea behind a retail CBDC is to allow users to have a digital equivalent of cash; therefore, their development and possible applications would be drastically different from the other type. In fact, they would be much more similar to stablecoins backed by central bank money, rather than settlement systems for interbank transfers. The said difference is pivotal as their introduction would represent a breakthrough in central bank money, while wholesale CBDCs would improve an already established mechanism. Given their disruptive characteristics, it seems obvious that most of the benefits that central banks would enjoy result from this type of digital currency: those in terms of AML and CFT (due to a more extensive traceability of payments), those related to monetary policy (as central banks would have a direct channel for its transmission, in addition to the classical commercial banks') and the economic ones (that would result from the erosion of the market shares of cryptocurrencies).

At the same time, retail CBDCs entail possible drawbacks amongst which the disintermediation of banks, a reduction in bank deposits with a consequent lower profitability, a flight to safety when banks are in distress and a more subtle and blurred demarcation between monetary and fiscal policy. For what concerns the first two risks, a possible threat for commercial banks could arise with users switching from deposits to CBDCs, whilst those institutions would not suffer from people's shift from cash to CBDCs. Therefore, when developing digital currencies, central banks should carefully evaluate how to mitigate this risk as it could undermine the overall banking system.

Should central banks opt for a more deposit-like digital currency, commercial banks' stability and profits would be negatively affected too. To be fair, bank runs are inherent to the nature of the banking business, so the introduction of CBDCs is not going to drastically affect the phenomenon. Moreover, as reported by Huber (2023, p. 134), bank runs occur only at times of instability and central banks would still intervene as lender of last resort. The fourth drawback is based on the citizens' perception of central banks. In fact, CBDCs would permit a more direct transfer of funds from the government to the public[84] and, if on one side, digital currencies would smooth the process, on the other side, this could undermine the citizens' trust in the independency of central banks (De Bonis and Ferrero 2022, p. 17). Finally, CBDCs expose central banks and citizens to digital risks requiring large investments in the cybersecurity.

III.3. Token-based and Account-based CBDCs

There are two possible systems of CBDCs: token-based and account-based. As the name suggests, the first is more centred on the object (token), rather than on the holder's identity, and could grant a higher level of anonymity: it would resemble digital banknotes. The latter instead consists in a digital currency held in the form of an account in a register at the central bank or intermediary, more similar to a bank account. They both entail benefits and drawbacks; therefore, central banks are considering hybrid forms of CBDCs so to exploit the appealing features.

More in detail, token-based CBDCs are easier to use due to the simplified authentication process. This feature would help its diffusion but could entail money laundering risks. Another key advantage of token-based CBDCs is the possibility to be used for offline payments: an interesting feature to allow digital currencies to be used also in remote areas with scarce internet connection. Also, the offline feature would be a strong incentive to adopt digital currencies especially for those concerned about privacy and data breaches. A token-based CBDC could also turn useful in those countries where cash is diminishing at a fast rate; Arslanian (2023, p. 208) cites a report by the Swedish central bank[85] that investigated the benefits stemming from the introduction of a token-based

[84] As an example, through the direct transfer of funds with expansionary fiscal policies.
[85] Sweden is one of the countries with the fastest rate of disapplication for cash.

CBDC: the e-krona. Besides the usual upsides of more financial inclusion (also for the unbanked), lower liquidity and credit risk of central bank money compared to commercial banks', the Swedish e-krona would be strategical for the central bank as it would help to contrast the monopoly of commercial banks in the payment system. A digitally oriented payment system such as the Swedish cannot rely anymore on banknotes and coins[83], so the e-krona could fill in the gap allowing central bank money not to be driven out of the market with consequent favourable policy implications.

For what concerns the other type of digital currency, the bank account-like feature renders it fit for AML and CFT goals. Consequently, it would imply a high burden in terms of authentication procedures that would probably be handled by commercial banks. In fact, in view of heightened competition, commercial banks are expected to provide the user interface and related authentication checks. According to Huber (2023, p.120), the digital Yuan, the largest retail CBDC developed so far, embeds those characteristics, being an account-based currency lent by the central bank to six major commercial banks and two digital banks. Customers can apply for a digital Yuan account in the form of an e-wallet. For its retail CBDC, China opted for a DLT system with asymmetric cryptography, but central banks could develop central based systems, alternatively. From the analysis presented, there is not an undisputed winner, and central banks could decide to issue hybrid CBDCs to serve the cause.

III.4. CBDCs architectures

Once monetary institutions have carefully analysed what features their digital currencies should have, they would need to build the architecture. Following the classification provided by Arslanian (2023, p. 213), five architectural kinds can be identified, despite some may be utopic and would probably not see the light of the day. The first is based on DLT and is known as the decentralised approach. The idea itself is counterintuitive as central banks should be in principle in control of the monetary policy, while they would have little influence with the said system. Arslanian (2023, p. 214) cites the Marshall Islands as leading example. Obviously, the proposed state is one of a kind and behind its unconventional approach there are specific reasons that could hardly be encountered in other states. Namely, the Marshall Islands risk being left out of the

financial system due to their remoteness; further, they have never established a central bank, heavily relying on US banknotes as mean of payments.

The second is the direct approach and would imply a direct involvement of the central bank in the payment and operational requirements. Central banks choosing this system would venture into uncharted territories, whilst it would be wise to delegate commercial banks as they have matured experience in the processing of transactions to smooth the process. From the central banks' perspective, the said approach could prove very resilient and provide a complete understanding of the account balances; however, commercial banks would face marginalisation with a consequent disintermediation that could degenerate in an obsolete system. As mentioned before, most of the innovations come from the private sector; therefore, said direct approach could disincentivise innovation as fintech companies and private banks would be driven out of the market.

The third method is the so-called synthetic approach. It would not consist in a classical CBDC as it would only require backing payment accounts with reserves at the central bank. The system could be implemented granting PSPs and fintech companies the possibility to hold reserves at the central bank. A possible drawback pointed at by Auer and Böhme (2020), would be the identification of payers and payees in case of failure of an intermediary. At the same time, it could be argued that fully backed payments would reduce such risk. To conclude, the synthetic approach represents a quite controversial system, and many central banks would probably base their digital currencies on other infrastructures.

The last two are those that would most probably be implemented. They both are intermediated approaches and can be considered a mix of the previously mentioned direct and synthetic architectural types. The first is called "two tier/intermediated approach" (Arslanian 2023, p. 218) and consists of a CBDC distributed by commercial banks only as a claim on central bank money. In the said system, only central banks are entitled to issue or redeem CBDCs, thereby keeping full control of monetary policy, while private banks can obtain or redeem the digital currency against the reserves held at the central bank. This architectural type is not dissimilar from the one in use: central banks would have to develop the ledger to record wholesale transactions while commercial banks would record and keep retail transactions. The decentralised storage of data would reduce both the negative consequences of a cyber-attack as data will be available in multiple

locations and the overall burden of central banks that would be limited to wholesale transactions. Moreover, monetary institutions would delegate the onboarding and authentication processes, the customer service and account management to private banks, who already have those systems in place for their card businesses. On the other face of the medallion, additional safeguards and prudential standards would be necessary with consequent compliance costs for the intermediaries. Further, the information available to central banks would be limited to wholesale transactions providing an incomplete picture of the capillary diffusion of CBDCs. The mentioned pitfall limits the applicability of the system with central banks that may opt for another intermediated approach: the platform system.

This alternative intermediated approach (also known as hybrid model[86]) is not dissimilar to the two-tier system presented; the core difference is the registration of data on retail transactions by central banks. According to Auer and Böhme (2020), the novelty lies in the legal framework that provides for a separation of the balance sheet and the CBDC accounts of the intermediary. By doing so, the holdings of digital currency users could not be claimed by the creditors of the intermediary in case of failure, stimulating trust in the system with positive spillover effects on the utilisation and diffusion of digital currencies. Also in this case, the Swedish central bank has been at the forefront of innovation proposing a model based on a core platform containing the central register for digital currency holders and the regulatory framework. The core platform will manage payments and the interactions with other systems. This feature set the foundations for a future interaction with foreign currencies. The second element is constituted by the user applications on mobile devices allowing CBDC holders to make transactions. Moreover, internal support systems would be in place to enable administrative and control functions (e.g. AML/CFT). Then, there are external systems needed to connect the central platform to the infrastructures through which the CBDC is offered: namely, card issuers, ATMs, PSPs and finally settlement systems allowing the central bank to carefully oversee the smooth transfer of funds.

[86] According to Auer and Böhme (2020).

III.5. The project of the digital Euro

Amongst the countries and unions that have investigated the feasibility of a digital currency, there is the European Union that is currently in the preparation phase for the issuance of its digital Euro. In fact, after an interactive consultation phase where the ECB collected data on the principal needs and expectations of tis citizens and firms (ECB 2021a) and a comprehensive investigation phase that lasted two years until October 2023 where the Frankfurt-based monetary institution examined the design choices and implications of a digital currency, the European central bank has entered the preparation phase composed of two stages that would lead to the introduction of the digital currency, once the legal framework will be laid down[87]. This phase will last at least two years and the ECB could later deploy its digital currency[88].The European central bank manifested its interest in digital currencies for the first time in late 2018 when a former member of the Executive Board held a conference on the new frontier of payments and market infrastructure. The said member, Benoît Cœuré, highlighted the novelty of Bitcoin but also its risks defining it the "evil spawn of the financial crisis" (ECB 2018). The French economist also reported that 69 percent of central banks were investigating the feasibility of a digital currency and concluded that it was unlikely for any monetary institution to release a digital currency in the current decade. Obviously, the situation has evolved since then and the ECB has made progresses that should allow it to issue its digital Euro before the end of the decade.

Then was the turn of the pandemic that started in 2020 and further accelerated the downward trend of cash transactions in favour of digital payments. Payers got interested in alternative forms of payments, and digital currencies grew popular. The President of the ECB, Christine Lagarde, released an interview stating that it had constituted an expert task force to study the feasibility of a Euro area CBDC in various forms, signalling the concrete interest of the Frankfurt-based monetary institution (ECB 2020a). The interview shows how the ECB was still unsure about which kind of digital currency to issue, but it

[87] According to the ECB paper *A stocktake on the digital Euro* (ECB 2023, p. 42), "A possible decision by the Governing Council of the ECB to issue a digital euro would be taken only after the legislative act is adopted".

[88] The ECB reported that the first stage will last two years after which the General Council will decide the possible subsequent steps (ECB 2023, p. 42).

already points out the central bank's effort to adapt to changes in consumer payment habits. This has been confirmed in September 2020, when President Lagarde gave a speech and identified the digital Euro as a viable tool to adapt to the trends in global payments (ECB 2020b). Indeed, she highlighted the digitalisation process, accelerated by the pandemic, and the competition to dominate global payments. This time, the speech sounded more pragmatic, and the ECB President did not hide her worries of a major shift in the payment system. She expressly reported that "Europe has fallen behind in this competition" and an "increase in protectionist policies, as sanctions and even exclusion from payment systems" (ECB 2020b). In such a scenario, a digital currency was deemed suitable to give an edge over competitors and serve the institutional goal of integration of the payment system. In fact, few weeks after the said speech, the ECB published its first report on the digital Euro.

III.5.1. The initial report

The first report on the digital Euro was published in October 2020. It is a comprehensive document providing the basis for the development of the digital currency. It is articulated as follows: firstly, it hypothesizes different scenarios that justify the introduction of the digital Euro, secondly it analyses the potential effects of the issuance, thirdly it addresses the related legal issues, and finally it highlights the possible functionalities and stylised approaches of the infrastructure (ECB 2020c, p. 8). Being the first published report on the digital currency, it does not delve into the technical aspects, but rather aims at setting the core principles and scenario-specific requirements that the digital Euro must satisfy. More in detail, the ECB states that a future digital currency must be "convertible at par with other forms of the euro, such as banknotes, central bank reserves and commercial bank deposits" (ECB 2020c, p. 7) so not to circulate as a parallel currency. Further, differently from cryptocurrencies and stablecoins, it would be a liability of the Eurosystem and consequently risk-free by default. This principle is needed to avoid undue financial risks to the system and disparities among the different forms of central bank money (banknotes, coins and digital currency). The third core principle points at a democratic participation to the digital Euro project. In the ECB's view, it should be accessible on equal terms to the users in the European countries allowing supervised entities to provide payment services (ECB 2020c, p. 8). The penultimate pillar

can be regarded as a useful reminder to keep in mind during the development process as the ECB is not interested in gaining the monopoly in the digital payment industry; therefore, the development and introduction of the digital currency shall not discourage nor crowd out private solutions for efficient payments. The Frankfurt-based monetary institution is aware that commercial banks and fintech companies matured experience in the field, and its novel currency shall not disrupt the said industry and negatively affect banks' profitability. The last principle refers to the credibility of the digital currency: developers shall ensure users' trust and come up with a safe product (ECB 2020c, p. 8). It could then be inferred that the digital Euro must be easy to access and cyber-attacks-proof.

In the report, the ECB also presents different scenarios and possible implications related to the issuance of the digital currency; consequently, it lists the connected requirements to be fulfilled. By doing so, the ECB offers an overview of the incentives for its introduction. In a scenario where digitalisation and independence of the European economy are key, a digital currency constitutes a building block for the overall infrastructure. The issuance will keep the European payment system up-to-date and support the digitalisation of the financial sector not only at the central bank level, but also at the commercial banks level. In fact, the digital Euro would both represent a viable way for users to access central bank money in a modern way and an incentive for private banks to develop and profit from end-users solutions. The first requirement stems directly from it as the ECB would focus on the "usability, convenience, speed, cost efficiency and programmability" features to develop its digital currency (ECB 2020c, p. 10). Moreover, the ECB points at a declining path of cash transactions[89] that implies increasing dependence on private forms of money and private payment solutions.

Should the digital Euro be introduced, it would boost the central bank' share in the overall payment industry; however, the chances of success are positively related to the cash-like features of the digital Euro. Indeed, it should be cheap and easy to use, secure and efficient to reach most of the population, but it should also grant the highest levels of privacy. According to the Eurosystem report on the public consultation on a digital Euro, a survey aimed at collecting the views of citizens and professionals on the CBDC, privacy

[89] See the *Study on the payment attitudes of consumers in the euro area* (SPACE) published in 2022 for a deeper understanding of the phenomenon.

was considered the most important feature by both categories of respondents (ECB 2021a, p. 3). This requires a relentlessly effort to embed ad-hoc features that enable payers' transactions to remain private. Consequently, this has prompted the ECB to focus on an offline version of the digital Euro too.

Another requirement for its digital Euro is to have "competitive features" (ECB 2020c, p. 12). One could be misguided by the term "competitive" as central banks shall not be in competition with payment service providers; however, many central banks around the world are planning to issue a digital currency that could cause substitution and foreign exchange risk in the Euro area economy, should they be accessible to European citizens too. Moreover, when the report was published, Facebook founder Mark Zuckerberg had just announced its stablecoin Libra; therefore, it can be inferred that this requirement was introduced to support European sovereignty and stability. Further, the report sustained that the CBDC could be used as a monetary policy tool. As mentioned before, central banks could directly apply rates to their CBDC holdings and add another instrument to its toolkit. However, this initial propensity to remunerate the digital Euro (ECB 2020c, p. 12) faded away as the ECB shifted towards a non-remunerated version of the digital currency[90]. Moreover, the Frankfurt-based monetary authority would be set to use its digital currency to mitigate the negative implications of adverse events such as natural disasters, pandemic or any other disruption of the payment system. In laying down the "back-up system" requirement (ECB 2020c, p. 14), the ECB manifested its intention to develop an entirely new infrastructure for its digital currency; indeed, only a separate channel will ensure the required stability and resilience. The last two scenarios for the introduction of the digital Euro listed in the report refer to the broader objectives of the EU: namely, its international relevance and ecological footprint of the payment system. The first can be justified on an interconnectedness basis. Indeed, as mentioned before, all central banks could benefit from compatible digital currencies that permit users to transfer funds at lower cost without resorting to private sector alternatives such as cryptocurrencies, due to the high fees requested by commercial banks for international transfers. The second instead, can be seen as an attempt to further contribute to the environmentally friendly goals of the European Union.

[90] In the *Summary report on the investigation phase* published in October 2023, the ECB stated that "it does not intend to develop any functionality to remunerate digital euro holdings" (ECB 2023a, p. 33).

The report also lays down the legal considerations for the implementation of the digital currency. Despite being only an initial document, it sets the basis for the proposal of regulation published in 2023[91] on the matters of legal basis for the issuance, legal tender status, private law issues and the implications of different designs of the digital Euro. More specifically, a European CBDC could hinge on the TFEU[92] and the Statute of the ESCB[93] (ECB 2020c, p. 24). The two documents provide a basis for the issuance of digital currencies with disparate features: as an instrument of monetary policy (and therefore a wholesale type) or as a complement to cash (retail form) available to households. Further, the report underlines that while a wholesale CBDC would be more straightforward and similar to the practices already in place[94], a retail form would be more innovative and therefore difficult to justify on a legal basis (ECB 2020c, p. 25).

The following section focuses on the possible designs of the CBDC. Namely, the central bank would decide on the most appropriate access model: either direct or intermediated. The ECB makes clear its view by stating that the "intermediated access model is preferable" (ECB 2020c, p. 26). Said model would entail pros and cons as on one side, the experience matured by private banks with bank accounts would serve as a starting point, while on the other, opting for an intermediated approach, the ECB would run the risk that supervised entities could adversely affect the quality and accessibility of the system. The intermediated and direct models would be suitable to be used both for a classical account-based or innovative decentralised token-based currency. More in depth, the ECB recognises that, regardless of the gatekeepers' aid, operating a centralised direct model would be an excessive burden in terms of number of transactions and technological implementations (ECB 2020c, p. 38). Conversely, with a centralised intermediated approach, the ECB would delegate the burdensome settlement procedures to commercial banks and still retain full control over the life cycle and processing of transactions. For what concerns the decentralised approach, the ECB would need to resort to DLT and venture into an already existing yet untried technology. Regardless of the direct or intermediated choice it would make, DLT would require the ECB to develop

[91] European Commission proposal for a Regulation (EU) No. 212/2023 of 28 June 2023.
[92] Treaty on the functioning of the European Union (EU) 2016 of 7 June 2016.
[93] Statute of the European system of central banks and of the European central bank (EU) 2016 of 7 June 2016.
[94] The infrastructure would not be too dissimilar from TARGET 2 (ECB 2020c, p. 25).

cryptography systems and validation methods allowing users and intermediaries to participate. Considered the institutional reputation of the ECB and the negative consequences of a faulty model, the ECB would probably discard this option. More recent documents provide evidence in support[95], with the ECB being more inclined to a centralised intermediated approach.

Turning to the privacy aspects, the ECB sets clear that it would rule out full anonymity, mainly to contrast improper uses of the digital currency for money laundering and financing of terrorism and would limit the scope of digital Euro holders to prevent excessive capital flows (ECB 2020c, p. 27). However, because of the privacy concerns expressed by Euro area residents and firms, an offline feature would be considered. In this report, the monetary institution remains vague on the practical aspects (e.g. possible limits, implementation, etc...) but already shows interest in the said feature.

Another concern of the ECB is the use of the digital Euro as a form of investment. The solution identified in the report was to limit the individual holdings not to exceed a specified threshold. When the report was published, the interest rate on safe AAA-rated government bonds was negative[96] and simply keeping money in the form of cash (or digital Euro) would have been better than purchasing those bonds. The ECB in fact states that unconstrained access to the digital currency would disrupt the financial flows in similar scenarios. Clearly, those circumstances were atypical, and under normal times with positive interest rates, it would be unreasonable to hold digital Euros as a form of investment. Nevertheless, limiting the individual holdings would also help to prevent a flight from commercial bank deposits to safer central bank money. Moreover, in the proposal for a regulation, the European Commission ruled out the possibility for an interest-bearing digital Euro to prevent users from investing in it[97].

For what concerns the transfer mechanisms, the ECB presents two valid alternatives: an account-based or a token-based instrument. The first is more similar to bank accounts transfers used today, while the second would resemble cash transactions. Practically, the choice will be between a higher degree of control by the ECB, that will

[95] The *Summary report on the investigation phase* refers that residents of the euro area would be able to choose their digital provider meaning that the ECB has opted for an intermediated model (ECB 2023a, p. 11).
[96] - 0.5 % according to the report (ECB 2020c, p. 28).
[97] Article 16 of the proposal for a regulation (EU) No. 212/2023 of 28 June 2023.

limit the functionalities of the digital Euro[98], and a more private system that would be suitable for offline payments too[99]. The term private however shall not be intended as anonymous, given that biometrics, fingerprints or other authentication methodologies would be needed to validate identities[100]; rather, it means that payers and payees, instead of the ECB or the intermediaries, would be responsible for the verification of any transfer of value. Deepening on the token-based, the ECB warns of the risks of a local storage system as any loss of a payment device would result in loss of CBDC (ECB 2020c, p. 30); therefore, it seems reasonable to expect a model with a centralised storage of data at the ECB and/or at the commercial bank level. Specifically, the digital Euro could be provided both as a web-based service and through physical devices such as smart cards. The first would enable users to access their digital Euro holdings in many ways such as smartphones, smartwatches, computers, while the latter would be akin to a debit card.

The systems defined so far, either with a card, smartwatch, computer, etc... all require an internet connection; however, the ECB committed to provide some offline functionalities to grant privacy and usability in badly connected areas. This feature would surely increase the user base as European citizens already transact privately with banknotes; but a completely offline digital Euro would be a utopia as devices shall connect to the internet to allow top ups at a certain point. Therefore, the digital currency is expected to have a dual nature: offline and online, and this would result in a parallel infrastructure.

III.5.2. The investigation phase

Soon after the publication of the initial report, the ECB launched a consultation phase that preceded the investigation phase. The consultation phase aimed at collecting the views of citizens (prospective users) and retailers on a digital Euro. It ended in January 2021 and was followed by a summary report published in April 2021[101]. As already mentioned, citizens and professionals were mainly concerned about privacy[102]; more

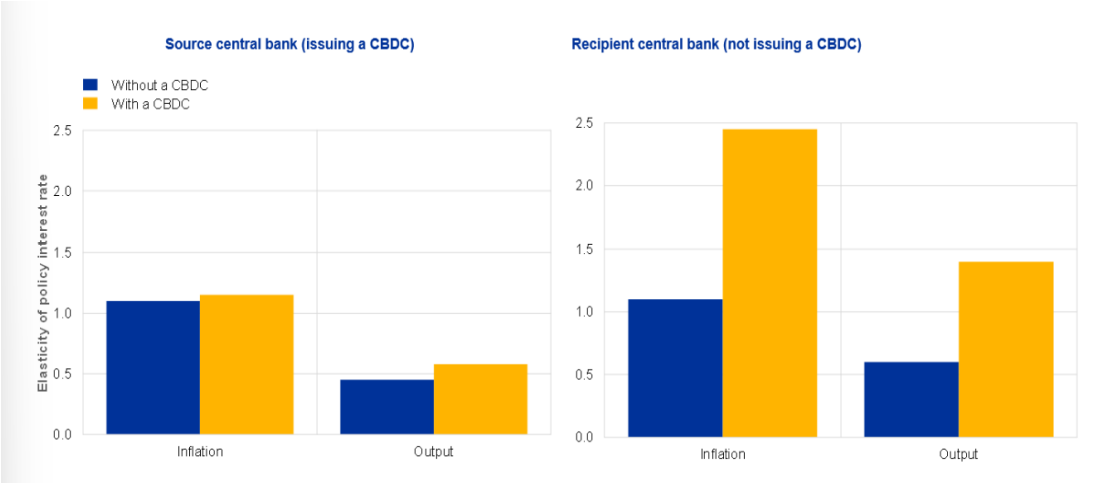
[98] According to the report, an account-based system could only be used online (ECB 2020c, p. 30).
[99] The ECB states that a token-based system "would fall outside the control of the Eurosystem or its supervised entities" (ECB 2020c, p. 30).
[100] More specifically, the report specifies that the customer authentication procedure shall comply with the Payment Service Directive (PSD2) (ECB 2020c, p. 42).
[101] The *Eurosystem report on the public consultation on a digital euro* (ECB 2021a).
[102] 43 % of the respondents ranked it first in a list of aspects to develop (ECB 2021a, p. 10).

specifically, the first preferred an offline solution, while the latter opted for a hybrid approach (ECB 2021a, p. 3). Nevertheless, a fully online digital Euro did not prevail in any of the two classes. Moreover, one fifth of the respondents[103] ranked security as the main feature they would look for. The rest of the respondents instead, chose usability in the Euro area, absence of additional costs and offline features as their preferred characteristics. Then, the survey presented questions on financial, payment and technology issues that resulted in a general preference for the involvement of commercial banks in the process, to facilitate the introduction of efficient services, and fast, interoperable and low-cost cross-border and cross-currency payments, according to the report (ECB 2021a, p. 29).

The ECB addresses cross-border and cross-currency payments mainly for three reasons: the risk of currency substitution, the cross-border transmission of shocks and implied exchange rate volatility and finally the reduction in the costs associated to international payments. Fabio Panetta, former member of the Executive Board of the ECB and Governor of the Bank of Italy, gave a speech in October 2021 highlighting how the digital Euro would play a major role in the safeguard of European monetary sovereignty (ECB 2021b). In fact, if a foreign CBDC were to be widely adopted, the Euro might lose its functions of medium of exchange and unit of account with consequent risks for the financial stability. Secondly, the introduction of foreign digital currencies will alter capital flows and, consequently, the standard relation between interest rate differentials, according to Panetta (ECB 2021b). From the central bank's perspective, these spillover effects would increase the sensibility to inflation and output fluctuations and would require a stronger response. In its speech, Panetta cited the study by Ferrari, Mehl, and Stracca on the *Central bank digital currency in an open economy* (2020) that offers a clear-cut perspective of the possible effects of cross-border digital currencies.

[103] 18% according to the report (ECB 2021a, p. 10).

Figure 5: Optimal monetary policy in the presence and absence of a CBDC



Source: Ferrari, M. M., Mehl, A. and Stracca L. (2020) *Central Bank Digital Currency in an Open Economy*

The graph above is self-explanatory. Clearly, the effects depend on additional features such as limits on the digital currencies holdings, but it already shows a striking difference in the optimal response function of central banks with and without the issuance of a CBDC. Should a central bank issue its own digital currency, its policy response to inflation and output shocks would not be affected much by foreign digital currencies; however, should a monetary authority not develop a CBDC (histograms on the right), its response would change[104] a lot depending on the other digital currencies. Finally, Panetta stated that the issuance of a CBDC will have an impact on the international role of currencies as units of account at a global level as they could reduce fees for international transfers (ECB 2021b). A currency would be more attractive, and consequently this

[104] The study assumes that central banks react to shocks according to the Taylor rule, with a more pronounced response in case of an inflation shock compared to an output shock.

would modify the exchange rate with other currencies with a negative effect on imports[105].

The investigation phase started in October 2021 and lasted for two years with the publication of the summary report *A stocktake on the digital euro.* However, the ECB released four intermediate reports on the progresses made. The first was released in September 2022, one year in the investigation phase and the ECB leveraged on the need to be independent of non-European providers and technologies as well as on the need to manage an increasing number of electronic transactions to justify the introduction of a digital Euro (ECB 2022b, p. 4). In fact, according to the ECB, the scope of application for the digital Euro would range from P2P to government payments, from physical (in store) to electronic (online) payments and from B2I transactions to machine-initiated payments[106].

Another topic discussed in the report is the transfer mechanism. At that stage, the ECB still investigated all the three possible mechanisms, also in view of a possibly hybrid digital Euro. Namely, it reported that studies had been conducted on peer-to-peer validated offline payments, online third party validated payments and peer-to-peer validated online payments; respectively, the first would yield a cash-like digital Euro, the second would be similar to debit/credit card payments and the last one to cryptocurrency infrastructures. However, the ECB also discloses that further studies on the peer-to-peer validation of online payments would not be carried forward in the next stages of the investigation phase (ECB 2022b, p. 5). This is an initial sentence on the first release of the digital Euro as it would be unlikely to have DLT-like features. To be fair, the decision is in line with rational expectations as the ECB is taking a big step towards digitalisation, and a DLT-like digital Euro would imply venturing into uncharted territories.

Turning to the main concern expressed in the public consultation phase, privacy, the ECB ruled out full anonymity due to public policy issues. Moreover, starting from a baseline scenario that shares the same level of privacy of current digital solutions[107], two

[105] The reduction in exports due to a strengthening of a currency is a classic macroeconomic implication. See as an example Song, Shin and Bruno (2021) *Dollars and exports: The effects of currency strength on international trade* to deepen on the matter.

[106] According to the report, those payments would be fully automated and will be initiated by a device or software based on predetermined conditions (ECB 2022b, p. 4).

[107] More specifically, users would need to identify themselves in the onboarding process, and intermediaries would perform customer checks. Those data would remain with the respective intermediary and would not

variants were proposed: a "selective privacy" for low-value payments and the "offline functionality". The ECB considered a simplified due diligence for small payments, but it would need to block any circumvention attempt to split large payments into smaller ones (ECB 2022b, p. 8). The novelty of offline functionality instead would be that real-time info about holdings, balances and transaction amounts would only be known to payers and payees, and not by third parties.

To control the amount of digital Euros in circulation, during the first year of the investigation phase, the ECB intended to incorporate limits, both on the overall amount and on the offline holdings, and remuneration-based tools to discourage hoardings of digital currencies. In the concluding section of the report, the ECB cited the "waterfall" tool to allow users to pay in digital Euros for transactions exceeding the holding limit; in that stage however, the functionality still had to be developed but received greater attention in the consecutive reports.

The second report was published in December 2022 and focused more on the role of the intermediaries. The ECB would delegate the user-facing, onboarding and offboarding services, KYC and AML checks to those private institutions (ECB 2022c, p. 5). Moreover, they would be responsible for transaction management tasks consisting of initiation, authentication, verification and post-settlement activities. The Eurosystem instead would manage the supervised entities and issue and redeem digital Euros. Deepening on the settlement model, there are two tasks the Eurosystem would be required to perform: the verification and recording. Namely, it would check on the integrity of the transaction to assess whether the payer has the money available and serve as a bookkeeper recording the actual transfer of money. The rationale is to be able to correctly record and verify the settlement of its own liabilities[108]. Intermediaries would then receive an immediate copy of the transaction, given that they have a contractual account management relationship with the end user. Despite being responsible for the settlement procedures, the Eurosystem would not be able to infer the individual digital Euro holdings and users' payment patterns (ECB 2022c, p. 7). The report does not explicitly state how

be shared with the Euro system. Finally, personal and transaction data would be accessible to intermediaries for AML/CFT purposes (ECB 2022b, p. 7).

[108] The digital Euro would be a direct claim on the ECB; therefore, a direct control would be preferable not to impair the central bank's liability side (ECB 2022c, p. 1).

this level of privacy would be granted, but it could be expected that the Eurosystem would collect data at a systemic level without knowing the identity of each payer and payee.

Intermediaries would also be responsible for funding and defunding functionalities. More specifically, users would be able to fund their digital Euro holdings with cash or deposits and, conversely, defund their wallet converting digital Euros into cash or private money. Users would also be able to manually perform those two activities but also to automatically allow the system to transfer funds. More in detail, should a payee receive an amount in excess of the allowed limit, a waterfall functionality would intervene to transfer funds from the digital Euro wallet to the bank account, whilst a reverse waterfall tool would permit payers to execute transactions above the permitted limit[109]. Obviously, the waterfall and reverse waterfall functions would require users to associate a bank account to their digital Euro wallet. To conclude, the funding and defunding processes must occur online and would require devices to be connected to the internet to allow intermediaries to validate the transaction.

In between the second and third report on the investigation phase, Panetta released an introductory statement at the Committee on Economic and Monetary Affairs of the European Parliament that further helps to complete the picture. Panetta said that, to improve user experience, "supervised entities could integrate the digital Euro into their own platforms so to enable individuals to easily access the digital Euro through their banking apps" (ECB 2023b). Moreover, the Eurosystem has considered to develop an app with basic functionalities. This innovation would be valuable for the users as they could quickly have a glance at their digital Euro holdings, top up or defund the wallet, thereby boosting the diffusion of digital Euro payments. It would also be ground of competition for commercial banks as they would strive to have on board more customers with possibly positive spillovers in terms of deposits. More specifically, the third report released in April 2023 specifies the core characteristics that each PSP would be required to develop[110] and leaves the development of value-added services to the market: therefore, open for competition.

[109] Uncertainty still looms over the limit for digital Euro accounts, but Panetta released an interview in February 2021 stating: "the threshold could be around € 3000" (ECB 2021b).

[110] For a complete list, please see the *Progress on the investigation phase of a digital euro – third report* (ECB 2023c, p. 10).

The first novelty of the said third report on the progresses of the investigation phase is the focus of the initial version on Euro area residents, merchants and governments to be extended to non-resident Euro area citizens with an account at a Euro area PSP (ECB 2023c, p. 4). This extension was introduced to allow the group to have access to the digital Euro regardless of their residence. Moreover, given the numerous facets of European groups[111], the report leaves the final decision on the access to the digital Euro to the legislators. Concerning the holding threshold for merchants, the ECB is ready to impose zero holding limit with limited temporary deviations for the implementation of the waterfall and reverse waterfall functionalities (ECB 2023c, p. 5).

Turning to the technological aspects, the ECB set clear that only credit institutions, electronic money institutions and payment institutions would be authorised to offer digital Euro services (ECB 2023c, p. 8). Those intermediaries could integrate the platform with the digital Euro app releasing newer and smaller PSPs from the burden of developing their own application. The technologies to be adopted in point-of-sales are mainly two: QR codes and NFC contactless payments. The QR technology entails fewer complexities in terms of standards and certification processes and does not depend on mobile device manufacturers, while the NFC would be more suitable for offline payments and could facilitate "card-lovers" to make payments in digital Euros without a smartphone (ECB 2023c, p. 8). The NFC technology however, could not be used in e-commerce payments; in those circumstances, QR codes would intervene. Therefore, a hybrid digital Euro relying on multiple technologies to serve different purposes is not to be excluded. For e-commerce payments instead, either QR codes or classical alias/proxy functionalities would be suitable[112].

Towards the end of the investigation phase, in June 2023, the European Commission published a proposal for a regulation of the European Parliament and of the Council[113]. The document allows to better understand the possible implications of the digital Euro. In fact, besides the speeches, interviews and reports published by the ECB,

[111] As an example, European member states that have not yet adopted the Euro (e.g. Denmark) or non- EU countries in proximity to the Union such as Switzerland.

[112] QR codes could be faster but require two devices to complete a transaction (one displaying the QR code and the other scanning the code) thereby ruling out smartphones e-commerce transactions. Alias/proxy functionalities instead would require users to insert their credentials but could be performed with only one device.

[113] European Commission proposal for a regulation (EU) No. 212/2023 of 28 June 2023.

only legal documents will be applicable and legally binding; therefore, those are to be analysed to examine the digital Euro project. The first thing to notice is the type of legal act chosen for the establishment of the digital currency: a regulation. The rationale behind is to assure a more uniform application of the law, constraining Member States to abide by the rules without the possibility to divert through transposing laws, as it would be the case for European directives. Indeed, a regulation is directly applicable by default.

Besides the general aspects that could be inferred from the reports presented (e.g. the legal tender nature, the involvement of intermediaries, etc...), there are some points of the proposal to be carefully addressed and that may prove pivotal for the diffusion of the digital Euro. For what concerns the distribution of the digital currency, the proposal reads as follows: "while all payment services providers may distribute the digital euro, only credit institutions that operate payment accounts would be required to distribute the digital euro account upon request of their clients. Requiring all payment services providers to distribute the digital euro would not have been proportionate to the objective of ensuring an effective use of the digital euro as a legal tender means of payment" (European Commission 2023, p. 5). In the proposal, PSPs are those defined in Article 4, point (11) of PSD2 directive[114] and mainly comprise credit institutions, electronic money institutions and payment institutions (European Commission 2023, p. 38). By imposing the burden to distribute digital Euros only on credit institutions, the proposal may result in the exclusion of certain groups: as an example, electronic money institutes[115] would not be required to distribute digital Euros. If, from an economic viewpoint[116], those PSPs should be willing to offer such service, they may, in principle, opt out (e.g. not to incur costs related to implement the service); this would require their user base to switch to another PSP. Obviously, there would be plenty of options to switch, but this provision may negatively affect the unbanked and those willing to keep their money at a PSP that does not offer the service. The European Commission addresses the problem later in the proposal ascertaining that: "For natural persons that do not have a non-digital euro payment account at a credit institution or do not wish to open a digital euro payment

[114] European Parliament and the Council Directive (EU) No. 2366/2015 of 25 November 2015.

[115] In Italy as an example Hype S.p.A., Postepay S.p.A. and Mooney S.p.A. National central banks usually keep updated lists of the electronic money institutes operating in their territories. For a more detailed list of the EMIs operating in the Italian territory, please visit the page "Albi ed elenchi di vigilanza" in the Banca d'Italia website.

[116] The revenues stemming from the fees applied for the provision of digital Euro services.

account at a credit institution or at other payment services providers distributing the digital euro, Member States should designate specific entities (i.e. local or regional authorities or postal offices) that would be required to provide the basic digital euro payment services" (European Commission 2023, p. 13). This provision, by vesting Member States with the power to decide how to address the problem, may result in a non-uniform application of the regulation with consequent negative effects for the citizens of non-compliant States.

Another crucial point in the proposal concerns the checks on the number of digital Euro accounts and the overall holding limit of each user. According to the proposal: "when on-boarding digital euro users, or during ex-post checks where appropriate, payment service providers in charge of distributing the digital euro should verify whether their prospective or existing customer already has digital euro payment accounts" (European Commission 2023, p. 22). The point may turn troublesome because PSPs have an incentive to manage digital Euro holdings, but at the same time, they are responsible for the controls. This conflict of interest shall be well managed by the ECB to prevent any circumvention. In fact, the proposal does not set a limit on the number of accounts; therefore, users could hold the same account at different PSPs. The ECB was aware of the possible implications and released a technical note to address the matter (ECB 2024b). In short, a multiple account scenario would require a coordinated effort to ensure that all PSPs updated their KYC procedures if a user's identity attribute changes (ECB 2024b, p. 2). The technical note also demonstrates how an SAP that acts as a repository for digital users could work. Onboarding PSPs could exploit it to verify that the user's holding limits has not been reached. More in detail, the privacy of digital Euro users should not be violated as the information would be anonymised and PSPs would only have access to the limits set for online and offline payments.

Further, the waterfall and reverse waterfall functionalities shall be carefully scrutinised. As mentioned before, those two features allow to make or receive digital Euro payments in excess of the holding limit. If on one side they are valuable, they also expose users to substantial losses in case of frauds. To prevent this risk, the Commission has proposed to require such functionalities to be expressly authorised by digital Euro users (European Commission 2023, p. 25); however, it does not specify whether an express authorisation would be required for every transaction exceeding the limit or if it suffices

to choose that feature in the account settings. In case the authorisation would not be required for every transaction, then the ECB should develop a safe system to ensure trust in the digital Euro. More in detail, PSPs could contribute to the creation of said system as they already have gained experience with the provision of debit and credit card services.

Further, the proposal addressed the fees applied by PSPs for the provision of the service. The document reported that "fees and charges are uniform across the euro area and proportionate" and "fees or charges are not higher than those requested for comparable private digital means of payment" (European Commission 2023, p. 27). More specifically, European authorities shall supervise the digital Euro holdings and avoid excessive concentration. In fact, specific sanctions shall be implemented to curb monopolistic behaviours, should a PSP get an edge over competitors. Instead, for what concerns offline payments, the ECB shall ascertain that fees would not be applied: only in that case, the digital Euro would be an effective complement of cash as it would share its two constituting features, respectively privacy and absence of costs.

Finally, the ECB shall pay attention to an excessive diffusion of the digital Euro. This new currency in fact, could have an impact on the size and composition of its balance sheet but could also have repercussions on monetary sovereignty and financial stability of foreign central banks. It could be argued that the Euro may benefit from an extensive distribution of its digital form that could help the currency of the Union to further improve its status, but the ECB shall be careful not to destabilize the central banks of non-Euro area member countries. Currently, the Euro is the official currency of twenty out of twenty-seven members, but the digital Euro could be harmful for the remaining seven countries, should it replace local currency. In fact, pursuant to Article 13 of the proposal of regulation, digital Euro payment services should be provided by PSPs to "natural and legal persons residing or established in the Member States whose currency is the Euro, natural and legal persons who opened a digital euro account at the time they resided or were established in the Member States whose currency is the euro, but no longer reside or are established in such Member States, visitors, natural and legal persons residing or established in Member States whose currency is not the euro, subject to the conditions laid down in Article 18 and natural and legal persons residing or established in third countries, including territories under a monetary agreement with the Union, subject to the conditions laid down in Articles 19 and 20" (European Commission 2023, p. 44). A

replacement of national currency would in fact interfere with the principles set in Article 140 TFEU (European Commission 2023, p. 27).

In July 2023, the ECB published the fourth and last intermediate report on the investigation phase. The document mainly treated the compensation model and the distribution options, but it also reported the outcome of the market research on the interaction with the private sector for the development of the digital currency. For what concerns the compensation model, the ECB ensures that all stakeholders could conveniently pay, receive and distribute the digital Euro. Finding the right balance not to discourage any stakeholder group to participate in the project is a hard task and free interaction would prove sufficient to strike a balance; nevertheless, the ECB set some guidelines so that the core principles are met. Firstly, private customers should not be charged for basic use[117] of digital Euro, given the costless nature of cash that the digital Euro aims to replicate. Secondly, merchants shall not be excessively charged to offer such payment method. In fact, this stakeholder group would have little bargaining power vis-a-vis PSPs, as they would be legally obliged to offer the said service. The point mentioned could be an obstacle to the diffusion of the digital currency, especially in cash-prone areas where merchants already oppose card payments. Thirdly, the ECB has identified two distinct subgroups amongst PSPs: those distributing the digital Euro to the public and those charging fees to the merchants for digital Euro acquiring services (ECB 2023d, p. 6). It then requires an inter-PSP fee to maintain a fair balance of incentives. Finally, being a public good, the ECB would bear its own cost, as it already does today for the banknotes. To sum up, the picture looks quite convoluted and, as mentioned in the analysis of the proposal for a regulation, the fees to be awarded are crucial for the success of the digital Euro project.

The second theme of the report deepens on the portability arrangements, fraud detection and prevention, the digital financial inclusion and the roll-out approach. The novelty of the document resides in the system for the transfer of digital Euro holdings between two PSPs for which the involvement of the central bank is not necessary; more specifically, the new intermediary would be able to acquire the necessary data directly

[117] Please see page 6 of the *Progress on the investigation phase of a digital euro – fourth report* (ECB 2023d) for a detailed list of the basic services to provide for free.

from the previous one. This could alleviate the central bank's burden in terms of data transfers.

Further, to safeguard financial inclusion, the report calls for a card version of the digital Euro and the establishment of a licensed entity to provide support in the onboarding process. Namely, the said entity would be in charge of "providing access to digital euro services and the necessary support, to those vulnerable to digital financial exclusion, without any cost to the eligible individuals" (ECB 2023d, p. 9). More in detail, dedicated face-to-face interaction could be offered to those in need. This is an unexpected yet welcomed approach in a world that risks leaving people with low digital and financial skills behind.

Finally, the report sheds a light on how the ECB may release the digital Euro. A gradual roll-out is foreseeable given the complexity of the project, in analogy to what other central banks have done[118], to ensure a smooth adoption of the currency. The prefigured first release could possibly be dedicated to P2P and e-commerce payments only (both online and offline), while it would take longer to build the infrastructure to pay and receive digital Euros in physical stores, according to the report (ECB 2023d, p.10). Concerning the market research to obtain feedback from the private sector on the potential technical solutions, the ECB reports that many European providers would be ready to develop digital Euro infrastructures so to foster a productive public-private sector interaction to introduce a fully European currency, independent of the major international players of the digital payment industry (ECB 2023d, p. 13).

The investigation phase of the digital Euro formally ended on October 18th 2023 with the publication of the report *A stocktake on the digital euro, summary report on the investigation phase and outlook on the next phase* (ECB 2023a). As the name suggests it is a collection of the developments and implementations occurred in the two preceding years and that would set the basis for the subsequent preparation phase. The report transcribes for a large part what can be found in the mentioned documents, yet there are some novel ideas that have not been mentioned nor deeply investigated.

The ECB would allow multiple commercial bank accounts to be associated to the digital Euro account; however, only one may be designated for the waterfall and reverse waterfall functions (ECB 2023a, p. 15). In principle, a user is not required to choose the

[118] As an example, China launched its digital yuan pilot programme in selected cities.

same PSP for the provision of digital Euro and classical banking services; still PSPs would try to lock in their clients also by offering dedicated functionalities to integrate the two services provided in the same app[119]. This choice was done in a competition perspective; indeed, users would be free to choose the best PSP for their digital Euro account, based on their preferences. By doing so, the ECB would foster technological development as not only well-established credit institutions could manage user's holdings but also the PSPs defined according to the PSD2, including also electronic money institutes. Given the multitude of accounts and consequently of data stored by PSPs, the ECB shall implement the required safeguards so that the balance of the digital Euro accounts may not be visible to the PSP providing the digital Euro and vice versa.

Consequently, the ECB reported the funding modalities that had been tested in the two-year long investigation phase. Namely, the digital Euro may be used as a budget management tool as people could opt for an automated funding so to better assess their cash outflows. Moreover, a case by case (manual) functionality would be admitted, together with a "continuous reverse waterfall" functionality (ECB 2023a, p. 15). This last option would allow users to pay in digital Euros with no prefunding necessary. More practically, the conversion between commercial bank money and digital Euros would be immediately executed anytime the user opts to pay in central bank money.

Further, the ECB lays down the allocation of the activities. Taking a quick glance, the Eurosystem would be responsible only for the settlement procedures, whilst the end user onboarding and servicing, the payment initiation and validation, post settlement activities and the offboarding would be carried out by PSPs. In analogy to what currently occurs with the creation of an account, digital Euro individual users would be provided with credentials (including a DEAN[120]), an app to access the holdings, the possibility to register aliases (such as a phone number) linked to the DEAN and a physical card, if requested (ECB 2023a, p. 20). Business users instead, would be provided one or multiple DEANs, an app and an upgrade for their POS/virtual terminal to enable the acceptance of digital Euro payments. Therefore, it could be inferred that it should not be hard for merchants to learn how to receive those payments given that they are already accustomed to card payments.

[119] According to the document, PSPs would be free to implement a user interface to access the digital Euro holdings directly in an existing proprietary application (ECB 2023a, p. 20).
[120] Digital Euro Account Number, serving the functions of an IBAN (ECB 2023a, p. 20).

Then the report provided an overview of the dispute management (ECB 2023a, p.26). The scheme comprises three phases to safeguard users: a pre-dispute, a dispute resolution and an arbitration. In the first, payers and payees should try to clarify the underlying case through their PSPs; should it not be sufficient, a second phase that requires the direct involvement of PSPs may solve the issue and finally an arbitration of a third party other than the Eurosystem. The ECB would also implement a platform to allow parties to initiate and resolve their disputes. Nevertheless, the system seems at an initial stage and more details on the dispute management are expected to be released in subsequent reports and legal documents.

Finally, for what concerns the liquidity management, the ECB states clearly that PSPs would have to make digital funding and defunding available to users on a 24/7/365 basis as well as defunding via cash (ECB 2023a, p. 22). Clearly, the 24/7/365 funding and defunding requirement is easily satisfied by digital forms while the funding and defunding via cash cannot be ascertained instead. In fact, this would require using ATMs, but not all machines allow to both withdraw and deposit banknotes. Moreover, ATMs are being dismissed thereby reducing the number of access points to cash[121] for digital Euro users, and people enlarged. For the reverse waterfall functionality instead, the ECB has proposed an innovative solution for those PSPs that have in place restrictive policies on the funds that may be withdrawn from a user's commercial bank account without pre-notice. The novel idea resides in the digital Euro issuance with a consequent reduction in the PSP's central bank money balance (reserves). By doing so, the ECB provided a viable method for users to have digital Euros readily available, regardless of the limits imposed, the underlying principle being the interconvertibility of central bank money.

III.5.3. The preparation phase

The new phase started in November 2023 and, in an introductory statement released in February, Piero Cipollone[122] reported that the four key issues of the preparation phase would be the "search for possible providers to develop a digital euro platform and infrastructure, the preparation of the digital euro rulebook, the stability of

[121] See the *5th issue of the Economic bulletin* for a deeper understanding of the downward trend in access points to cash. (ECB 2022d, p. 94).
[122] Member of the Executive Board at the ECB.

the financial system, and offering a higher level of privacy when making digital payments" (ECB 2024c). It can be decomposed into two sub-phases: the first that would last two years and the second still to be defined. Specifically, it would be the Governing Council's task to choose whether to continue with the second stage after a thoughtful analysis of the results of the first and the legislative developments. According to the final report on the investigation phase (ECB 2023a, p. 44), in the first stage "the Eurosystem will focus on further testing and experimenting and will continue to consult with all stakeholders, including the public, to ensure a digital euro meets the highest standards of quality, security and usability". In fact, the ECB already launched five calls for applications to establish framework agreements with potential providers of digital Euro components and services to develop the alias lookup component[123], the fraud and risk management component, the app and software kit developments, the offline service components, and the secure exchange of payment information component (ECB 2024d). The call for applications shall be interpreted both as an attempt to integrate the public and private sector as well as a request for aid in the development of the digital Euro. In fact, the ECB has gained experience in the digital payment area, as an example through the implementation of the TARGET 2 settlement system[124], that could be useful in the digital Euro project as well. However, the offline functionality would be a first of a kind and therefore should be scrutinised[125].

Another hint at the difficulties that offline payments may entail can be found in the opinion of the ECB on the digital Euro[126]. The document reports the proposed comments and modifications of the Frankfurt-based authority to the proposal of regulation published in June 2023. The ECB is fully committed to deliver both the online and offline functionalities in the first release, in compliance with the proposal of regulation, but also reminds that should any unexpected circumstance occur, it would be constrained to postpone the launch of the project so to have both features in the first release.

[123] In layman's terms, it is the set of credentials that could be used in place of account numbers to facilitate transactions (e.g. phone number, e-mail, etc...).
[124] TARGET2 is the real-time gross settlement (RTGS) system owned and operated by the Eurosystem.
[125] Cipollone further stated in a letter to the Chair of the Committee on Economic and Monetary Affairs (ECON), Irene Tinagli, that the call would be useful "particularly for components that are not yet on the market, such as offline functionality" (ECB 2024f, p. 2).
[126] European Central Bank Opinion (EU) No. 34/2023 of 31 October 2023.

Moreover, the document offers interesting causes for reflection to better draft the regulation. In fact, the ECB proposes to enlarge the definition of "comparable means of payment"[127] to comprise all payment instruments that may be used in a digital environment. Indeed, the definition should also include the situations in which credit transfers and direct debits are not initiated at the point of interaction (European Central bank opinion, p. 5). The proposed modification would safeguard users as PSPs would not be able to levy unreasonable fees for the provision of said services[128]. In the same view, the ECB proposes to expand the list of basic services granted for free by PSPs to funding, defunding and change of PSPs (European Central bank opinion, p. 10). By doing so, users would not encounter unexpected charges whenever they reach the holding limit and would be forced to defund the account. Moreover, they would not be tied to one specific PSP, due to excessively high switching fees. Finally, the ECB stated that if digital Euro payments could be concluded with the same terminal already available to merchants, they should not incur further fees for the provision of the service (European Central bank opinion, p. 14).

Together with the ECB, another group is working on the digital Euro project: the Rulebook Development Group (or simply RDG). The group was established in January 2023[129] and its purpose is to define the roles of all actors involved in the digital Euro ecosystem (ECB 2024e, p. 1). In their second update, they define the relationships amongst the different actors and develop step by step guidelines to smooth the application process of the digital Euro. The group has mainly focused on the end user and intermediary onboarding and offboarding and on their lifecycle management processes, but also on the liquidity management activities comprising funding, defunding and the two waterfall functions. Finally, it has also studied the transaction management procedures and the architectures and standards to define the digital Euro interfaces. The

[127] See Article 2, point (25), of the proposal of regulation.

[128] According to Article 17 of the proposal of regulation: "any merchant service charge or inter-PSP fee in relation to digital euro payment transactions shall comply with the principle of proportionality. Any merchant service charge or inter-PSP fee shall not exceed the lowest of the following two amounts:
(a) the relevant costs incurred by payment services providers for the provision of digital euro payments, including a reasonable margin of profit;
(b) fees or charges requested for comparable digital means of payment" (European Commission and the Council 2023, p. 47).

[129] According to the *Update on the work of the digital euro scheme's Rulebook Development Group* (ECB 2024e, p.1).

reason for the establishment of this specialised group must be found in the need to come up with a uniform digital Euro; in fact, the Union has finally the chance to integrate the European payment system being independent of the major international players in the industry. In an interview released in April 2024, Piero Cipollone in fact identified three hurdles still in place: a payment system that remains fragmented along national lines[130], a limited competition in the digital payment industry and the dependence on non-European players. The member of the Executive Board consequently called for a tighter European control over the payment industry. To conclude, the preparation phase would be key for the development of the digital Euro as European authorities shall work unwaveringly to develop cutting-edge solutions to finally integrate the payment system.

IV. IMPLICATIONS OF THE DIGITAL EURO

Despite a final decision on the features of the digital Euro is still pending, the information collected so far allow to make inferences on the possible implications for the banking sector, the macroeconomic policies and, finally, for households. In fact, to assess whether the benefits would outnumber the downsides of the digital Euro, a thorough analysis of these three aspects is necessary having in mind the most accredited characteristics of the new digital currency: the cash-like features, the online and offline functionalities and the foreseeable 3000 Euro holding limit.

IV.1. Banking sector implications

One of the main actors of the digital Euro project would be the banking sector as it would be responsible for the distribution, authentication and check processes. The classical banking business is founded on the collection of deposits and loan issuance and, regardless of the limits imposed, the digital Euro would affect this relationship and therefore spark considerations on how to substitute this form of funding. In fact, deposits are amongst the cheapest form of financing for commercial banks (Beau *et al.* 2014, p. 11), and given the possibility to fund digital Euro wallets directly from the deposit

[130] More specifically, European solutions are confined within national borders and there is not a European digital solution for P2P payments covering the entire Euro area (ECB 2024g). To provide further clarity, a European PayPal has not been introduced yet.

account, banks would lose up to 3000 Euro per bank account[131]. However, the banking business has evolved and a decrease in deposits would not necessarily lead to a drop in loan issuances[132]. Indeed, commercial banks in Europe have plenty of funding measures; according to Adalid *et al*. (2022, p. 29), as an example they could resort to the interbank market (Short, Medium and Long-term financing), central bank funding and even debt and equity issuance.

Leaving the ECB's intentions to issue a CBDC akin to banknotes[133] aside, the academic literature has tried to assess whether the deposit substitution concerns expressed by commercial banks are reasonable. It can be concluded that credit institutions should not worry about deposit substitution, as a considerable portion of deposits should be exchanged for digital Euros to witness significant changes in their balance sheets[134]. In fact, as pointed out by Lambert *et al.* (2024, p. 11), reserves could be redirected, and banks' assets could be left untouched. Nevertheless, a punctual analysis of the implications for commercial banks' balance sheets is necessary so to understand how the system would react to the introduction of the digital currency[135].

In the paper by Infante *et al.* (2022) three scenarios are hypothesized to classify the balance sheet mechanics of commercial banks, central banks and households with the advent of a CBDC. The first is called the "cash-CBDC reallocation" and consists of an exchange of cash for CBDC (Infante *et al.* 2022, p. 25). The scenario is plausible for the digital Euro, especially in the case of a 500-1000 Euro holding limit where the wallet would be akin to a digital version of banknotes. In the said case, the balance sheets would remain unchanged with the ECB liabilities and households' assets moving from cash to

[131] If the said threshold would be left unchanged. As previously mentioned, the said limit was proposed by a former Member of the Executive Board at the ECB, Fabio Panetta, in 2021 and would be suitable for a cash-like CBDC. However, changes to the said limit may occur, also in light of the letter sent by the European CFO network (a group comprising the 27 largest banks' CFOs in Europe) in 2023 calling for a 500-1000 Euro threshold (ECB 2023e). In the said scenario, the effects for banks would be limited.

[132] A drop in loan issuances to match the right-hand side and left-hand side of the balance sheet would surely occur in the presented fictitious scenario with loans and deposits as the only two forms of assets and liabilities.

[133] Therefore, non-interest-bearing and not in competition with commercial bank deposits.

[134] More specifically, Auer *et al.* (2024, p. 51) and Lambert *et al.* (2024, p. 13) calculate that percentage to be 15 %.

[135] In fact, as reported by Auer *et al.* (2024, p. 17) a non-interest-bearing digital currency would still trigger a shift from deposits under two circumstances: in periods of instability, as a flight to safety, and when interest rates are at the effective lower bound, as households would prefer zero interest bearing assets (CBDCs) rather than negative interest, riskier deposits.

CBDC for the amount converted. The second is called the "CBDC injection" and could materialise in case households exchange government bonds for digital Euros (Infante *et al.* 2022, p. 25). Also, in this case there would be no implications for commercial banks' balance sheets but, conversely from the former, this scenario is unlikely to occur.

The remaining three would imply balance sheets' expansions or contractions and would have macroeconomic implications. The first is the "bank disintermediation" in which households would exchange deposits at commercial banks for digital Euros (Infante *et al.* 2022, p. 26). The scenario perfectly fits the European digital currency as it would materialize when households top up their wallets from the associated bank account. In technical terms, households' balance sheets would be unchanged as the increase in CBDCs would be matched by a decrease in bank deposits, the commercial banks' would in turn shrink as the reduction in deposits would be offset by a decrease in reserves, and finally the central bank's would stay still as the CBDC increase would be counterweighted by a reduction in reserves on the liability side. The resulting drop in deposits could be troublesome for commercial banks as it would affect their cost of funding, competitiveness and the regulatory requirements (e.g. Liquidity coverage ratio (LCR) and Net stable funding ratio (NSFR)[136]). Nevertheless, the € 3000 threshold would be sufficiently low not to cause sudden changes in the bank's balance sheets. More in detail, in the study by Lambert *et al.* (2024, p. 10), it has been demonstrated that the estimated maximum outflows of overnight household deposits with the € 3000 limit is around 9%, well below the aforementioned 15 % that would result in significant changes for the banks. This implies that, should an overnight rush to deposits occur, the banking sector would still be able to reallocate reserves[137] without the need to sell assets.

Under a bank disintermediation scenario, the ECB may react mainly in two ways that are classified by Infante *et al.* (2022, p. 27) as "banking contraction" and "bank funding contraction". In the first case, the ECB could intervene by buying government

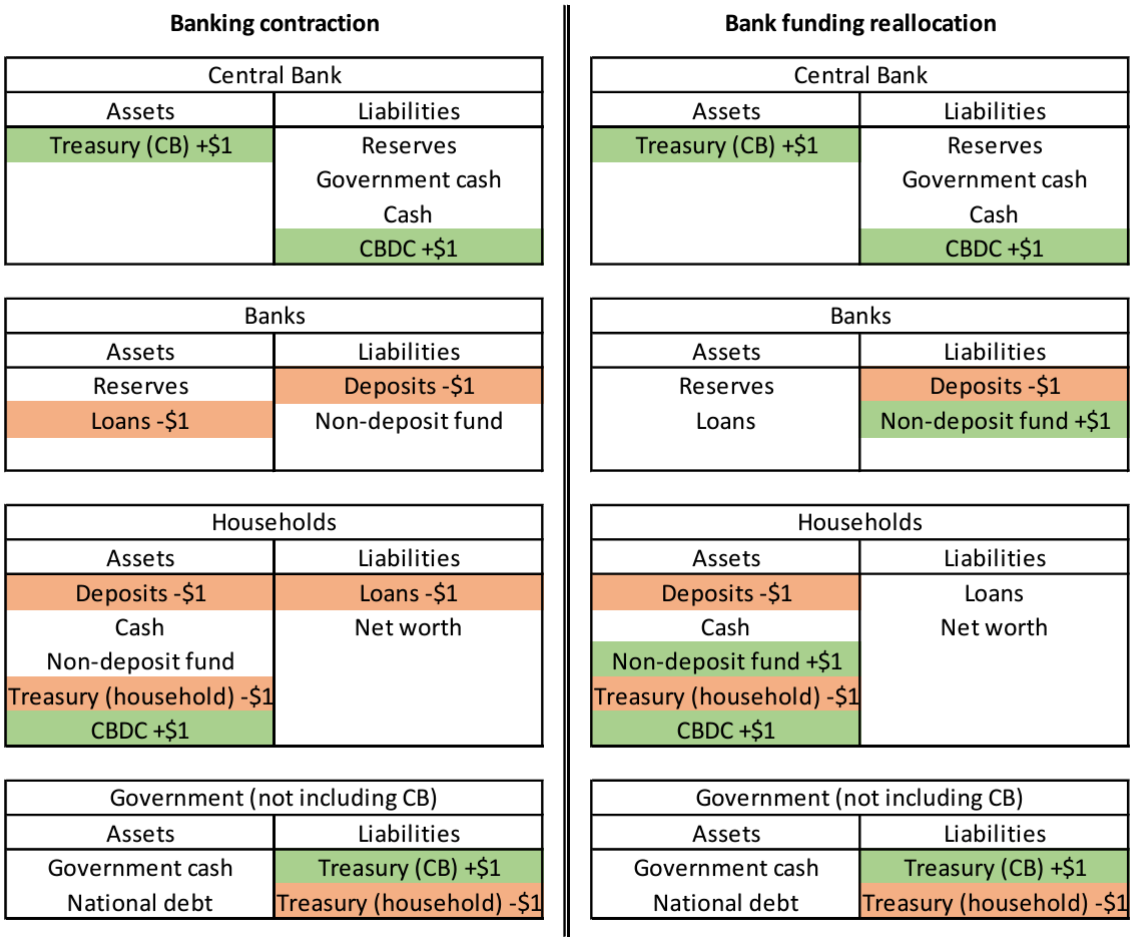
[136] These two measures of banks' stability were introduced following to the Basel III agreements. The LCR "promotes the banks' resilience to a sudden reduction in short-term funding. The requirement aims to ensure that intermediaries have an adequate stock of assets that can be easily and immediately sold in private markets to meet their liquidity needs under a stressed scenario lasting for 30 calendar days" while the NSFR is the ratio of the amount of available stable funding to the amount of required stable funding over a one-year horizon and should be greater than 100 per cent" (Auer *et al.* 2024, p. 19).

[137] The importance of reserves derives from their role as capital buffer. More specifically, in the calculation of the LCR, they affect the numeraire as they are comprised in the HQLA (High quality liquid assets); an excessive reduction would diminish the value and may lead to undercapitalization.

bonds from households through commercial banks, causing an increase in households' deposits and thereby replenishing indirectly commercial banks reserves This would reestablish the equilibrium in the banking sector. Then, once households' deposits are replenished, they may allocate their money as they prefer (e.g. repaying loans, or holding it in cash form, as deposits or as digital Euros). The net impact would be an expansion in the central bank balance sheet (due to the increase in assets (government bonds) and liabilities (CBDCs)), a reduction in the banks' balance sheet (loans and deposits would diminish) and finally, households' balance sheets would deleverage as loans would be repaid (Infante *et al.* 2022, pp. 27-28). Under this scenario, the rationale for the ECB intervention would be to restore the safety of the system and keep commercial banks' reserves unaltered.

Alternatively, the effects of the "bank disintermediation" could be mitigated through the "bank funding reallocation" (Infante *et al.* 2022, p. 28). In fact, another option households enjoy once they sell their government bonds is to provide money to the banking system in the form of non-deposit bank funding (e.g. investment in commercial banks bonds, shares and funds). The two scenarios are represented by the graph below with Treasuries to be intended as government bonds, given that the study was carried out in the United States.

Figure 6: Balance sheets comparison in banking contraction and bank funding reallocation scenarios



Source: Infante, S. *et al.* (2022) *The Macroeconomic Implications of CBDC: A Review of the Literature*

The scenarios presented hinge on a substitution of deposits with alternative sources of financing such as non-deposit funding; another way of financing for credit institutions would be the ECB deposit or marginal lending facility (depending on the bank's needs). However, as previously mentioned, deposits are considered economically convenient funds compared to the other alternative sources, and the impact of deposit substitution on banks' profitability in terms of RoE would have opposite signs depending on how they would be replaced: negative with non-deposit funding and positive with negatively remunerated reserves[138]. Given that it would be more convenient to fund

[138] However, the paper by Auer *et al.* (2024, p. 34), warns that the impact may turn negative, should reserves be positively remunerated.

CBDCs with reserves, Auer *et al.* (2024, p. 34) expect a positive relationship between CBDCs issuance and excess reserves.

Two papers that investigated commercial banks' responses to deposit outflows were those by Meller and Soons (2023) and Auer *et al.* (2024); the first insisted on Euro area banks, while the latter on Italian credit institutions. They both are insightful and have similar findings, but given the European nature of the research, the first will be treated more deeply. It simulates a fictitious digital Euro introduction in 2021 and examines how European commercial banks[139] would cope with deposit substitution[140]. They considered a baseline scenario with banks willing to draw down half of the voluntary liquidity buffers in excess of the minimum regulatory requirements in an interconnected interbank market (conformable to the European scenario). Concerning the funding costs, short-term liquidity, secured funds, and market funds were rightfully assumed to be cheaper than long-term liquidity, unsecured funds and central bank funds, respectively.

They solve a constrained optimization problem[141] to study the best response function. In brief, the study moves along four directions: the connectedness of the interbank market, commercial banks' policies in terms of LCR and NSFR (either allowing them to float until they reach the consented limit (Scenario A), keeping at least half of the excess buffer those banks had (Scenario B) or keeping those ratios at their starting level (Scenario C)), the deposit outflow percentage and the banks size. Assuming a € 3000 limit per account, the most extreme scenario would be an outflow of 1 trillion[142] Euros, in which all depositors would reach the holding threshold. Based on 2021 data, it emerges that under Scenario B, even a 1 trillion Euros deposit outflow would have had little impact

[139] Specifically, the sample comprised more than 2000 Euro area banks (Meller and Soons 2023, p. 5).
[140] According to Meller and Soons (2023, pp. 4-5), when retail depositors withdraw funds from a bank to exchange them for digital Euros, their bank will transfer either banknotes or reserves to the national central bank. In case of shortages, the bank could borrow in the interbank market or from the central bank and would need to adjust its balance sheet considering the relative costs, and the regulatory requirements (the NSFR and LCR in the paper).
[141] Namely, researchers assumed that for any deposit outflow, any bank would choose to readjust its balance sheet to maximise the spread between the change in interest income and cost of funding (Meller and Soons 2023, p. 38). The constraints imposed matching deposit outflows with reserves held at the central bank or borrowed in the interbank market, ensured that each bank could not lend or draw more central bank reserves than it owns. Moreover, they captured the aggregate interbank market liquidity position, as well as commercial banks' stocks of HQLAs and regulatory requirements (LCR and NSFR) (Meller and Soons 2023, p. 39).
[142] It would roughly consist of a 15 % outflow of deposits held in the Euro area in Q3, 2021 (Meller and Soons 20223, p. 33).

on the Eurosystem as banks could have borrowed funds in the interbank market (Meller and Soons 2023, p. 6). The banking sector would have experienced a significant shift (over 10 % in total assets) towards wholesale funding only if outflows exceeded 28 % of retail deposits (Meller and Soons 2023, p. 6). Further, even under Scenario C with banks willing to keep their ratios high and reluctant to lend in the interbank market, only a 16 % outflow of retail deposits would have resulted in more than 10 % of the longer-term central bank funding to be sought against non-eligible collateral (Meller and Soons 2023, p. 19) with significant effects on banks' profitability. However, 16 % and 28 % outflows would be unrealistic given the holding threshold.

Then, researchers investigated the impact on banks' balance sheets, should they have resorted to central bank or wholesale funding. Regardless of the safety and stability of central bank funding, an excessive reliance on the ECB may expose the Eurosystem to counterparty and market risk and affect banks' profitability, being a costly form of financing. The paper found evidence to sustain the insignificant effect of digital Euro, as even under scenario C, less than 10 % of the banking sector would have experienced an unusually high increase in central bank reliance in the event of a 15 % deposit outflow (extreme case). More specifically, the effect would have been more pronounced for LSIs (Meller and Soons 2023, p. 21). Unsurprisingly, under scenario B, an irrational 32 % outflow in deposits would have triggered material changes in central bank funding (Meller and Soons 2023, p. 21). Moreover, a slow introduction of the digital currency would render any changes to central bank reliance less drastic, enabling commercial banks to adapt and reduce the impact on their profitability.

The paper considered five types of interbank (wholesale) funding in ascending order of riskiness and cost: short term secured, medium term secured, short term unsecured, medium term unsecured and long term (Meller and Soons 2023, p. 23). The banks in the model then faced a choice as the cheapest funding, short term secured, would have negatively affected their LCRs and NSFRs by increasing their liquidity risk; whilst unsecured debt would have been costlier, but it would not have impacted the regulatory requirements. However, the situation in terms of profitability is reassuring: under scenario B, even with a 15 % outflow of deposits, only 1 % of banks would supposedly have relied on the costliest long term unsecured funding (Meller and Soons 2023, p. 23). Analogously to central bank funding, a smoother adoption of the digital currency would have changed

wholesale funding reliance even less by allowing commercial banks to adapt to deposit shortages (Meller and Soons 2023, p. 24).

The ECB paper further assessed the impact of a digital Euro in a lower reserve environment (Q3 2019) as the 2021 framework considered before may have been too specific given the pandemic and the consistent reserves held by commercial banks at the ECB. Running the same simulation, the findings were different, but the overall stability was still granted. Under scenario B, a 12 % deposit outflow (equating 0.7 trillion Euros) would have triggered central bank funding (Meller and Soons 2023, p. 26). Said outflow corresponds to an average balance of 2100 digital Euros for each depositor: a possible, yet improbable level. Further, most banks would have qualified for secured funding from the Eurosystem (Meller and Soons 2023, p. 27), so the implications on profitability would have been limited.

Finally, the researchers examined other two alternative scenarios using 2021 data: a segmented interbank market and a retail bank run. Despite being realistic scenarios, the ECB would not rationally release the digital Euro under those circumstances; however, an overview would provide further evidence to sustain the digital Euro as even in these cases, the implications would be manageable. The first could materialise under economic uncertainty with banks lending channels functioning at a national rather than European level. The study pinpointed that, under scenario B, the banking sector would have accommodated the demand without requiring additional reserves. Some states would have been best placed to do so (Belgium, Cyprus and Luxemburg), but no Euro area banking system would have suffered (Meller and Soons 2023, p. 28). The model does not discriminate amongst various causes for a bank run, but rather considers it simply as a rapid outflow of deposits (Meller and Soons 2023, p. 29). Also in this situation, the 3000 Euro holding limit was found suitable to contain liquidity risks with some LSIs and only three systemic institutions breaching the regulatory requirements for lower deposit outflows.

The evidence presented highlights how a € 3000 holding limit would prove sufficient to safeguard the overall system. The ECB would nevertheless carefully decide the most suitable launching date for the digital currency as some institutions (mainly LSIs) may suffer under specific scenarios and considerable deposit outflows.

The study by Auer *et al.* (2024) also found that smaller credit institutions would suffer more than major banks under distressed scenarios, while the effects on profitability for lower deposit outflows would be similar across institutions (Auer *et al.* 2024, p. 43). The point addressed however calls for a closer examination, especially considered the high number of European LSIs; in fact, despite modern trends pointing towards banking conglomerates, there are about 2000 LSIs on the European soil[143]. The matter is of particular interest for the implications that it will bring at a local level (especially for the Austrian, German and Italian sector, given the key role those institutions play in their economies).

The rationale behind this divergence must be found in the banks' core businesses. Most of the LSIs belong to the cooperative sector and saving network (SRB 2023, p. 8) and rely on the founding paradigm of the banking business: deposit creation and loan issuance. For those institutions it would be more challenging to resort to non-deposit funding, and this could negatively affect local enterprises too; according to Whited, Wu and Xiao (2023, p. 6), CBDCs would lead to a drop in banks' lending three times the size for small banks as for large banks. Additionally, a CBDC take up would affect smaller institutions also curtailing the synergies between banks' assets and liabilities. As reported by Infante *et al.* (2022, p. 14), credit lines (LSIs' core businesses) immediately associate an asset to a liability for a bank and economize their business in two ways. Primarily, they permit credit institutions to keep deposits for realised transactions only; secondly, they allow banks not to rush to invest in assets to back their deposits, consequently avoiding unexpected losses due to excessive risk.

As it can be inferred from the studies cited, a consistent strand of literature started from commercial banks' worries of deposit substitution and developed numerous models and econometric analysis to investigate the effects. However, the digital Euro could have positive repercussions too. According to Infante *et al.* (2022, p. 18), despite the negative implication for banks' profitability due to the deposits drop, a wholesale CBDC would be useful not to block the payment system in case of a bank run. Indeed, it could be inferred that a digital Euro could be a viable option under said circumstances, regardless of the originating cause. Bank runs in fact could occur due to multiple reasons ranging from

[143] According to the Single Resolution Board, Austria, Germany and Italy with 1500 incorporated LSIs, account for 75% of those institutions (SRB 2023, p. 8).

perceived uncertainty of the banking sector to specific bank related news, as well as a sudden tightening of monetary policy (and consequent drop in assets value)[144], still users would be able to complete transactions in digital Euros with their digital wallet.

Moreover, commercial banks shall see the innovation as a profit opportunity. Users' demand shall be matched by the provision of services and, despite the basic ones would likely be offered for free, they have plenty of room to innovate and could earn on the fees applied for ancillary services. The digital Euro in fact could incentivize tech companies and tech departments at credit institutions to develop ad hoc characteristics to better serve their clients and possibly convince new customers to transfer their funds at that credit institution. As an example, banks could boost their customer loyalty favouring their depositors smoothing the waterfall and reverse waterfall functionalities or could offer favourable rates on the deposits for new digital Euro users willing to transfer their bank accounts too. Regardless of the specific incentives provided, commercial banks would surely strive for customers, and in the cost benefit evaluation of the digital Euro also the positive spillovers in terms of job creation and inter-industry synergies must be considered. Focusing on the competition process, an initial scenario with customers opening accounts at different PSPs could be reasonable, especially because said behaviour is expected to be permitted by the regulation. That would be a springboard for creativity and innovation to capture potential users. Then, as it usually occurs, a leading standard would probably emerge, and banks would be more constrained on their ability to innovate.

IV.2. European monetary policy implications

Moving to the implications that more directly affect central banks, it seems reasonable to start from the reduction in crypto assets holdings (that would consequently affect deposits, and therefore monetary policy) to continue with the analysis of CBDC-related effects on deposits and demonstrate that the digital Euro could also lead to an increase in the said demand. Clearly, the bulk of the demand for cryptoassets would be left untouched by the introduction of the digital Euro, given the sparking differences amongst CBDCs and cryptocurrencies, yet some holders may be willing to switch back

[144] As an example, the 2023 Silicon Valley bank default mainly occurred due to its over exposure to government bonds and a hawkish monetary policy by the FED.

to central bank money. The potential switchers would not be crypto enthusiasts nor speculators, rather those that purchased mainly stablecoins and that could consider the digital currency a valid alternative. Indeed, once the ECB would have introduced the digital Euro, it would enjoy a competitive advantage (the legal tender status) and consequently, there would be little room for stablecoins to exist. Those stablecoin holders then, could direct their funds to the digital Euro, but they would be limited to do so by the holding threshold; therefore, any excess could be reverted to deposits. Having described the rationale for a boost in the demand for deposits (that would probably be lower in absolute terms than the digital Euro-related deposit substitution), it is time to describe how central banks might be affected. This would occur through the bank lending channel: commercial banks' profitability would be aided by the reduction in funding cost and those institutions would respond lowering the interest rate charged on loans, resulting in a loosening of the financial condition. The ECB could then have a hawkish approach or leave the interest rates unchanged, after a thorough analysis of the magnitude of the said increase in demand.

The bank lending channel however is not the only channel of the transmission of monetary policy; namely, there are the interest rate, the asset price and the exchange rate channels[145] too. Das *et al.* (2023) published a report where they closely examined said effects and found that the overall effect of a CBDC would be to strengthen those transmission channels (Das *et al.* 2023, p. 17). The peculiarity of the study is that the CBDC considered ("a non-remunerated retail CBDC that is accessible only domestically" (Das *et al.* 2023, p. 6)) could well resemble the first release of the digital Euro. The study found that an increased competition for bank deposit funding could strengthen the interest rate and bank lending channels (Das *et al.*2023, p. 17). More in detail, the pass-through from policy rates to deposit rates would be stronger due to the heightened competition and consequent reduction in each bank's market power. However, the lower the degree

[145] According to Das *et al.* (2023, pp. 16-17), monetary policy transmission through the interest rate channel occurs when changes in the policy rate affect the level of interest rates in the economy and, in turn, the overall demand for credit. More specifically, changes in the interest rate would alter the marginal cost of borrowing and induce households and firms to rebalance investment and consumption needs. Monetary policy through the asset price channel occurs with interest rates affecting borrowers' balance sheets quality (mainly equity and bonds) that in turn affects the creditworthiness and costs of borrowing. Finally, the exchange rate channel works through net exports: when monetary policy rate is tightened, domestic real interest rates rise, and domestic deposits are preferred due to a higher interest paid. In the short run, before price rebalancing, this would lead to a real appreciation of the currency and a contraction of net exports.

of substitutability between CBDCs and bank deposits, the lower the pass-through (Auer *et al.* 2024, p.27). For the digital Euro, this may result in an insignificant strengthening given the cash-like features. Moreover, the bank lending channel would be affected by increased wholesale funding. Especially larger institutions rely on this form of financing that is more sensible to changes in the monetary policy than deposit rates; consequently, this would affect the overall funding cost and therefore banks' lending rates and standards.

For what concerns the interest rate and asset price channels instead, financial inclusion would be a driver of change. In fact, the digital Euro has the potential to enhance financial inclusion for the unbanked. It would mainly work through the cost reduction as the primary reasons not to hold a bank account were fees and minimum balance requirements, according to Infante *et al.* (2022, p. 12). The digital Euro would be fit to promote financial inclusion as at least the basic services would be offered for free to anyone possessing a digital device. Moreover, the ECB, with its stated commitment to provide physical card and free interchange of digital Euros with banknotes is set to widen the diffusion of its digital currency even more. On the contrary, privacy concerns may hinder the goal and remain an insuperable obstacle to a complete financial inclusion, regardless of the fees applied by banks.

In practice, higher degrees of financial inclusion would allow monetary policy to be more effective as the pool of Euro users would enlarge. More people would then make intertemporal budget choices being faced with the possibility to spend or save Euros and, consequently, asset prices would be affected too. One could argue that a large percentage of the unbanked would not be in the position to save money, yet the digital Euro wallet could be a starting point that could eventually lead to the opening of a bank account. Moreover, the implied absence of carrying cost, compared to cash would be an incentive to adopt it. On the other side, the aggregate impact of financial inclusion is limited by the relative share of the financially excluded population that, due to the inclusion policies already adopted, is currently low[146].

[146] According to Demirgüç-Kunt *et al.* (2021), 3.6 % of the European population remained financially excluded in 2021. Despite the improvements compared to the 2017 situation (8.2 % unbanked), there are great divergencies in European countries' shares with the best in class being Denmark and Austria, whose unbanked population remained below 0.5%, and the worst being Romania with more than 30 % still financially excluded.

So far, reserves have been mentioned only in conjunction with deposits as it was proven that a common response of commercial banks to the drop in deposits would be to reduce them, consequently shrinking the overall balance sheet. However, they are necessary for the implementation of monetary policy, and the required amount to smooth the process may change with the introduction of a digital Euro. The goal of monetary policy is to effectively steer short-term money market rates to a determined level; to do so, the main two approaches are the floor and the corridor system. According to Caccia, Tapking and Vlassopoulos (2024, p. 35), in a floor system, central banks set only the interest rate paid on overnight reserves (deposit rate) trying to steer short-term money market rates towards it[147]; in a corridor system, they steer short term money market rates to the midpoint between the rate paid on overnight reserves (deposit rate) and the rate charged on overnight borrowings (the lending rate)[148].

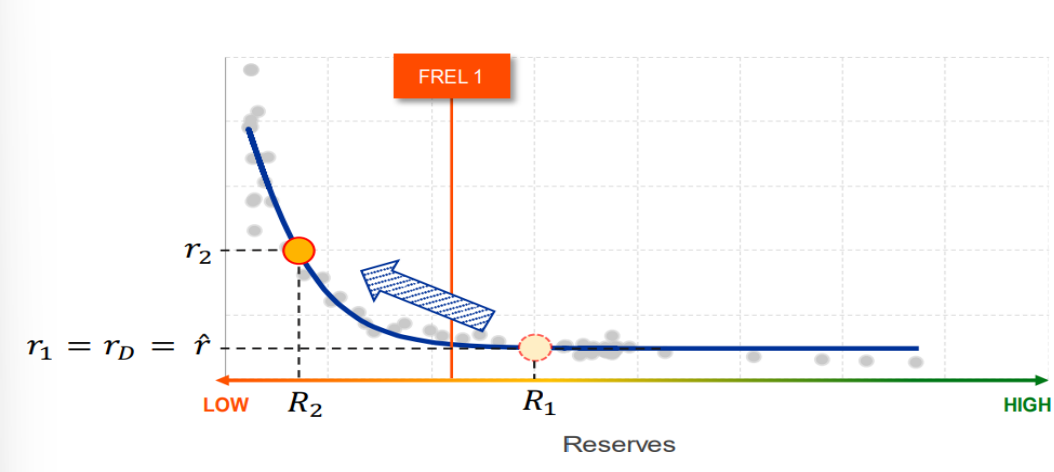
Considering the floor system, if the introduction of a CBDC were to cause a reduction in deposits and consequently reserves, short-term market rates could increase above the target deposit rate. Examining the relation between reserves held by banks and the short-term money market rates, in a situation of ample reserves (R_1), the money market rate (r_1) would remain at the target deposit rate (r_D), whilst in a lower liquidity scenario (R_2), an increased number of banks would need reserves trying to borrow in the interbank market. This demand would drive up the money market rate (r_2). The graph below summarises the movement along the curve with FREL 1 being the floor required excess liquidity which is the "threshold amount of reserves below which market rates increase as reserves decline" (Caccia, Tapking and Vlassopoulos 2024, p. 29). The shift from r_1 to r_2, would not be welcomed by the central bank that could respond providing

[147] More in detail, in a floor system, the central bank would set the deposit rate equal to its predetermined interest rate, it would then provide reserves through credit or outright operations to ensure a liquidity surplus for any rate above the short-term money market rate (Caccia, Tapking and Vlassopoulos 2024, p. 28). Banks would then trade reserves among themselves until the two rates are equalled. In fact, at equilibrium, it would be irrational for banks to keep lending if they could deposit those reserves at the central bank and receive the same interest, with a lower credit risk (central banks are assumed to be default-free, compared to credit institutions).

[148] More deeply, in a classic corridor system, the goal interest rate will be in between the two interest rates (deposit rate paid to commercial banks leaving excess reserves at the central bank) and the lending rate (the rate charged on commercial banks in need of reserves). The central bank would provide liquidity through regular credit operations or selling assets to absorb liquidity (Caccia, Tapking and Vlassopoulos 2024, p. 35). A downside of the corridor system is the opportunity cost entailed by the excess reserves; in fact, holding excess reserves at the central bank would yield the deposit rate, while lending in the interbank market would yield a higher rate. Banks could therefore be incentivised not to keep excess reserves.

additional amounts of reserves to drive down the short-term interest rate to r_1 either granting additional credit to banks or purchasing assets. However, the central bank would need to offer credit at a favourable rate (below r_2 and possibly with a long maturity) otherwise commercial banks would continue to borrow in the interbank market with rates that would not reach the deposit rate r_D.

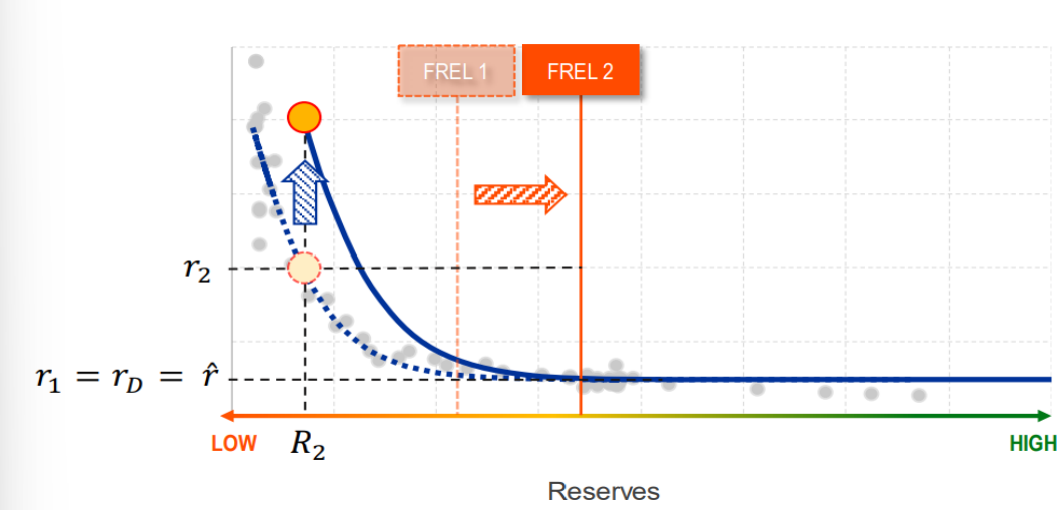
Figure 7: CBDC impacts money market rates pushing excess liquidity below the amount required to anchor money market rates



Source: Caccia, E., Tapking, J. and Vlassopoulos T. (2024) *Central Bank Digital Currency and Monetary Policy Implementation*

The CBDC however could affect the market rate through another channel too: the demand for liquidity. CBDCs, regardless of the remuneration, would imply uncertainty on the amounts withdrawn and credit institutions may opt to hold reserves for precautionary reasons. This would shift the curve to the right increasing even more the equilibrium interest rate in the market, due to a higher spread between available reserves (R_2) in a low liquidity scenario and demand.

Figure 8: CBDC impacts money market rates increasing bank demand for liquidity and moving the FREL higher



Source: Caccia, E., Tapking, J., Vlassopoulos T. (2024) *Central Bank Digital Currency and Monetary Policy Implementation*

The situation described could be exemplified in a very simple way: the weekend case. If bank customers were to withdraw deposits on weekends, then banks would need to have a sufficient buffer to accommodate the requests. Those reserves would have to be obtained before the weekend, driving up the demand. Should the central bank offer ample liquidity, the banks would borrow directly from the monetary institution leaving the rate unchanged; however, should it not occur, the interbank rate would spike shortly after the weekend began (Caccia, Tapking and Vlassopoulos 2024, p. 31). Clearly, this would not be in line with a smooth implementation of monetary policy. However, the said unwanted effects may be limited through sufficiently tight holding limits, as it would be the case for the digital Euro.

The ECB has currently adopted the floor system; however, it cannot be excluded the switch to the corridor system as it was the case for the Federal Reserve that used it before the great financial crisis. The main difference is that in the event of a reduction of reserves due to the CBDC introduction, banks would then borrow from the central bank, rather than from the interbank market. In fact, in a corridor system, the monetary institution would also set the lending rate above the target policy rate to implement its

monetary policy. The introduction of a CBDC could result in greater volatility of money market rates constraining banks to narrow the corridor or set an average level of minimum reserve to keep at the central bank for a given period to act as a buffer to converge to the target policy rate. The averaging mechanism, as it could be inferred by the name, does not require banks to always stay above the limit; rather it mandates the average level of reserves for the period to stay above the minimum. This results in credit institutions avoiding rushing to the market in case of a sudden drop or increase in reserves as they can remedy the shortages or excesses in a subsequent period. Moreover, reserves held at the central bank would be remunerated at the deposit rate r_D.

Deepening on a practical case to prove how CBDCs will boost the demand for excess reserves, commercial banks should be aware that their customers may withdraw their deposits both in the form of cash (at ATMs) and in digital currency. The heightened potential withdrawal requires larger buffers to be fulfilled before the withdrawal takes place. However, customers withdrawals may diverge from the expected value resulting in a lower need for reserves. Consequently, banks would have on the asset side of their balance sheets low yielding reserves (namely they would yield the deposit rate r_D) and would be willing to offer them at rates below the policy rate, but still above the deposit rate. Therefore, the central bank should intervene to manage this liquidity surplus and steer the short-term market rate to the policy rate again. It could be concluded that, should the ECB switch to a corridor system, it shall carefully value the holding limit on the digital Euro so to stop the connected boost in the demand for precautionary reserves and a possible divergence from the target policy rate.

To conclude the analysis of the implications of a cash-like CBDC for central banks, there are two minor effects that need to be mentioned: the effective lower bound entrenchment and the heightened flexibility of CBDC as a monetary policy tool (Infante *et al.* 2022). For what concerns the first, it would occur in a low or even negative scenario as the main advantage of CBDC with respect to cash is the absence of holding/carrying cost. The digital Euro then has the potential to raise the ELB (which is the level of interest rate that makes agents indifferent between investing or keeping money in liquid forms) reducing the room for central banks' manoeuvres. On the opposite side, the second would be a welcomed effect for the ECB as it would be able to observe digital Euro balances,

differently from cash balances that are by default private. The said advantage may turn useful to better understand the effects of the monetary policy.

IV.3. Implications for households

This last aspect of the digital Euro has been the least investigated by scholars. Indeed, whilst a consistent strand of literature focused on the macroeconomic and commercial banks implications of the digital Euro, few studies addressed the effects of a European-based CBDC on its potential users. A reason may be a marked heterogeneity of European people even amongst citizens of the same country. Nevertheless, households' demand will play a major role in the diffusion of the digital Euro and its drivers shall be carefully scrutinised. Two prominent studies on the propensity to adopt a digital Euro were published by the central banks of the Netherlands and Germany: the authors surveyed their residents with specific questions on the digital Euro and then analysed the responses. Despite the samples are not representative of the European population, they already provide a starting point to develop a discussion on the implications of the digital Euro.

The Dutch study (Bijlsma *et al.* 2021) is insightful as the authors modelled the adoption and intensity of usage of a CBDC current account on consumer demographics, knowledge factors and trust variables. More specifically, one of the proposed questions was to decide how much money to deposit in a CBDC current account ranging from 0 to 3000 Euros (Bijlsma *et al.* 2021, p. 11). The choices offered therein were in line with reasonable expectations of the holding threshold, so they help picture a plausible consumer demand for digital Euros netting out the possible implication of an unrealistic demand for CBDC as a store of value. More specifically, concerning the explanatory variables for consumer demographics, the authors controlled for sex, age (dividing the sample in 5 categories) and education (the threshold being a bachelor's or higher education degree) with income (with three subcategories: low, medium and high (above 2600 Euro)) and homeownership as proxies for wealth and finally the degree of urbanization to discern those living in the cities from those in less urbanized areas. The second category of explanatory variables instead, mainly focuses on people's views and interests on CBDCs, the banking sector and privacy. In fact, respondents were asked if

they had previous knowledge of a CBDC, if they were satisfied with their current account (and thus could be oriented towards alternative forms to manage their liquidity) and how important money and data protection together with privacy were for them. Finally, the authors investigated the trustworthiness of central banks and commercial banks in light of a potential substitution of commercial banks current accounts with CBDCs holdings (Bijlsma *et al.* 2021, p. 12).

In the analysis on the intentions to adopt a CBDC, they found that males as well as young people were more inclined towards a CBDC adoption. The result is in line with the expectations as citizens in their earlier stage of life are usually more tech-educated and inclined towards cashless means of payments. Deepening on it, the result signals not only that the youngest group is expected to adopt a CBDC current account more than the other four, but also that the intention decreases as age increases (Bijlsma *et al.* 2021, p. 14). This result should raise the attention of the ECB as it calls for the implementation of ad hoc measures for the elderly to facilitate their adaptation to this new form of central bank money, also to foster financial inclusion. In this light, the provision of a digital Euro card is welcomed, but other measures such as dedicated physical offices for the onboarding, account management and offboarding procedures may be needed at least in the early phases of its adoption, as well as hotlines for any issues users may incur into. These measures would help spreading the digital Euro across the ageing European population. Turning to the investigation on the intensity of usage, males are also expected to deposit a higher amount in digital Euro (Bijlsma *et al.* 2021, p. 16), but the striking data is that all the age groups are expected to use a CBDC current account less than the reference group of under 35 respondents. This put even more pressure on the ECB to make its digital Euro accessible to all age classes as user friendliness would not only influence the number of adopters but also the intensity of usage.

In the study, education too has been found to affect positively both the adoption and intensity of usage of a CBDC account; however, concerning the adoption study, the explanatory variable is not statistically significant when trust factors are included in the regression, meaning that heterogeneity in education helps to explain a different intention to adopt a CBDC current account, but said explicative power is transferred to other variables when the regression is expanded. Unsurprisingly, wealth also has been found to influence the intention to adopt a CBDC as wealthier individuals (income above € 2600

per month and homeowners) are associated with a higher adoption rate, and medium and high-income groups with higher intensity rates. The causes may be multiple as wealthier people may be more apt to support innovations, but an indirect cause may also be individuated. Namely, people's wealth may be positively correlated with education and consequently to the adoption and intensity of usage of CBDC through this channel.

The knowledge factors need a more detailed analysis as the two explanatory variables are found to influence the adoption of a CBDC (at the highest significance level, namely 0.01) and the intensity of usage. More specifically, the study investigated whether respondents had no prior knowledge of CBDCs, whether they had heard of CBDCs but did not know the details and if they had sufficient knowledge of a CBDC (Bijlsma *et al.* 2021, p. 11). In line with the expectations, a higher knowledge was correlated with higher adoption and intensity rates. At the time of the survey, less people than today knew of the digital currency so the situation may not be comparable to the current scenario, still the result allows to infer the negative consequences for the digital Euro, should users not possess a basic knowledge in proximity of the introduction. The German study echoes this finding as some respondents did not perceive the differences between commercial bank and central bank money (Deutsche Bundesbank 2021, p. 79). The two studies therefore convey that an extensive communication campaign shall be implemented to raise awareness on the differences with commercial bank money and available cashless means of payments. Namely, the ECB shall identify various channels to reach the heterogeneous group of potential users; as an example, online communications (also using social media) would be suitable for a younger audience, whilst television ads or newspaper articles may help getting the elderly on board.

The trust factors complete the set of explanatory variables chosen in the Dutch study. The authors expected the intention to use a CBDC to be positively correlated with people's trust in the central bank and distrust in commercial banks (Bijlsma *et al.* 2021, p. 12). More specifically, trust in the central bank was found to positively affect the spread of the digital Euro in the same way that trust in a central bank helps banknote circulation, whilst distrust in the commercial bank sector was found to increase users' willingness to switch to a CBDC current account.

To conclude, the authors also included explanatory variables to model users' attitudes towards money protection, data protection and privacy. In fact, the digital Euro

would test ECB's resilience as whenever cyber-attacks would be launched, the Frankfurt-based institution should be able to fend off those incursions and protect both users' privacy and money. The researchers found those with prior knowledge of CBDCs and those concerned about privacy to be more likely to adopt digital currencies than those with little knowledge of CBDCs or having a neutral standpoint on privacy (Bijlsma *et al.* 2021, p. 15). This underlines even more how privacy would be determinant to spread the digital Euro and calls for heightened standards not to lose people's trust.

The German study also provides insights on households' perspective concerning the digital Euro and helps to identify focus points for the ECB. As previously stated, some respondents seemed to be unaware of the differences between central bank and commercial bank money in terms of safety (Deutsche Bundesbank 2021, p. 79). Many in fact perceive the fail-safe feature of central bank money only an abstract advantage with respect to commercial bank money, in light of the € 100000 deposit protection scheme available in Europe[149]. Despite not welcomed from a central bank perspective, the finding shall not heavily influence the adoption of digital Euro by virtue of the cash-like feature.

People's attitude towards digitalisation needs to be carefully addressed instead, as its implications could be far more profound. In fact, survey responses highlighted that the attitude depends heavily on people's views of digitalisation in general: namely, those overweighting the positive aspects of it tend to have a greater affinity with the digital Euro, whilst the more pessimistic expressed fears of hidden surveillance, loss of control and restrictions of uses (Deutsche Bundesbank 2021, p. 79). An even more interesting finding is that some study participants mentioned that they might lose track of the finances with the introduction of the digital Euro (Deutsche Bundesbank 2021, p. 79). The ECB shall address this aspect as it would introduce another mean of payment in an already convoluted industry. Indeed, the sector evolved dramatically with the advent of digitalisation that reshaped people's preferences with the introduction of faster and easier means of payment. Further, the problem may be exacerbated by the possibility to open multiple accounts. In fact, Article 16 of the proposal of regulation (European Commission 2023, p. 47) allows users to distribute their holdings across many PSPs (with the overall amount bounded by the holding threshold) and may result in ineffective control of the finances. The automatic top up feature might render it even more difficult too as people

[149] European Parliament and Council Directive No. 49/2014 of 16 April 2014.

might lose track of their deposit account and digital Euro holdings. Ad hoc solutions need to be implemented to ensure, as an example, the possibility to quickly have a glance at the overall balance in the digital Euro app or even in the PSPs apps. The latter would prove harder to build as PSPs shall be required to share information to provide a uniform picture to their users.

For what concerns the assessment of the main features of the digital Euro, the findings of the German enquiry are in line both with comparable studies and the ECB's commitment, as respondents expressed interest in the "free and simple use, privacy and security with regard to data protection and universal usability" (Deutsche Bundesbank 2021, p. 80). However, an insightful finding is that most of the respondents did not expect full anonymity in their transactions, recognising the radically different task of the central bank compared to credit institutions[150]. This diffused trust in the ECB functions may turn useful in the implementation of AML and CFT control frameworks that would inevitably require access to data on consumers payment habits. Also, it could help to defy critiques and opposition from households that would switch from a completely private form of central bank money (cash) to a traceable yet privacy-oriented digital Euro.

Moving to the fields of applicability, many respondents saw great potential in the context of e-commerce, whilst few referred to the digital Euro as having an edge over comparable means of payments in private persons proximity payments (Deutsche Bundesbank 2021, p. 81). Needless to say, there is little room for improvement in the payment system, and this could hinder digital Euro's ambition to attract users. The offline functionality instead could be a turning point as many welcomed the feature, especially those that had experienced connection problems in the past (Deutsche Bundesbank 2021, p. 81); however, the ECB would need to fit AML/CFT controls and private payments in the same picture but striking the right balance may prove challenging.

Finally, the holding threshold was examined too. The study sheds a light on high earners needs as it reports that the potential € 3000 holding limit may hinder its diffusion amongst them (Deutsche Bundesbank 2021, p. 81). High net worth individuals may be disincentivised to use it as their transactions would exceed the limit frequently. The reverse waterfall function may then be welcomed as it would allow users to draw money

[150] In this respect, the study highlighted that German respondents are not concerned of the ECB's use of the digital Euro for commercial purposes, given its profitless nature (Deutsche Bundesbank 2021, p. 81)

from the associated deposit account. Then, transactions exceeding the holding threshold would be paid in digital Euros. Should funds be insufficient (due to the holding limit), immediate conversion from the associated deposit account would ensure a smooth payment, thereby incentivising those people to use the digital currency. However, those innovative features may not be enough as keeping mental account of transactions in commercial bank deposit accounts and central bank money could be cumbersome. On the flipside, high net worth individuals are a residual part of the population and, should they find the digital currency unadapt for their needs, the digital Euro would still be welcomed by the remaining part of European population.

Amongst the three stakeholder groups considered (commercial banks, central banks and households), this last one is the most heterogeneous and, despite trade-offs and arrangements will be necessary to proceed with the project given the highly-intertwined nature of the digital currency, the ECB shall strongly focus on the desirability of its digital currency because, should it fail to stimulate the demand, its innovation may prove unsuccessful.

V. CONCLUSION

This paper addressed how a digital Euro conformable to the one portrayed in the proposal for a regulation by the European Commission will fit in the European environment, examining its potential implications for the ECB, commercial banks and households. After an in-depth investigation of the incentives, it can be concluded that the foreseeable digital Euro has the potential to get a foothold in the European framework. Nevertheless, a decision on its issuance is still pending and will be taken after the first stage of the preparatory phase, ending no earlier than November 2025, when the ECB Governing Council, after a thoughtful analysis of the results matured and the legislative developments in the field, will decide to continue or abort the project. The path towards the first households-oriented digital form of ECB money is still long, and synergies across all the stakeholders would be necessary for the digital Euro to see the light of the day.

Whilst many aspects are still to be formalised and no binding decision on the specific characteristics has been taken yet, available information highlights how a digital Euro would benefit contemporaneously the ECB, commercial banks and households. The

first will have the chance to bridge the gap between private sector digital means of payments and strengthen the passthrough of monetary policy. Those would be two major achievements as studies confirm the accelerating trend towards digitalisation of payments that consequently implies the need for a modernisation of central bank money. Further, the ECB would have another arrow in its quiver; namely, the digital Euro could help the passthrough of monetary policy to deposit rates, that are considered rather stickier compared to other interest rates (Messer and Niepmann, 2023). More specifically, the inevitable yet limited drop in deposits associated to the CBDC issuance would result in a heightened competition amongst credit institutions, affecting the overall level of interest rates through the banks lending channel. Finally, a traceable form of money would also provide new insights on consumer spending, improving ECB's macroeconomic forecasts.

The research also found that commercial banks could benefit from the provision of ancillary services to the public. Whilst the applicability of the results may be limited given that a definitive list of basic free services is still to be drafted, the study has proven how the digital Euro introduction would incentivize intermediaries to offer ad hoc features to attract digital Euro users and increase banks' profits. Spillover effects could materialize too with commercial banks striving for depositors. The multi-account feature in fact, may induce potential users to exploit said opportunity and, should they prefer a new intermediary, they could opt to transfer not only their digital Euro holdings, but also their bank accounts. Regarding commercial banks' main concern of large deposit outflows, an extensive strand of literature found that the safeguards in place (especially the holding threshold) would be enough to prevent negative consequences, with banks' profitability that would be affected only marginally. Namely, a considerable portion of deposits should be exchanged for digital Euros to witness significant changes in their balance sheets, and the quantity required would be incompatible with the mentioned holding limit.

Besides the ECB that would implement the system and commercial banks that would distribute digital Euros, the chances of success would largely depend on households' attitude towards it. Despite the samples characteristics may limit the generalisability of the results, the paper found the digital Euro adoption rate and intensity of usage to be positively correlated with knowledge of the CBDC and trust in the central bank, whilst negatively correlated with age and attention to privacy. The result calls for a

deep examination by the ECB of the most suitable methodologies and strategies to exploit said drivers, with regulators that should smooth the adoption process for middle aged and the elderly, also considering an ageing European population. In this view, the provision of a digital Euro card, as well as dedicated support, would help spreading the digital Euro amongst these age cohorts. Moreover, the ECB shall come up with a safe and secure money to both defend users' data from cyber-attacks and avoid leakages that could negatively affect the adoption by lowering people's trust in the central bank and failing to protect privacy. Finally, the ECB shall publicize its novel digital currency, focusing particularly on the offline feature, whose specific functionality has not been defined yet, to foster adoption. The paper also highlighted the competitive advantage it would enjoy with respect to other digital payments: the legal tender nature. The acceptance granted by the law and the lower costs of carry and storage compared to cash are expected to bolster the demand.

The findings of the paper point at a positive evaluation of European citizens, however the results depend on the features laid out in the proposal for a regulation and official publications by the ECB. Should the Frankfurt-based monetary authority drastically modify them, the adoption rate and intensity of usage may change. Specifically, the interaction with the stakeholders could act as a double-edged sword with the ECB that shall welcome a rightful exchange of views with third parties representatives while preventing an excessive intrusion in the implementation process. The considerable time before the go live of the digital Euro further adds uncertainty to the framework, with the CBDC that would probably not see the light of the day before the end of 2027. This calls for a closer examination with subsequent studies that shall focus on cash-like rather than deposit-like digital currencies. Finally, the success would also depend on the feasibility of the proposed features, with the ECB that would need to develop a well-functioning system to sustain its ambitious project.

The history has proven how money adapts to evolving needs, and the digital transformation currently in place shall be sustained by the introduction of a widely acceptable, fast and secure mean of payment. The ECB should then continue to invest in the development of a competitive digital currency as its benefits would not be limited to the payment system but could extend to the overall economy with a stronger Euro independent from foreign providers.

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