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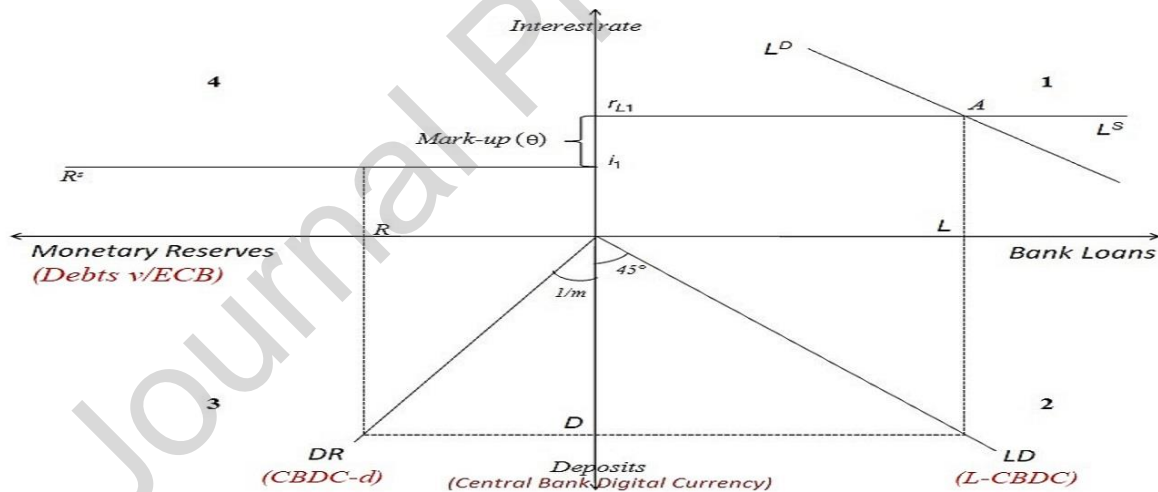
The interpretation of CBDC within an endogenous money framework

Bibi Samuele¹ and Canelli Rosa²

Abstract:

Central bank digital currency (CBDC) has increasingly received attention among policymakers and academics. From a theoretical perspective, the introduction of a CBDC arouses long-standing questions, foreseeing the possibility for the private (non-financial) sector to access the central bank reserves. The aim of this paper is to strengthen the understanding of the CBDC through the Endogenous Money Theory (EMT). The paper examines the balance sheets of the central bank, commercial banks, and the non-financial private system, tracking all the assets and liabilities of the macro-agents involved in the introduction of a CBDC. It explains the logical chain of relationships starting with the creation of bank loans from commercial banks, transformed into deposits, and ultimately converted into CBDC. Such a chain of relationships is also explained by amending the four quadrants model proposed by many post-Keynesian scholars.

Graphical abstract



Keywords: CBDC, Endogenous Money, Cryptocurrencies, Central Bank, Commercial Banks

“Everyone can create money; the problem is to get it accepted” (Minsky, 1986).

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1. Introduction

The XXI century has been characterised by an increasing digitalisation of the economy. Money and its institutional foundations have evolved throughout time, providing innovations and transforming infrastructures that have improved in parallel with the available technology. The ongoing digitalisation of the economy is changing the way people engage with payment methods. In the last decades, the use of cash for transactions has been reduced in many countries. The shift towards electronic payments has increased even more since the COVID-19 pandemic spread out in 2020, due to the potential virus transmission risks (BIS, 2021; Tamele et al., 2021).

Bitcoin and other cryptocurrencies, including stablecoins - and in general the entry of big techs into financial services -, are penetrating all areas of the financial system and, therefore, have been receiving growing attention (Allen et al., 2022). For instance, the number of cryptocurrencies increased from less than 100 in 2013 to more than 1,600 in 2018 reaching more than 10,000 in 2022 (Statista, 2022a). Also, cryptocurrencies capitalization increased strongly from about 1 billion USD in 2013 up to more than 1,700 billion USD, at the beginning of 2022, after a peak of more than 3,000 billion USD in November 2021.

Despite the extreme volatility, it is undeniable that Bitcoin and other first-generation cryptocurrencies played an innovative and attractive role in the digital world in the last decade - with the dominance of Bitcoin, currently detaining about 40% of the market capitalization in the cryptocurrencies scenario (Statista, 2022b).

While cryptocurrencies have spread and fortified both in terms of number, market capitalization, and users, central banks around the world answered with an initially strong scepticism about the possibility of issuing their own digital currency, namely the Central Bank Digital Currency (CBDC). CBDC is a form of digital money that is denominated in the national unit of account and that represents a direct liability of the central bank (BIS, 2021). According to the Bank of International Settlement (BIS, 2020), the negative comments of central bank governors and board members were majorly negative until mid-2019. Since then, however, there has been an increased awareness of the need to deal with CBDC. Probably many central banks started realising that the widespread use of electronic payments and the consequent decline in the use of cash have been posing a threat to the centrality of the central bank as an institution and to the centrality of its policy instruments (Serrate and Lopez, 2021). While the interest in CBDC started to rise, changing with much more optimism, both research and pilot CBDC projects significantly increased, also in light of the current geopolitical context. The threat for central banks became explicit in the current Russian-Ukrainian war. In fact, many central banks and governments - that tried to sanction Russia containing its possibility of financial movements - have feared that "cryptocurrencies provide a back door to move money around the world" (Oliver and Stafford, 2022). The fear was not empty since, as the authors show, the trade between the Russian rouble and crypto-assets increased by about 500% in less than a month, arriving at \$60mn a day at the end of February 2021.

Surveys indicate that around 80% of central banks are investigating CBDC and half of them are experimenting and running pilots (BIS, 2020; Boar et al., 2020). More specifically, while in May 2020 only 35 countries were considering a CBDC, today more than 114 countries

(representing more than 95% of the global GDP) are examining it, and 11 of them have already fully launched a CBDC³ (Atlantic Council, 2022).

From a theoretical perspective, the introduction of a CBDC arouses long-standing questions. The idea is often traced back to James Tobin (1987), who suggested converting central bank reserves from wholesale money into retail money, accessible to everyone - in this way constituting the precursor of the CBDC. Although there is no common agreement among policymakers or academics, CBDC can be described as the possibility for the private (non-financial) sector to access central bank reserves, a concept exemplified as “reserves for all” (Niepelt, 2021).

Beyond examining whether the CBDC serves the function of money, as a medium of exchange, a store of value, and a unit of account (e.g., Dow, 2018; Umlauft, 2018), several studies have focused on the variety of technical features of the CBDC. These investigations include whether central banks should issue CBDC (Keister and Sanches, 2021); whether CBDC should be provided directly to households and firms (retail CBDC) or indirectly through commercial banks (wholesale CBDC) (e.g., Auer and Boehme, 2020; BIS 2020, 2021); whether it should be interest-bearing or not (Bank of England, 2020; Meaning et al. 2021); whether it should be conceived as a token-based form of money or an account-based one, namely cash or commercial bank deposits, respectively (Auer et al., 2021). Answering these questions opens a deep research agenda which allows to assess the impact of CBDC introduction on commercial banks, monetary policy, and financial stability (e.g., Andolfatto, 2018; Agur et al., 2019; Bhaskar et al., 2022; Barrdear and Kumhof, 2016; Brunnermeier and Niepelt, 2019; Chiu et al., 2019; Fernandez-Villaverde et al., 2021; Keister and Sanches, 2021; Niepelt, 2020).

Notwithstanding the relevance of the ongoing research and the growing interest of the international and academic community, the literature on CBDCs is still limited and several research questions need to be further and deeply addressed (see Elsayed and Nasir, 2022). Specifically, the literature still lacks a proper contextualization of the topic in the economic theory. To the best of our knowledge, few contributions go in this direction. Dow (2018) offers some preliminary reflections on private digital currencies and on the evolving role of central banks from different theoretical perspectives. Cesaratto and Febrero (2022) focus on the banking and monetary policy issues raised by private currencies and CBDCs, in light of the post-Keynesian monetary theory. Cesaratto and Febrero (2022) also analyse the credit-debit relationships between the different economic agents involved in the issuance of the main private and CBDCs, examining the advantages and disadvantages of those instruments. Moreover, they underline how the lack of clear understanding of the CBDC introduction in the monetary system might lead to the wrong interpretation of the process of money creation. In particular, the authors highlight how a (misleading) parallelism is often drawn with the “Chicago Plan” proposal, where banks should operate with a 100% reserve ratio and where – particularly in the hard version of the Chicago Plan – reserves must come before commercial loan deliberation.

Building on those contributions, the purpose of this paper is to enrich this theoretical line of research by providing an interpretation of the CBDC in light of the theory of endogenous money (EMT). The EMT highlights the active role of banks in creating money ex-nihilo, by granting loans to creditworthy borrowers. Money is a social relationship which arises from the interactions between macroeconomic agents and it is always introduced in the form of credit

³ Bahamas, Jamaica, Nigeria, Anguilla, Saint Kitts and Nevis, Antigua and Barbuda, Montserrat, Dominica, Saint Lucia, Saint Vincent and the Grenadines

(Graziani, 2003; Fontana, 2003). This paper uses the EMT to shed light on the movements of debits and credits flowing in the balance sheets of the main actors involved in the introduction of CBDC, namely commercial banks, the central bank, and the non-financial private sector. This work supports the idea that the introduction of a CBDC does not need to conform to a narrow banking system⁴. The endogenous money theory describes the appearance of CBDC, interpreting the crucial chain of relationships starting with bank loans from commercial banks, then transformed into deposits and ultimately converted into CBDC. The EMT can be used to understand those transactions in detail, for example in a full conversion scenario, “as long as central bank automatically provides reserves when deposits are converted into CBDC” (Cesaratto and Febrero, 2022, p. 1) but also in a broader sense, when the central bank accommodates commercial banks requests replenishing with credit the deposits converted into CBDC by the non-financial private sector.

To this aim, the paper is structured as follows. Section 2 introduces and discusses the main features of cryptocurrencies and CBDCs. Section 3 examines the main possibilities and threats related to the CBDC. Section 4 discusses the post-Keynesian endogenous money theory, highlighting the main theoretical pillars of the approach. An interpretation of the CBDC that relies on the theory of endogenous money is presented in section 5. Section 6 concludes.

2. Background: cryptocurrencies, stablecoins, and CBDC

The economic literature has highlighted how money and the relationships between banks, central banks, and the general public change and evolve constantly over time. The relevance and magnitude of cryptocurrencies in recent years require briefly clarifying the characteristics of cash *vis-à-vis* cryptocurrencies and CBDCs. The major difference is that cryptocurrencies are private digital currencies, emitted by private companies, while CBDCs are issued by central banks. However, even this broad distinction might be a matter of discussion since critics of crypto-currencies prefer to call them crypto-assets, arguing that those instruments do not have the basic properties to be correctly defined as currencies.

How are those instruments different from money? Money is generally conceived to perform three functions, namely means of payment, unit of account, and store of value/wealth (Dow, 2018; Fontana & Setterfield, 2010; Itoh and Lapavitsas, 1999; Umlauf, 2018; Weber, 2015). The means of payment characteristic is linked to the ability of an instrument to pay taxes to the government and to settle down all the other debts, beyond its ability to pay goods and services. The store of value/wealth characteristic is linked, on the contrary, to the ability of an instrument to maintain or increase its value over time. The unit of account characteristic is related to the possibility of money to value goods and services, also considering its ability to be divisible and countable.

The literature has confidently agreed that bitcoins fail in serving the three functions of money from both the orthodox as well as from the heterodox school of thought (Dow, 2018, p.8; Umlauf 2018, p.1). Bitcoins lack intrinsic value and government support, being more an object of speculation than of purchasing goods and services (Powell, 2021; Weber 2015, p.16; Yermack 2013). It is often claimed that those instruments are used rather to facilitate money laundering,

⁴ Cesaratto and Febrero (2020) clarify that “A 100% reserve system is called a “narrow banking system” (e.g. Ferrari and Ferrero 2020, p.20) as opposed to the traditional “fractional” system, in which reserves are a small fraction of the deposits created.” As we highlight in section 4, we will study the CBDC under the fractional system.

ransomware attacks, and other financial crimes (BIS, 2020). Although challenging the core of the monetary and payment system (Cesaratto and Febrero, 2022), the high volatility of Bitcoins has hampered their circulation as means of international settlements, strengthening their speculative feature (Amato and Fantacci 2021). However, the example of countries adopting bitcoins as a legal tender - and of other countries banning its use - stresses the threats posed by this instrument. Bibi (2022) discusses this point further by analysing the nature of Bitcoins as money, in light of their recent adoption as legal tender in El Salvador.

To tackle the extreme volatility of bitcoins, a new generation of cryptocurrencies, named stablecoins emerged. Stablecoins are a form of digital money built to maintain a stable value relative to a specified asset or a pool or basket of assets (Delivorias, 2021). Therefore, stablecoins bring together the stability of value - proper of conventional bank money - and the advantages of cryptocurrencies⁵.

Perhaps one of the most challenging developments consists in the public response to private digital currencies throughout the introduction of a CBDC. According to a report published by the Bank of International Settlement (BIS, 2018), CBDC is a new form of digital money denominated in the national unit of account, which represents a direct liability issued by the central bank. Like cash, CBDC would be the typical money instrument absorbing all previously mentioned characteristics of means of payment, unit of account, and store of value. CBDC would be convertible one-to-one into currency in circulation, keeping the stability of its value over time. Several reports provided by the Bank of International Settlement (2018, 2020) offer a taxonomy of CBDCs, underlining three key features of money, namely form (digital or physical), accessibility (broadly or restricted), and technology (token or account-based). Panetta (2021a) clarifies that CBDC (i.e., digital euro) is different from crypto assets, such as Bitcoin. CBDC would not be issued by any private entity but by the central bank; it would be convertible into a corresponding government-issued currency; guaranteed by the State, maintaining its stability over time. Similarly, Panetta (2021a) argues that CBDC would be also different from stablecoins which are instead linked to a portfolio of assets and guaranteed by ad-hoc regulation.

Table 1 summarises the main features of cash *vis-à-vis* cryptocurrencies, stablecoins, and CBDC offering a comparison among them. This comparison might be useful to contextualise CBDC specific features and properties compared with the other instruments.

Table 1. Properties comparison: Cash, Cryptocurrencies, Stablecoins, and CBDC

PROPERTIES	Cash	Cryptocurrencies	Stablecoins	CBDC
Real-time settlement	Immediate	Immediate	Immediate	Instant or near-instant
Anonymity of payment	Yes.	Yes.	Yes.	Design choice: Token-based: Yes, Account-based: No.
Independence of central counterparties	Yes. Central authority is not responsible for bookkeeping. Ledger is distributed.	Yes. Central authority is not responsible for bookkeeping. Ledger is distributed.	Yes. Central authority is not responsible for bookkeeping. Ledger is distributed.	No. Central authority is responsible for bookkeeping. Ledger is centralised.
Asset, beyond instrument	Yes.	Yes.	Yes.	Yes.

⁵ See Bullman, Klemm, and Pinna (2019) for the taxonomy of stablecoins and their design. Among others, Dow (2018), Delivorias (2021), Morgan (2022) discuss their potential benefits and main concerns.

Offline payments	Yes	Under proposal ⁶	No.	Design Choice.
Counterfeitable	Possibly but very difficult. Non-counterfeit ability is tangibly based (<i>with machine-readable optical and electromagnetic security features</i>). Counterfeiting is extremely expensive.	No. Non-counterfeitability based on verified transaction records and double-entry bookkeeping.	No. Non-counterfeitability based on verified transaction records and double-entry bookkeeping.	No.
Legal Tender	Yes.	It can be: El Salvador (<i>and likely to be in 2022 in Panama, Paraguay and Guatemala</i>). Some countries banned cryptocurrencies, i.e. China, Qatar. Some countries allow them, i.e. the US.	It could be. (In the US, it can be considered "Convertible virtual currency" ("CVC"): either has an equivalent value in real currency or acts as a substitute for real currency. [FinCEN])	Yes.
Stability of Value	Subject to inflation and exchange rate variation.	Subject to exchange rate variation.	(Relatively stable) Pegged to a specified asset, or a pool or basket of assets.	Subject to inflation and exchange rate variation.
Remuneration	No interest rate remuneration.	No interest rate remuneration. Financial profit derived from revaluation.	No interest rate remuneration. Financial profit derived from revaluation.	Interest rate remuneration subject to design.
Risks	Loss, theft & fraud.	Loss, theft & fraud.	Loss, theft & fraud.	Token-based: theft, fraud & cyber risk. Account-based: fraud & cyber risk.

Source: authors' categorization. Adapted from BoF Economics Review (2017) and BIS Annual Economic Report (2021)

3. CBDC: Possibilities, threats, and potential remedies

The introduction of CBDC still raises uncertainty related to its potential strengths and weaknesses, which depend on the different configurations throughout which CBDC can be implemented. Without trying to be exhaustive, there are some features of the CBDC that can be briefly recalled for the purpose of our analysis. In principle, the literature identifies two types of CBDC, namely wholesale and retail CBDC. The former entails that CBDC is provided indirectly via commercial banks while the latter, namely retail CBDC, is directly accessible to households and non-financial private sectors (Auer and Boehme, 2020).

More specifically, CBDC can be designed through the adoption of different types of architectures that strictly depend on the active operational role played by the central bank and by commercial banks and on the relationships between these actors in managing the CBDC. Therefore, CBDC can be implemented through three architectural structures, namely direct issuance, two-tiered issuance, and hybrid model (Bindseil, 2020; BIS, 2020, 2021). Briefly, *direct*

⁶ (Dmitrienko et al., 2017)

issuance is based on the pivotal role of the central bank. It is a centralised model, which reduces the presence of other institutions. The central bank issues the CBDC directly to end-users, keeps track of all transactions, and handles retail payments. All claims are kept by the central bank, just as banknotes. The *two-tiered issuance* structure actively involves the central bank and commercial banks. The central bank issues CBDC while commercial banks manage all the operations with retail customers. The *hybrid model* englobes key features of the two above-mentioned structures. As in the direct architecture, the central bank issues CBDC, provides a backstop to the payment system and keeps a full record of all CBDC transactions. Other private financial institutions play an operational role supporting the system, like in the two-tiered issuance model.

Alongside the benefits and potential problems highlighted by the literature and shared by the official documents of the major central banks (see, among others, De Bonis and Ferraro, 2022; Morgan 2022), one of the main challenges brought by the introduction of a CBDC is the (possible) disintermediation of the traditional banking sector and the impact on the conduction of monetary policy (Cesaratto and Febrero 2022; Keister and Sanches, 2022).

Disintermediation entails a potential transmigration of deposits from commercial banks to CBDC accounts at the central bank. In this regard, crucial aspects are how CBDC would interact with bank deposits and how to limit such a transmigration from bank deposits to CBDC. It is worth stressing that the degree of disintermediation is strictly linked to the architecture adopted and to the intrinsic features of the CBDC, especially in terms of interest returns. In fact, among others, Cesaratto and Febrero (2022) clarify that disintermediation would arise whether CBDC accounts provided interest returns. A no-interest-bearing CBDC does not challenge the holding of deposits, as it would replicate the characteristics of cash. Being assimilated to e-cash, CBDC would simply change the composition of central bank liabilities, excluding the risk of disintermediation and the possibility to influence monetary policy transmission (Bank of England, 2020, p. 38). Conversely, an interest-bearing CBDC - which offers payment services similar to bank deposits - might alter the allocation of deposits, affecting the traditional banking sector. In this case, CBDC accounts at the central bank would compete with traditional bank deposits, compelling commercial banks to increase the interest rates on deposits in order to maintain those resources into their balance sheets. This might affect the cost of credit or bank profitability as well as the transmission of monetary policy (Meaning et al. 2018; Cesaratto and Febrero, 2022).

The literature highlights that the disintermediation risk and the potential bank runs can be mitigated by the introduction of some frictions, aimed at preventing massive transfers from deposits to CBDC. For instance, by introducing a notice period for large CBDC withdrawals (it is currently done with cash); by not remunerating CBDC holders if their balances are above a certain limit; by imposing fees on balances above certain thresholds or introducing daily transfer limits (Meaning et al. 2018, p.14).

Among the above-mentioned proposals, two strategies seem to be mostly endorsed by the literature: setting a ceiling to the amount of CBDC that can be held and applying a negative interest rate on the (extra) amount that exceeds the ceiling (see, for instance, Bindseil and Panetta, 2020; Panetta, 2021b); introducing a remuneration system which provides a lower interest on CBDCs (Bindseil, 2020; Meaning et al., 2018). By this means, both establishing limits to the transformation of deposits into CBDCs and adjusting the interest rate would allow the central bank to monitor the attractiveness of CBDCs, leading to only a partial disintermediation system. As underlined by Cesaratto and Febrero (2020), this scenario would not strongly affect

monetary policy transmission, as the central bank would still be able to implement its monetary policy.

4. CBDC and economic theory

The analysis of the supply of money as an exogenous variable dominated the academic debate until the first decade of the twentieth century. The exogenous money theory maintains that the central bank defines money supply through changes in monetary reserves. According to this idea, commercial banks provide loans as a fixed or variable multiple amount of the monetary reserves given by the central bank.

The present paragraph presents an alternative approach to the creation of money, namely the idea of an endogenous money supply which highlights the active role played by commercial banks in the money creation process. This approach represents the lens through which the introduction of a CBDC will be analysed. The post-Keynesian endogenous money theory (EMT) considers money supply as demand-determined and credit-driven. The quantity of money in circulation is defined by the effective demand for loans coming from (creditworthy) borrowers to commercial banks and it is equal to the amount of bank deposits. Commercial banks create money *ex-nihilo* - *money out of nothing* (Werner 2014) -, namely with no prior needs for saving, funds, reserves or monetary base. Hence, commercial banks do not act as mere intermediaries between saving and investment decisions (Deleidi, 2020; Fontana, 2003; Graziani, 2003). Money is endogenous, being the outcome of the interaction between private demand for bank loans and the supply of loans by commercial banks, rather than being exogenously determined by the central bank⁷.

Through the activity of lending loans, commercial banks simultaneously create deposits and then demand monetary base from the central bank, namely reserves which allow converting deposits into cash (Deleidi and Fontana, 2019). Monetary reserves are provided at a certain interest rate and represent a result of bank loan creation.

The process of endogenous money creation can be explained by making use of the four-quadrants diagram in Figure 1 (Fontana and Setterfield, 2009a, 2009b; Palley, 1996a)⁸. The central bank sets the base rate i_1 , which represents the reference rate for the banking sector (Moore, 1989, pp. 487). Commercial banks settle the interest on loans r_{L1} , considering i_1 as the reference rate upon which they apply a markup (θ). The markup is influenced by the loan duration, the liquidity, the insolvency risks perceived by commercial banks, and by the monopoly power of commercial banks (Eichner, 1987).

$$r_{L1} = i_1 + \theta$$

In the top-right quadrant, the supply of bank loans (L^S) is illustrated by the horizontal line at the rate r_{L1} . The interaction between the supply of loans (L^S) and the demand coming from creditworthy borrowers (L^D) identifies the amount of loans (L) provided by commercial banks. Throughout the second quadrant, the 45-degree line (LD) shows the loans-deposits causality

⁷ For an extensive examination of the exogenous and endogenous views of money, see among others Fontana et al. (2020).

⁸ For sake of simplicity, Figure 1 explains the post-Keynesian perspective as defined by the horizontalist approach (see Moore 1988; Lavoie 1996; Rochon 2001; Deleidi 2020).

direction, namely the volume of loans granted to borrowers which creates an equivalent quantity of deposits (D).

$$L \equiv D$$

Once deposits are determined, the amount of (compulsory and/or voluntary) reserves (R) is identified through the DR (Deposit-Reserves) line (quadrant 3). The slope of the DR line is influenced by the proportion of reserves that commercial banks detain with respect to deposits, namely the so-called credit divisor (Lavoie 1984, p. 778). The credit divisor is shown in quadrant 3 by the reserve ratio ($1/m$). Hence, the quantity of reserves demanded by commercial banks depends on the credit divisor ($1/m$) and by the level of deposits (D).

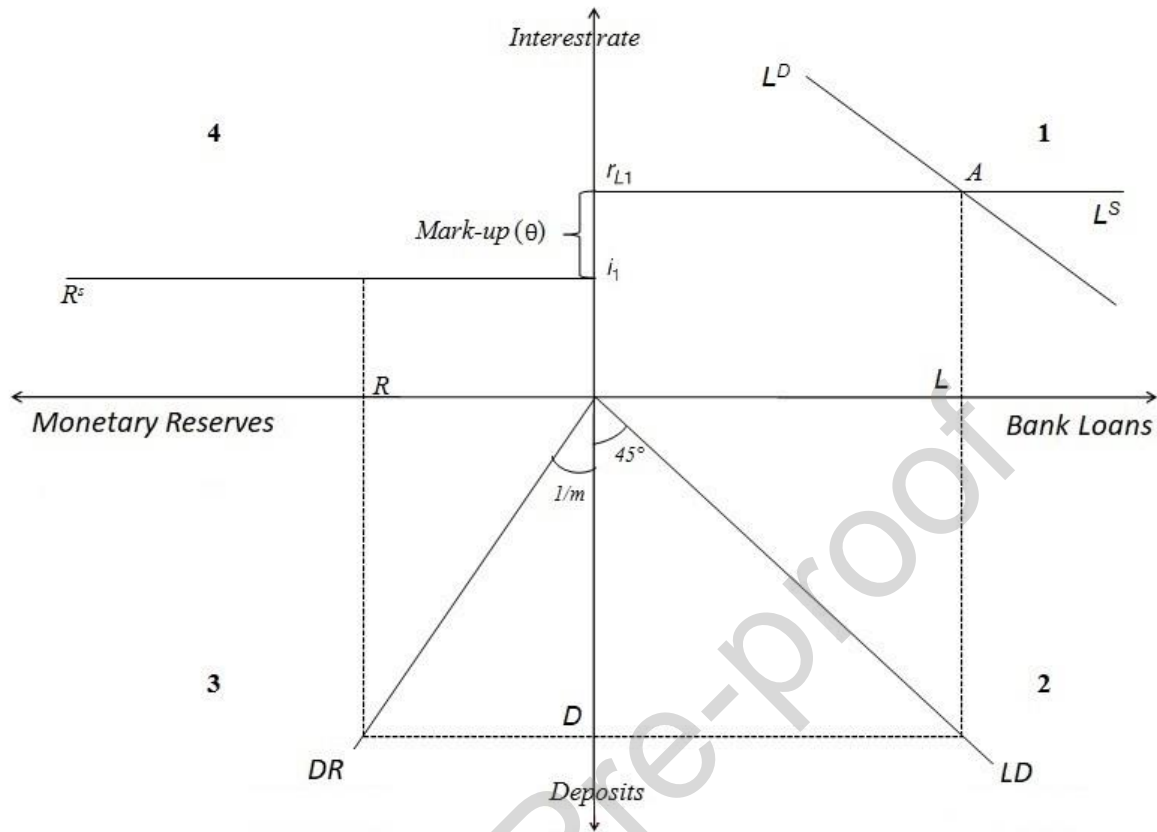
$$R = (1/m) D$$

Reverses are then supplied by the central bank at a given interest rate i_1 . Therefore, the monetary base (reserves) can be considered as the residual of commercial banks lending activity. Although recognising the above-mentioned steps and the loans-deposits and deposits-reserves causality direction, there are different perspectives among the EMT scholars, which are mainly related to the interest rates determination, the degree of accommodation of the central bank, and the concept and application of Keynes's liquidity preference (Fontana, 2004). These controversial arguments are often described in terms of the debate between the Horizontalist (or Accommodationist) and Structuralist approaches to the EMT⁹.

As portrayed in Figure 1, the horizontalist view states that the supply of loans (L^S) and the supply of reserves (R^S) can be drawn as infinitely elastic with respect to the interest rates (r_{L1} and i_1 , respectively). The interest rates can be regarded as exogenous variables¹⁰ being defined by the autonomous behaviours of commercial banks and of the central bank in the loans and reverse markets, respectively. On the contrary, the structuralist approach to the EMT emphasises the relevance of the liquidity preference of the macro agents involved in the money-supply process and considers the interest rate as endogenously determined by the interactions between supply and demand for loans. According to the structuralist perspective, the horizontalist representation of an infinitely elastic money-supply function, as shown in Figure 1, would be replaced by an upward-sloping supply curve. Moreover, also the full accommodation behaviour of the central bank in providing reserves to the banking system is questioned by the structuralists. According to their perspective, the central bank could apply price and quantity constraints on banks' reserves implying an upward-sloping supply of reserves.

⁹ Supporters of the horizontalist perspective are, among others, Eichner, 1987; Kaldor, 1970; Lavoie, 1996; Moore, 1988; Rochon, 1999, 2001). The structuralist view is supported, among others, by Wray (1990, 1992a, 1992b, 1992c, 2007), Palley (1994, 1996a, 1996b, 2002, 2017), and Dow (1996). See Fontana (2003, 2004) for a constructive interpretation of the debate.

¹⁰ The exogeneity means that the interest rate is not conceived as a market phenomenon, but it is affected by policy goals and by the state of the economy (Moore, 1989, p. 487; Lavoie, 1996).



Source: Fontana and Setterfield (2009) and Deleidi and Fontana (2019).

5. Full Disintermediation in the Endogenous Money Theory

Although several contributions are discussing the possibility of issuing a CBDC assessing its impact on the current monetary framework, very few studies have provided a formalisation in light of the economic theory. To the best of our knowledge, the first study of the CBDC through the lens of the EMT is carried out by Cesaratto and Febrero (2022). Building on this contribution, this section tracks the steps that are associated with a *full disintermediation (and full conversion)* scenario, where all the deposits held in the account of commercial banks are ultimately fully converted into CBDC. This scenario analyses the interconnections among three actors: the central bank (ECB afterwards), commercial banks (CBs), and non-financial private sector (NFPS).

According to the EMT, commercial banks are the main source of money creation by making loans (L) and creating deposits (D) held by NFPS. After granting bank loans, commercial banks demand a certain amount of reserves (R) from the central bank. To guarantee the convertibility of those deposits into cash, commercial banks can detain reserves - on granted loans or on deposits - for compulsory or voluntary reasons (Terzi 2021, p.65). However, reserves only constitute a fraction of the commercial banks deposits. In fact, as Lavoie (2015, p. 188)

highlights “...the causality associated with bank reserves is also reversed, with reserves being endogenous and demand-led, thus being a fraction (the divisor) of deposits...”.^{11 12}

Figure 2 displays the balance sheets of the ECB, CBs and NFPS, recording the assets and liabilities of the main actors involved in the transitioning process from deposits to CBDC.

Figure 2. Steps in the full disintermediation and conversion from Commercial Deposits to CBDC

	Commercial Banks (CBs)		ECB		NFPS	
	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
Initial Situation	Loans L 1,000 € Reserves R 100 €	Deposits D 1,000 € Other liabilities 100 €	Other As. 10,100 €	Other liab. 10,000 € Reserves H 100 €	Deposits D 1,000 € Other Assets ...	Loans L 1,000 € Other liabilities ...
Step 1	Reserves H -100 €	Deposits D -1,000 € Debt v/ECB +900 €	Loans v/CBs +900 €	Reserves R -100 € CBDC +1,000 €	Deposits D -1,000 € CBDC +1,000 €	
Final Situation	Loans L 1,000 €	Debt v/ECB 900 € Other liabilities 100 €	Other As. 10,100 € Loans v/CBs 900 €	Other liab. 10,000 € CBDC 1,000 €	CBDC 1,000 € Other Assets ...	Loans L 1,000 € Other liabilities ...

Source: authors elaboration

In figure 2, the initial situation represents a state of affairs, with a loan of 1,000 € granted by CB to NFPS and an equal amount of deposits. Deposits are (short-term) liabilities in the balance sheets of commercial banks, while loans are (long-term) activities. Considering, for the sake of simplicity, that a commercial bank detains 10% of reserves with respect to deposits¹³, the balance sheet of the CB will record: 1,000 € deposits and 100 € as other liabilities within its liabilities side; 1,000 € as loans, together with 100 € reserves in its assets side. The NFPS detains 1,000 € of deposits as an asset and 1,000€ of bank loans in its liabilities side. The ECB balance sheet is composed of 100 € reserves (as a liability toward the commercial bank), together with other liabilities which are (hypothetically) supposed to be equal to 10,000 €. The overall value of liabilities is then equal to 10,100 € which is matched with an overall value of assets of 10,100 €.

Step 1 shows the *full disintermediation* scenario, namely a situation where the NFPS converts all deposits into CBDC. In the balance sheet of commercial bank, there will be a reduction in deposits by 1,000 € and a reduction in the corresponding proportion of reserves by 100 € - in the liability and asset sides, respectively. The reduction by 100 € in reserves will be also recorded within the liabilities side of the central bank. It is important to underline that the drops in the commercial bank liabilities and assets sides do not have the same magnitude. Liabilities dropped by 1,000 € while assets were reduced by only 100 €. In accountability terms, this unbalance can be solved by mainly two options.

The first option is the emergence of a debt that the commercial bank has toward the central bank, for the difference of 900 €. In this first case, we observe that the commercial bank has replaced its previous liability, made of deposits (held by the private sector) with a liability toward the central bank, for the remaining amount of 900 €. As Lavoie (2014, p.207)

¹¹ “It does not matter whether the reserves are imposed on deposits, as they are in most countries and in the USA in particular, or on loans or other assets, as they used to be in France and in other European countries and as is now suggested by Palley (2006)” (Lavoie 2015, p.207).

¹² “Minimum reserves are a common monetary policy tool in central banking. However, some central banks, for example the Reserve Bank of Australia, the Bank of Canada and Sveriges Riksbank, do not use them” (European Central Bank, 2022)

¹³ This percentage has been chosen purely for simplicity reasons in the description of the debt-credit relationships. Different percentages in the detained reserves would not alter the significance of the study.

recognizes: “Banks are perpetually engaged in passive liability management, as they must first consent to loans, and later search for funds to finance the currency drain ...”. In this situation, commercial banks are simply changing their creditors, namely from NFPS to the ECB. The substitution in liability is stressed by Niepelt (2021b, p.39) that clarifies: “Banks continue to engage with the real sector, in particular, extending credit; only the composition of their liabilities changes as household and firm deposits are substituted by central bank loans”.

The second option is instead a reduction of the commercial bank assets by 900 €. In this scenario, the commercial bank might be selling loans, bonds, or other assets to the central bank. The presence of this second solution is recognised also by Panetta (2021a) that clarifies: “if the digital euro attracted deposits... it could affect the cost and supply of credit and the transmission of monetary policy through bank balance sheets. The central bank could mitigate or eliminate these effects by increasing refinancing of banks or through asset purchases, thereby expanding its own balance sheet”.

Representing the first scenario, figure 2 displays an increase in commercial bank liability towards the central bank. Looking at the accounting framework, the commercial bank registers a new debt (900 €) towards the central bank while the ECB records a credit of the same amount in its asset side. Reserves shrink in the assets side of commercial banks by 100 €, as well as in the liabilities side of the ECB with the same magnitude.

Simultaneously, as (1,000 €) deposits disappear from the NFPS and CB balance sheets, the ECB transfers an equivalent amount to the CBDC account owned by NFPS. CBDC constitutes a debt toward the NFPS which is registered in the liability side of the ECB. Finally, the NFPS deals with a transformation of its credits: deposits (credits *vis-a-vis* the CBs) transform into CBDC (credits *vis-a-vis* the ECB).

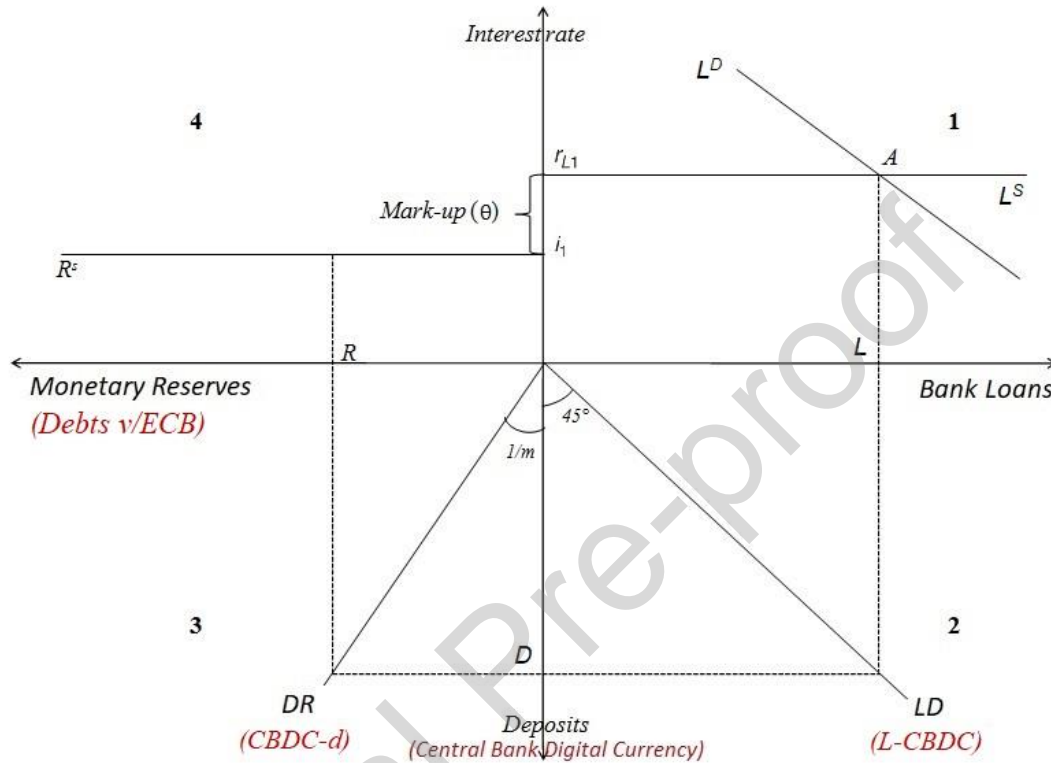
The conversion process of deposits into CBDC (analysed in step 1) affects the magnitude and the composition of commercial bank balance sheet. In fact, under the assumption that reserves are a fraction of deposits, reserves are completely depleted while deposits are only partially replaced by the newly originated debt toward the ECB. After the conversion of deposits into CBDC, the balance sheet of the CBs registers total assets and liabilities equal to 1,000 €, showing a reduction compared to the initial situation (1,100 €). As observed, also the composition of the CBs assets and liabilities changed. In fact, in the final situation, CBs do not hold any reserve among their assets and the deposits have been replaced by a new debt toward the ECB.

From the central bank point of view, there has been an expansion of its balance sheet by 900 €, compared to the initial situation. That is exactly the difference between the CBDC emission (1,000 €) and the reserves erosion (100 €).

Figure 3 illustrates the disintermediation process, drawing the logic chain of deposits migration into CBDC, through the lens of the endogenous money theory. The four-quadrants diagram can be read from the top-right first quadrant, in a clockwise way. It indicates the amount of loans (L) generated by commercial banks in the economy that gives rise to an equal amount of deposits (D), as shown by the LD line. That captures the initial situation. However, as previously analysed by the accounting framework in step 1, deposits are completely converted into CBDC. The migration implies that deposits are depleted to zero, as well as the amount of reserves. The second and third quadrants show the disintermediation process. In the second quadrant, the LD line contracts because of deposits disappearance and of their transmigration into CBDC. Correspondingly, the deposits vertical axis is now replaced by the CBDC vertical axis. The LD line in the second quadrant - that previously linked bank loans and bank deposits - is replaced by the L-CBDC line, which shows the relationship between bank loans and CBDC. In a similar way, the DR line - which previously showed the relationship between bank deposits and

reserves - is replaced by the link between the CBDC and the debts (d) that commercial banks owe toward the central bank (CBDC- d line). Quadrant 4 shows that the central bank accommodates the request of the commercial bank, providing means of refinancing.¹⁴

Figure 3. CBDC with the Endogenous money model



Source: authors adaptation from Fontana and Setterfield (2009).

An implication of this study supports the idea that the EMT allows interpreting recent phenomena of current time, such as the introduction of the CBDC and the dynamics among macro-agents. Those dynamics are often studied only within an exogenous money theory analysis, implying that all the relevant insights obtainable by the adoption of an EMT perspective are neglected.

The amended four-quadrants diagram enables deepening the transformation of deposits into CBDC. The first quadrant still underlines the credit creation step through which commercial banks provide loans to creditworthy borrowers. The second quadrant now reflects the conversion process of deposits into CBDC and the link that CBDC continues to hold with commercial bank loans. Quadrant three reveals the impact that such a conversion of deposits into CBDC would have on the relationship between CBDC and the replacement of reserves requested from commercial banks to the central bank. The core mechanism of the EMT highlights that commercial banks provide loans first and only later they look for financial resources to back up their needs. This mechanism maintains with the introduction of the CBDC. Quadrant four finally shows the level of indebtedness of commercial banks toward the central bank.

¹⁴ For the sake of simplicity, it is supposed that the central bank continues to apply the same level of i_1 accommodating commercial banks requests. It is also supposed that CBs continue to apply the same mark-up (θ) in establishing a higher interest rate level on loans (r_{L1}). Those simplified hypotheses can be removed and further analysed in future research.

It is important to underline that the introduction of a CBDC does not need to conform with a narrow banking model (Dow, 2018): credits and bank loans are still provided on demand by commercial banks, paving the way to the indebtedness relationship that CBs have toward the central bank, which accommodates their requests. Within the above-considered full conversion framework, the balance sheets of commercial banks are shrunk while the balance sheet of the central bank is increased. Notwithstanding, commercial banks retain the crucial role of granting loans.

Furthermore, including the CBDC, the central bank is still not controlling the quantity of money in the economy, in the same way it was not controlling the quantity of money in the traditional endogenous money theory (Graziani, 2003). As Godley (1997) observed “governments can no more control stocks of either bank money or cash than a gardener can control the direction of a hosepipe by grabbing at the water jet”. However, one could argue that in the extreme case of a full conversion of deposits into an interest-bearing CBDC, no one would need to access ordinary cash and therefore there would be no need for commercial banks to keep some cash in their vaults.

This study gives rise to many questions and potential areas for future research in need of further investigation. Using the accounting steps in figure 2 and the adapted four-quadrants diagram shown in figure 3 several scenarios can be examined. First, the analysis could be further expanded considering the different architectures analysed in section 3, namely direct issuance, two-tiered issuance, and hybrid model. Second, the analysis can be enriched by looking at the different measures to be introduced to mitigate and prevent the full conversion of deposits into CBDC, such as the imposition of a maximum threshold of deposits that can be converted into CBDC or the interest rate on CBDC. Third, the analysis can be further extended also considering the effects produced by a change in the liquidity preference of NFPS, which modifies the slope of the L-CBDC, shown in quadrant 3 (Figure 3). Such a variation could change both the potential level of deposits to be converted in CBDC and the level of reserves to be detained by commercial banks. Finally, this study highlighted how the conversion of deposits into CBDC would influence the balance sheet composition and size of both commercial banks and the central bank. In particular, the study showed that the transformation of commercial banks indebtedness would change, passing from being composed mainly of deposits to a configuration where liabilities would be composed mainly of debts versus the central bank. The analysis of the balance sheet composition could represent an interesting natural development of this study, examining the potential impacts of those changes.

6. Conclusions

This paper investigated the relevance of the CBDC using an endogenous money framework. The XXI century has been increasingly characterised by a deepened digitalization of the economy, by a shift towards electronic payments and by a consequent decline in cash. Such a digitalization of payment methods has found a fertile field in the exponential growth of private digital currencies, such as Bitcoins and stablecoins.

However, one of the most challenging developments consists in the public response to private digital currencies through the CBDC. Alongside the academic community, the introduction of a CBDC has increasingly attracted the interest of international institutions and central banks around the world, which have proposed and discussed a variety of technological designs. Depending on the design, a CBDC may produce different impacts on the monetary and banking system. Building on Cesaratto and Febrero (2022), this paper represented one of the

few attempts in interpreting the introduction of a CBDC, in light of the theory of endogenous money. The paper extensively explored the effects of the full conversion and transition of commercial bank deposits into CBDC. Such an analysis is done by examining the debit-credit relationships among commercial banks, the central bank, and the non-financial private system, using two main tools. First, the paper used a step-by-step accounting approach tracking all the assets and liabilities of the macro agents involved in the introduction of a CBDC. Second, it studied those relationships through an amended version of the four-quadrants diagram, used by many post-Keynesian scholars. The combination of both tools allowed to grasp the essence of the full transition from deposits to CBDC and allowed also to study the change in the magnitudes and the compositions of the balance sheets of both the central bank and commercial banks.

The analysis suggested that the endogenous money theory explains the introduction of the CBDC, describing the logical chain of relationships that starts with bank loans issued by commercial banks, which create deposits ultimately converted into CBDC. In the extreme case of a full conversion and transmigration of deposits into CBDC, the paper highlighted both a shrink and a change in the composition in the balance sheets of commercial banks, together with an expansion and change in the composition of the central bank balance sheet. The European Central Bank report underlines the same point; in particular, central bankers have warned against the structural or cyclical disintermediation of deposits caused by CBDC. However, the introduction of a CBDC does not need to conform to a narrow banking model, where commercial banks lose the power of creating money.

This study has raised many questions in need of further investigation. The combined use of the accounting records and the amended four-quadrants diagram constitute a powerful baseline for future research questions. Future work should concentrate on the analysis of the different alternative scenarios, explaining potential variations in the monetary economic system generated by changes in the liquidity preference of NPFS, by a variation in the cost of borrowing connected to the change in the size and composition of CBs balance sheets. Furthermore, this combined framework could also serve to analyse a change in the monetary policy transmission mechanisms, as well as the effects of different CBDC design features, namely a zero-remunerated CBDC, or a remunerated CBDC with resistance in the transition between deposits and CBDC.

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Highlights

- Analysis of money in view of CBDC
- Potential risks and benefits of CBDC
- CBDC would not change the Endogenous Money framework
- CBDC could change the composition and shrink the balance sheets of Commercial Banks
- CBDC could change the composition and increase the balance sheets of Central Banks