Contents lists available at ScienceDirect

Structural Change and Economic Dynamics

journal homepage: www.elsevier.com/locate/strueco

Is the time ripe for helicopter money? Growth impact and financial stability risks of outright monetary transfers

Jacopo Temperini [a], Carlo D'Ippoliti [a,*], Lucio Gobbi [b]

[a] Sapienza University of Rome, Italy
[b] University of Trento, Italy

ARTICLE INFO

JEL codes:
E5
G0
E12

Keywords:
Helicopter money
Central bank Digital Currencies
Monetary policy
Transmission channels

ABSTRACT

We study the effectiveness of helicopter money, once a thought experiment that is now a feasible option given new digital technologies. We consider the effects of central bank digital currencies (CBDC) from a theoretical point of view, by means of a stock-flow consistent model of a growing open economy. We compare the effectiveness of this tool with that of traditional fiscal and monetary policies. We find that issuing a CBDC by expanding the central bank's balance sheet can have a durable impact on GDP and crucially, it allows for the activation of a new transmission channel, which depends on the sensitivity of investment and of the interest rate to firms' leverage. But it might reduce the demand for bank deposits, and even more crucially for bank loans, thus creating challenges for financial stability.

1. Motivation

Technological progress in the field of digital technologies, and specifically the development of blockchain, have finally made "helicopter money" a real policy option for central banks and not anymore a mere thought experiment. As Buetzer (2022) puts it, "Outright Monetary Transfers" would now be feasible, in the sense of a direct transfer of resources from the central bank to firms and households. Such a policy would be engendered in the issuance of central bank Digital Currencies (CBDCs), namely "a digital form of central bank money that is widely available to the general public" (Federal Reserve, 2022a). In this work we reflect on the implications of such a new tool of monetary (or possibly hybrid fiscal) policy, and use a stock-flow consistent (SFC) model to assess its cons and pros vis-à-vis more traditional tools of fiscal or monetary stimulus.

Over the past fifteen years, policy makers have faced a number of large shocks that have forced them to devise and use exceptional economic policy instruments (Eichacker, 2022). Among these, the so-called unconventional monetary policy, that is, policies that attempt at controlling the monetary base and/or money supply rather than an interest rate (see next section for a more detailed explanation) – which after several years of Quantitative Easing (QE) cannot really be referred to as "unconventional" anymore. Legislators and economic institutions have sometimes found themselves unprepared to the side effects that these new instruments have had on the economic system; for example, a wide ranging debate has developed, on the possible redistributive impact of QE measures, only after these measures had been implemented. From some points of view, the future may have similarly challenging times in store, and our work should thus be seen as a purely theoretical attempt to understand what are likely to be the main potentialities and risks, should central banks see themselves in need of starting to use CBDCs as a new monetary policy tool.

For our aims here, the attribute "digital" in the name could cause misunderstandings. That a CBDC must necessarily be a digital asset is a technical requirement – it's what makes it finally possible to implement a helicopter money policy on a large scale (Shah et al., 2020) – but it is not an economic requirement, and will not be further discussed here. Households, firms, and financial intermediaries already hold currency primarily in a digital form: for example, bank deposits are typically considerably larger than physical cash. The difference between a CBDC and electronic bank money is that a CBDC would be a direct liability of the central bank toward households and/or businesses, possibly even without the intermediation of banks or financial corporations (simplifying, one could say that households or firms might begin holding reserves with the central bank).

This tool has been increasingly discussed by commentators and central banks especially in light of fast innovation in the private financial sector (fintech), and it has often been presented as a defensive move

* Corresponding author
E-mail address: carlo.dippoliti@uniroma1.it (C. D'Ippoliti).

https://doi.org/10.1016/j.strueco.2023.11.003
Received 2 November 2022; Received in revised form 31 October 2023; Accepted 4 November 2023

against market movements or experimentation from other central banks (Auer and Bohme, 2020; Bank of Canada et al., 2020; BIS, 2020 ; Federal Reserve, 2022a; Soderberg et al., 2022). By contrast, we consider here the possible positive contribution of CBDCs, as a way of enlarging and differentiating central banks' toolkit (Meaning et al., 2018; Bordo and Levin, 2017; Chen and Siklos, 2022; Federal Reserve, 2022a). The main stated purpose of central banks, for the moment, is to conceive of CBDCs as an instrument to improve the efficiency of the wholesale and/or retail payments system (Panetta 2022). However, the implications for monetary policy and financial stability are multiple and need to be studied carefully; any instrument, and thus CBDCs, might become a tool of monetary policy even if they were not originally intended for that aim.

In this context, we compare the effectiveness of traditional fiscal stimulus (with monetary financing), and of QE, with the introduction of a CBDC. Given our primarily theoretical aims, we adapt a stock-flow consistent (SFC) model that was already proposed in this journal by Sawyer and Passarella (2021). This model was designed with the aim to provide a comprehensive comparison of fiscal and monetary policies, including QE. It especially suits our aims here because, differently from other contributions in this literature, it has not been designed to mimic the dynamics of any specific country, but rather to approximate those of a generic advanced capitalist economy. In our simulations, we too calibrate the model to roughly reproduce conditions of "secular stagnation" in an advanced economy.[1]

Moreover, that model is especially useful to clarify that even in a post-Keynesian model in which private (bank) money is endogenously supplied, the central bank can exogenously change the supply of at least some monetary aggregates. In Sawyer and Passarella (2021) this is the case of QE, in our work it is also the case with the issuance of CBDC. In order to preserve the comparability of our results with those by Sawyer and Passarella, we have modified the original structure of their model as little as possible – evidently, except for the introduction of the CBDC. Crucially, although central banks currently consider CBDCs as a means of payment, our SFC framework allows us to clarify that – by being a liability of the central bank – this tool might nonetheless become a store of value.

A prime advantage of CBDCs emerges from our analysis: their activation of a new and different transmission channel, different from those activated by the other currently available monetary policy tools. This new channel crucially depends on households' propensity to spend the CBDC, and on the sensibility of private investment and of bank loans to firms' financial leverage.

Yet, extant literature has highlighted a possibly crucial risk of CBDCs: that they might reduce the demand for banks' *deposits*, thus posing challenges for financial stability in so far as deposits constitute a reliable source of funding at relatively low cost for banks (Meaning et al., 2018; Bordo and Levin, 2017; Keister and Monnet, 2020; Kim and Kwon, 2022; Federal Reserve, 2022a). Our analysis shows that a reduction of the demand for banks' *loans* might be an even more serious issue, due to its negative impact on bank profitability. This both vindicates the cautious approach of most Western central banks, and calls for more research on the specific design of this policy tool.

In order to investigate the theoretical potential of CBDC for the implementation of helicopter money policy, the rest of the paper develops as follows: Section 2 qualifies what precisely we mean by helicopter money, and why this term is sometimes used improperly; Section 3 contextualises the CBDC in the world of cryptocurrencies and provides a short review of the literature on this topic; Section 4 describes the baseline model and explains the different treatments we tested. The fifth section reports our main results, and Section 6 draws some conclusions.

2. Helicopter money and fiscal monetization

Among the different types of anti-deflationary policies proposed by mainstream economists following the Great Financial Crisis and the European sovereign debt crisis, some have been labelled as helicopter money (e.g. Gali, 2020; Grenville, 2013; Ryan-Collins and Van Lerven, 2018). Then, in the wake of the pandemic too, several proposals have been referred to as helicopter money policy (e.g., Benigno and Nisticò, 2020; Goodhart et al., 2021).

The term "helicopter money" was introduced by Friedman (1969) to describe a one-off increase in the money supply. In today's context, the rationale for this proposal could lay in a perception of limited effectiveness and/or drawbacks of QE (Turner, 2015). Some authors argue that the net acquisition of financial assets, acquired by issuing new money, does not generate significant direct benefits for low-income households in the short run, but only in the medium term (e.g. Kappes 2021). Even before the recent move towards more restrictive monetary stances (ostensibly caused by inflation spikes), mainstream economists were already questioning the effectiveness of persistent "unconventional" monetary stimulus and widely recognized some of its drawbacks, such as the negative impact on income inequality (most recently and in connection to CBDCs, see Buetzer, 2022; for a review see, Kappes, 2021). Indeed, both mainstream and heterodox contributions have found evidence of negative side effects of QE (e.g. Bernanke 2015; Cui and Steck 2021; Gornemann et al., 2012; Kappes 2021; Palley 2011).

Post-Keynesian economists have argued that fiscal policy is a more effective policy tool than monetary policy (e.g. Lavoie, [2014] 2022), and several authors highlighted that, already before Covid hit, advanced economies were already mired in stagnation (e.g. Fàtas and Summers, 2017).

In contrast to QE, helicopter money could be able to generate an immediate increase in households' wealth. However, this proposal has been commonly framed as a fiscal expansion financed by an irredeemable loan from the central bank to the government. This way, despite the fact that it permanently expands the central bank's balance sheet, helicopter money is more akin to fiscal than to monetary policy (Buiter, 2014; Fullwiler, 2013). This is true even if helicopter money were implemented through a CBDC that the central bank could issue by directly crediting households' and/or firms' bank accounts (with the central bank itself, or with financial intermediaries). This option might have been possible in the past, but until modern computing capabilities and digital technologies (including security standards) evolved sufficiently, it was not considered by policy makers. It is now practically possible, although the mentioned risk of blurring the boundaries between monetary and fiscal policy makes it not immediately implementable in all countries due to institutional and political constraints.[2]

This risk is all the more evident if the issuance of a CBDC were to be targeted, for distributive or other reasons, to specific population groups, a specific sector of the economy, or even to a specific class of economic units within a sector. Therefore, in this work we do not compare such policy with QE only, but also with the possibility of a monetary financed

[1] We leave the analysis on the possible effects of CBDCs in developing economies to future research. According for example to Arauz (2021), a domestic CBDC could help increase the potential of money creation in a developing economy, but foreign CBDCs could contribute to the movement offshore of domestic payment systems, and even risk facilitating capital flight.

[2] An anonymous reviewer notices that large-scale payments from the government to large strata of the population have already happened in the past, even recurrently, in the case of the payment of wages to public sector employees. However, we do not regard these policies as 'helicopter money' because they remained confined in the remit of fiscal policy, they did not necessarily (and frequently did not) lead to an expansion of the monetary base, and were typically intermediated by banks, the post offices, or some other party, and so in most of the cases they did not constitute examples of sustained changes in the monetary base with households or firms as direct counterparts - in which we are interested here, and that, in practice, have only become feasible with the advent of new digital technologies.

fiscal expansion or what has been called "fiscal monetisation". The term indicates different procedures that involve an expansion of the central bank's balance sheet (be it permanent or temporary), combined with an increase in public deficit (Turner, 2015).[3]

However, the term monetisation is often used improperly, and it seems convenient to distinguish four kinds of policies: (i) an increase in deficit that leads to an increase in general government debt only; (ii) an increase in the central bank balance sheet due to the acquisition of general government debt on secondary markets; (iii) an increase in public deficit accompanied by a central bank purchase of general government debt securities on primary or secondary markets; and (iv) deficit financing through funding from the central bank. In the first case there is no deficit monetization because the central bank's balance sheet remains unchanged; the government finances its deficit by issuing debt on the primary market. The second case represents a simple open market operation in which a monetary but not a fiscal expansion is determined. Therefore, this procedure too does not constitute monetisation. In the third case there is fiscal monetisation even if it could be enacted with a temporary monetary expansion (that the central bank could offset at any time by selling securities). On the contrary, when the financing of the public deficit takes place against an irredeemable debt granted by the central bank to the government, the central bank registers a permanent increase in the balance sheet.

A first consideration to be made is that these policies, besides the correct use of the term, may have different impacts on the economy. According to mainstream economists, all four options described above imply an increase in aggregate demand (though with possibly negative side effects, as mentioned in Section 1). For post-Keynesian economists the effects of the second option (QE) are more uncertain, given the inelasticity of investment to the interest rate (Rochon, 2016), even though Keynes himself argued in the *Treatise on Money* Keynes (1930) that a policy of increasing the central bank balance sheet through significant open market operations would reduce short- and long-term interest rates and increase security prices. This would increase the aggregate demand through a wealth effect. As mentioned, in the next section we will use a typical SFC model, encompassing the endogeneity of money as a main hypothesis, coupled with the central bank's targeting of a specific interest rate. Therefore, as will be seen, in our model even traditional fiscal policy might imply an "automatic" change in the size of the central bank's balance sheet, aimed at preventing changes in the relevant interest rate(s). In that sense, all the scenarios we will consider exhibit some change in the monetary base. Our focus will be on assessing their potential impact on GDP.

A second consideration, however, that we leave for future research, is what is the democratic legitimacy of the central bank's targeting of support measures to some sectors or actors and not others, or what is the legal basis for its involvement in decision-making at least partly related to fiscal policy. We do not intend to downplay the relevance of these concerns (on which see e.g. the recent Rochon and Vallet, 2022). However, a thorough discussion of these issues would extend well beyond the scope of this theoretical paper, and would need to take into account the various constitutional and institutional environments in which central banks operate in the different countries.[4]

3. The burgeoning literature on CBDCs

3.1. Pilot projects and public consultation on digital currencies

In the aftermath of the Great Financial Crisis (GFC), due to growing scepticism towards the global financial and monetary system as well as technological innovations, a multitude of decentralised financial and monetary experiments flourished (De Bonis and Ferrero (2020)). Private digital "currencies" (or financial assets by that name) tend to attract negative assessment in the literature (G7 Working Group on Stablecoins, 2019; Carstens et al., 2021). In contrast, a number of authors note that introducing a (public) CBDC could lead to systemic efficiency improvements.[5] These can be summarised on the basis of four recent documents by prime monetary institutions: the BIS (Bank of Canada et al., 2020), ECB (2020), Federal Reserve (2022a) and the IMF (Soderberg et al., 2022). First, CBDCs can be viewed as digital cash capable of replacing physical cash or at least flank it as a complementary tool to it. This would simultaneously ensure for users the safety of having the central bank money and the convenience of a bank deposit (e.g Meaning et al., 2018; Cesaratto and Febrero, 2023). Second, a CBDC reduces transaction costs (e.g. Cecchetti and Schoenholt, 2021). Third, many people who currently do not have bank deposits could access the financial system (e.g. Cecchetti and Schoenholtz, 2021). This process of democratisation of finance, in the sense of greater financial inclusion, could be a necessary condition for the implementation of unconventional monetary policies such as helicopter money (e.g. Bilotta and Botti, 2021; Reis and Tenreyro, 2022). Fourth, a CBDC can make it possible to track payments, facilitating in this way the containment of tax evasion and criminal activities (e.g. Meaning et al., 2018; Bank of Canada et al., 2020).[6]

Extant literature is mainly composed of theoretical contributions since CBDCs have not been implemented at scale in almost any advanced economy. A notable exception is China, which has recently introduced the e-Yuan (or e-CNY) after a long period of experimentation that started in 2014.[7] Further pilot projects and advanced studies are currently being undertaken by the Eastern Caribbean central bank, the Sveriges Riksbank, and the Banco Central de Uruguay; while a central bank that has already implemented a CBDC is the central bank of the Bahamas (Soderberg et al., 2022).

One of the main topics of discussion around CBDCs is their detailed design. Existing technology (blockchain and instant payment services) allows many degrees of freedom to policymakers, and the design of a CBDC depends primarily on the policy objectives to be achieved (Shah et al., 2020). Several aspects have so far emerged in the literature (for a review, we refer the reader to Chen and Siklos, 2022). The first concerns the type of CBDC recipient. There are two possibilities: a retail CBDC, or a wholesale CBDC. The former is a currency issued directly to households and businesses, an instrument that would allow the central bank to directly reach economic units currently excluded from the financial system. In contrast, a wholesale CBDC would involve financial institutions that already carry reserve deposits with a central bank (Boar and Wehrli, 2021). This instrument presents fewer technical difficulties and would considerably limit the process of banking disintermediation that would be generated by a retail CBDC (Bindseil, 2020). In this work we focus on the introduction of a retail CBDC, for its greater potential for innovation and to more clearly highlight the possible risks associated

[3] See Ryan-Collins and Van Lerven (2018) for an in-depth analysis.

[4] See e.g. the ECB's plan for 'green bond' purchases (https://www.ecb.europa.eu/press/pr/date/2022/html/ecb.pr220704~4f48a72462.en.html)

[5] For a recent review and a comparison of the main differences between CBDC and private cryptocurrencies, see Temperini and Corsi (2023).

[6] The issue of possible transaction tracking and the related questions of the protection of the privacy of CBDC users are a central component of the ongoing debate on the design of CBDC, especially for the European and American institutions (see e.g. ECB, 2020; Federal Reserve, 2022a).

[7] At the time of writing, it should be noted that the e-Yuan project is still under development. So far it is organised as a digital payment infrastructure aimed at commercial banks, that does not constitute net new money supply because the PBOC issues e-CHN only in exchange for and for the same amount of "certificates of indebtedness" (Siu, 2023). Therefore it is a wholesale CBDC design as a loan. Some economists argue that one of the main goals of the People's Bank of China's (PBoC's) issuance of a CBDC is to expand the use of the e-CNY in the international payments system in order to erode the hegemony of the dollar as an international currency (e.g. Fantacci and Gobbi, 2021; Fantacci et al., 2022). Others do not consider this goal so relevant.

with it.

Another important aspect of design regards the possibility to issue an interest-bearing CBDC. On the one hand, such a tool would provide an attractive safe store of value and a safe asset for the financial system.[8] Indeed, interest-bearing CBDCs compete with the other risk-free assets already used in the implementation of monetary policy (Bordo and Levin, 2017). On the other hand, a non-interest-bearing CBDC is a cash substitute (Panetta, 2021a).

In this contribution we analyse the possible effects of a non-interest bearing CBDC in a developed economy. We choose this option because the vast majority of projects currently under consideration by central banks are oriented in this direction (e.g. Allen et al., 2022; Soderberg et al., 2022). However, as will be discussed below, introducing an interest rate would not qualitatively change our results. Further, we consider the case of a retail CBDC to highlight the highest opportunities and risks associated with the relatively more ambitious projects.

Some proponents (e.g. Panetta, 2021b) argue that central bankers "have explicitly and repeatedly stated that we want the banks to be our partners, not our competitors. We will offer safe money, not financial services". However, if it is designed without a clear time limit or limitations in its use, a CBDC is also likely to be perceived and used as a store of value. Being issued by the same entity that sets and issues the unit of account in the economy, by definition a CBDC cannot suffer from capital losses in nominal terms. It is "safe money" and as such, a financial asset class. It is thus difficult to argue that by issuing a CBDC the central bank does not enter to some extent in the business of commercial banks, and for this reason, most central banks are threading cautiously. For example, the ECB is considering a limit of 3,000€ on each individual holding of digital euros.[9] In Section 4 we will show that if agents who are credited a certain amount of CBDC use these new resources to reduce their exposure toward commercial banks, a CBDC is not only a substitute for bank deposits but, worryingly, for bank loans too.

3.2. Previous studies on the economic impact of CBDCs

Given all the experimentation undergoing or being considered, there is growing interest in the possible impacts of CBDCs on the economic and financial system. But with the notable exceptions of Kregel (2019) and Cesaratto and Febrero (2023), these issues have mostly been analysed by mainstream economists.[10]

Barrdear and Kumhof (2016) use a New Keynesian DSGE model to analyse the effects of a CBDC on macroeconomic variables at different phases of the business cycle. They find that a CBDC has a positive impact on GDP in the long run, and this effect is mainly due to the reduction in the interest rate. A controversial issue is the capacity of controlling monetary aggregates once a CBDC is introduced. Chen and Siklos (2022) use McCallum's monetarist approach in which the conduct of monetary policy is linked to the control of some monetary aggregates. They estimate that the introduction of a CBDC would have not been inflationary in the period from the 1970s to the 1990s.

Keister and Sanches (2021) indicate that a trade-off emerges from the introduction of an interest-bearing CBDC. On the one hand, a CBDC reduces the opportunity cost of holding money for households, and increases their demand for it. On the other hand, the increase in the cost of funding for banks translates into an increase in the cost of credit, which reduces the level of aggregate investment. Considering an oligopolistic bank deposit market, Chiu et al. (2019) show that higher deposit rates can increase lending by increasing the demand for deposits. The authors show that the introduction of a CBDC provides a lower bound on deposit rates, limiting banks' monopoly profits in the deposit market.

Kim and Kwon (2022) emphasise the importance of bank's reserves in examining the effects of introducing a CBDC. The authors show that for a wholesale CBDC an increase in the amount of the CBDC that does not require banks to hold reserves could even strengthen financial stability and lower interest rates.

On the same issue, Keister and Monnet (2020) point out that in times of financial stress, CBDCs are preferred by economic agents over bank deposits, for example because of their lower (or absent) counterparty risk. Therefore, the authors emphasise the macroprudential importance of observing the aggregates of deposits and CBDCs in order to monitor the bank run risk perceived by economic agents.

4. Helicopter money, quantitative easing, and fiscal transfers in a SFC model

The SFC approach is especially suitable for the assessment of complex economic systems. In particular, it ensures the consistent integration of the stocks and flows of all sectors in the modelled economy through the compliance with four main accounting principles: flow consistency, stock consistency, stock-flow consistency, and quadruple-entry accounting (for a survey on the SFC methodology, see Nikiforos and Zezza, 2017; Carnevali et al., 2019). Among the advantages of the SFC approach, for our aims, is the importance given to money, credit, the financial system and banks; but the complexity of these models is a shortcoming that in some cases could complicate the direct interpretation of some mechanisms.[11]

Within the SFC literature we selected the recent Sawyer and Passarella (2021) model as the baseline structure in which to introduce a CBDC. Table 1 represents the nominal balance sheet of each sector, while Table 2 shows the transaction flows. We deliberately attempted to modify the original model only in so far as it was strictly necessary in order to introduce a CBDC. As shown in table 1, the CBDC is always a liability of the central bank, but we allow for the possibility that it is issued without a counterpart, thus leading to a potential loss for the central bank (differently from Sawyer and Passarella, 2021, the central bank's net worth, v_{cb}, can be different from zero in principle). However, given how contentious this choice might be, in what follows we rather consider the case that the CBDC is issued as a loan - this is for example what the PBoC currently does, issuing digital yuan against "certificates of indebtedness". In the next section, we consider the case of a CBDC issued as an open-ended, non-interest bearing loan. In appendix 4.3 we report the accounting of a CBDC issued as a grant. In the former case (considered in the main text) the debt towards the central bank is

[8] A CBDC may become an appealing option for users if it is designed to tackle some of the typical risks associated with financial instruments in modern economies, making it a secure store of value and a risk-free asset for the entire financial system.While inflation poses a risk to all monetary assets, including CBDCs, it is just one of many possible risks. Another significant risk that may compromise the credibility of a CBDC concerns the reliability of the platforms on which it will operate. To prevent cyber-attacks and maintain the CBDC's underlying infrastructure's technological and IT validity, appropriate measures need to be taken. Nevertheless, the technological risk is not unique to CBDCs: they affect any payment system whose infrastructure relies on information technology.

[9] Although ours is a theoretical exercise and does not relate necessarily to any specific plan, let alone that of the ECB, in Section 4 we simulate a policy shock with the issuance of a CBDC for 5% of GDP. This figure would not be very far from the ECB's proposal, since multiplying potentially up to 3,000€ for 340 million citizens results in a potential issue of CBDC in the order of 1-1.5 trillion euros (as highlighted by Panetta, 2022), which is around 6-8% of the Eurozone GDP.

[10] For a comprehensive overview of the literature see Carapella and Flemming (2021), Bank of Canada et al. (2021), or Chen and Siklos (2022).

[11] Previous attempts at integrating new financial assets/liabilities as an innovative tool of economic policy into SFC models have been proposed for example by Dowicquet et al. (2018), who study Eurobonds as a financial instrument in order to reduce territorial inequality within a currency union; and Dafermos et al. (2017), who study the use of financial assets as a means to reach ecological/environmental goals.

Table 1
Balance sheet matrix.

	Lower-class households	Upper-class Households	Production firms	Commercial banks	Central bank	Government	Foreign sector	Σ
Cash	$+ h_w$	$+ h_r$			$- h_s$			**0**
Account deposits	$+ m1_w$	$+ m1_r$		$- m1_s$				**0**
Savings deposits		$+ m2_h$		$- m2_s$				**0**
Loans	$- l_h$		$- l_f$	$+ l_s$				**0**
CBDC	$+ \boldsymbol{CBDC_w}$	$+ \boldsymbol{CBDC_r}$	$+ \boldsymbol{CBDC_f}$		$- \boldsymbol{CBDC_s}$			**0**
CBDC loans	$- \boldsymbol{l_{CBDCw}}$	$- \boldsymbol{l_{CBDCr}}$	$- \boldsymbol{l_{CBDCf}}$		$+ \boldsymbol{l_{CBDCs}}$			**0**
Required reserves				$+ hb_d$	$- hb_s$			**0**
Discretionary reserves				$+ hb_d^*$	$- hb_s^*$			**0**
Central bank advances				$- a_d$	$+ a_s$			**0**
Capital stock			$+ k$					$+ \boldsymbol{k}$
Shares issued		$+ e_h$	$- e_s$					**0**
Government securities		$+ b_h$		$+ b_b$	$+ b_{cb}$	$- b_s$		**0**
Official reserves (net)					$+ h_f$		$- h_f$	**0**
Balance (net worth)	$- v_{wn}$	$- v_r$	$- v_f$	$- v_b$	$- v_{cb}$	v_g	v_{fs}	$- \boldsymbol{k}$
Σ	0	0	0	0	0	0	0	0

Table 2
Transaction-flows matrix.

	Lower-class households	Upper-class households	Production firms		Commercial banks	Central bank	Government	Foreign sector	Σ
			Current	Capital					
Consumption	$- c_w$	$- c_r$	$+ c$						**0**
Investment			$+ id$	$- id$					**0**
Government spending			$+ gov$				$- gov$		**0**
Export			$+ x$					$- x$	**0**
Import			$- im$					$+ im$	**0**
Memo: national income			$[y]$						
Taxes on income and wealth	$- tax_w$	$- tax_r$					$+ tax$		**0**
Fiscal transfers	$+ tr_w$	$+ tr_r$					$- tr$		**0**
Wage bill	$+ (1 - \Omega_r) \cdot wb$	$+ \Omega_r \cdot wb$	$- wb_f$				$- wb_g$		**0**
Interest on loans	$- rl_{-1} \cdot lh_{-1}$		$- rl_{-1} \cdot lf_{-1}$		$+ rl_{-1} \cdot ls_{-1}$				**0**
Repayments on loans	$- rep \cdot lh_{-1}$				$+ rep \cdot lhs_{-1}$				**0**
Interests on savings deposits		$+ rm_{-1} \cdot m2h_{-1}$			$- rm_{-1} \cdot m2s_{-1}$				**0**
Return on government securities		$+ rb_{-1} \cdot bh_{-1}$			$+ rb_{-1} \cdot bb_{-1}$	$+ rb_{-1} \cdot bcb_{-1}$	$- rb_{-1} \cdot bs_{-1}$		**0**
Seigniorage income						$- f_{cb}$	$+ f_{cb}$		**0**
Entrepreneurial profit		$+ fd_f$	$- f_f$	$+ fu_f$					**0**
Amortisation funds			$- a_f$	$+ a_f$					**0**
Bank profit		$+ f_b$			$- f_b$				**0**
***Change* in cash**	$- \Delta h_w$	$- \Delta h_r$				$+ \Delta h_s$			**0**
***Change* in CBDC**	$- \boldsymbol{\Delta CBDC_w}$	$- \boldsymbol{\Delta CBDC_r}$		$- \boldsymbol{\Delta CBDC_f}$	$+ \boldsymbol{\Delta CBDC_f}$	$+ \boldsymbol{\Delta CBDC}$			**0**
***Change* in CBDC loans**	$+ \boldsymbol{\Delta l_{CBDCw}}$	$+ \boldsymbol{\Delta l_{CBDCr}}$		$+ \boldsymbol{\Delta l_{CBDCf}}$		$- \boldsymbol{\Delta l_{CBDC}}$			**0**
***Change* in loans**	$+ \Delta l_h$			$+ \Delta l_f$	$- \Delta l_s$				**0**
***Change* in account deposits**	$- \Delta m1_w$	$- \Delta m1_r$			$+ \Delta m1_s$				**0**
***Change* in saving deposits**		$- \Delta m2h$			$+ \Delta m2_s$				**0**
***Change* in shares**		$- \Delta eh \cdot pe$		$+ \Delta esr \cdot pe$					**0**
***Change* in government securities**		$- \Delta bh$			$- \Delta bb$	$- \Delta bcb$	$+ \Delta bs$		**0**
***Change* in Required reserves**					$- \Delta hbd$	$+ \Delta hbd$			**0**
***Change* in Discretionary reserves**					$- \Delta hbd^*$	$+ \Delta hbd^*$			**0**
***Change* in Central bank advances**					$+ \Delta ad$	$- \Delta ad$			**0**
***Change* in official reserves (net)**						$- \Delta hf$		$+ \Delta hf$	**0**
Σ	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

evidently written among the household's and/or firms' liabilities. In the latter case (reported in Appendix), the CBDC increases net worth for the recipient(s), which too is recorded in the recipients' balance sheets as a liability. Therefore, the accounting in the two cases is the same, and the results shown here do not depend on this specific aspect of the design of a CBDC.

The model consists of seven sectors: lower-class households, upper-class households, production firms, commercial banks, central bank, government, and foreign sector. Lower-class households use their income to consume and save. Their consumption (see Appendix 2.2, equation 18) depends on their disposable income, their stock of wealth, the amount of cash they hold, cheque deposits, as well as the previous quarter's consumption. Our only innovation here is to include the CBDC

among the determinants of consumption (evidently, the wealth effect associated with the receiving of purchasing power in this form is a major determinant of the predicted GDP impact of issuing a CBDC to households).[12] The lower-class households might demand loans to commercial banks in order to bridge the gap between their desired consumption and their disposable income. Upper-class households receive the remaining part of the aggregate household income, and they hold a range of financial assets. In addition to the options available to lower-class households (namely cash, bank checking deposits, and the CBDC), they can allocate their wealth in an interest-bearing savings deposit, government bills, and firms' shares. Their portfolio choices are based on Tobinesque principles (see online Appendix 2.3 for the full model).

Production firms (Appendix 2.1) are owned by the upper-class households, and the members of both types of households are employed in this sector, receiving different wages. Firms' investments depend on a target level of capital that, among other things, depends on their financial leverage, and they are financed by retained earnings and bank loans. Regarding the banking sector (Appendix 2.4), the model assumes zero production costs; banks are subject to prudential requirements, and they distribute all profits to the shareholders (who are upper-class households, see Appendix 2.4).

The government sector provides transfers to the private sector, and collects taxes from both classes of households. It finances any deficit issuing general government debt (Appendix 2.5). The model assumes that all the profit generated by the central bank is entirely transferred to the government, so that in practice the central bank's net worth is always zero.

Finally, the central bank sets the policy rate. In this way, the money supply is endogenously determined by the economic system. Specifically, one can distinguish between $M_0 = h_s + hb_s + hb_s^* + CBDC_s + CBDC_f$ (the liabilities of the central bank), which in the model represents the monetary base, and $M_1 = M_0 + m1_s + m2_s$, or money supply (broad money).[13] The central bank acts as the lender of last resort: it buys all the unsold government bonds; and it receives all reserves that the commercial banks wish to hold on top of the required reserves, and/or it provides any loans (advances) that the commercial banks demand (Appendix 2.7).

Similarly to Passarella and Sawyer (2021), we do not calibrate our model to a specific economy because, in this preliminary work, we are interested in showing from a theoretical point of view some of the possible effects produced by a CBDC on a complex economic system approximating the conditions of a generic advanced economy. The model's parameters and initial values are retrieved from the literature on SFC models or from time series on the U.S. economy. To see model specifications, look at Appendix 2 for all equations, while for a full list of the single parameters and for the baseline scenario, see the online Appendix 3 (we interpret a period in the model as a quarter of a year). As shown in the appendix, figure A3.1, consistent with the secular stagnation hypothesis our parametrization allows us to represent the behaviour of a growing economy, albeit at a very slow pace. Nominal GDP grows by about 13% in 60 quarters (i.e. 15 years). Households' disposable income has a similar increasing trend, and the aggregate value of the disposable income of the lower-class households is always higher than for upper class-households. Our baseline economy is in a (low) steady-growth path, with stable values of the capital, wealth, public debt, and broad money to GDP ratios.

4.1. - Treatment analysis

With this baseline, we simulate four main treatments. The time horizon of our simulations is 130 periods (quarters). The system is always hit by a shock at the 70th period (that we refer to as period 1 throughout and in all figures, in order to match dating with the shock). Table 3 summarises the four treatments tested, while in Appendix 1 balance sheets representation of the treatments are reported.

In treatment 1, "fiscal transfers to households", the government deliberates new social transfers to households for a total value of 5% of the GDP of the previous period; the shock lasts one period. The amount of transfers is divided between the two classes of households in proportion to their share of aggregate household disposable income (approximately 75% for lower-class households, and 25% for upper-class households).

In the "CBDC to households" and in the "CBDC to firms" cases (Treatments 2 and 3) we assume that the central bank engages in helicopter money operations for 5% of the previous period's GDP. And under the "Quantitative Easing" (Treatment 4), the central bank decides to increase its holdings of government securities by a value equal to 5% of the pre-shock's GDP. In order to ensure the comparability of their effectiveness, the hypothesised shocks have the same size for all treatments. This choice follows from our primarily theoretical aims, but evidently constraints the realism of the results, which should be interpreted allowing for the fact that 5% of GDP is a large shock for fiscal policy, and probably a small one for QE.

Table 3
Description of the treatments.

Scenario	Treatment	Target sector	Shock type	Transmission channel
1	Fiscal transfers to households	All households	The government increases social transfers to households by 5% of the previous period's GDP value	Marginal propensity to spend out of income (MPSY)
2	CBDC to households	All households	Issuance of CBDC credited to households equal to 5% of the previous period's GDP value	Marginal propensity to spend the CBDC (MPSC)
3	CBDC to firms	Firms	Issuance of CBDC credited to firms equal to 5% of the previous period's GDP	Sensitivity of investments, and of the interest rate to firms' leverage
4	Quantitative Easing	Upper-class households	The central bank purchases government bonds held by households for a value equal to the 5% of the previous period's GDP	MPSW

In terms of design, treatments 2 and 3 feature a non-interest-bearing retail CBDC designed as an open-ended loan. As an irredeemable loan, it is not qualitatively different from a grant (or an "outright monetary

[12] In line with the consumption function in the original model of Sawyer and Passarella (2021), in our model the consumption decisions of the households are also a function of their disposable income as well as their total assets but not of their net wealth.

[13] Evidently, one could consider even larger monetary aggregates, for example including short-term government securities. However larger aggregates are not exclusively related to the money market and increasingly less directly linked to monetary policy, so consideration for these aggregates would go beyond the scope of this paper.

transfer").[14] But as a loan, in principle it would always be possible for the central bank to impose an interest rate and/or an expiration date, providing more degrees of freedom to this policy tool. We assume that the central bank carries out such expansionary policy by increasing the size of its balance sheet. The shock consists of one-off crediting of CBDC to all households.[15] We hypothesise that the central bank first sets the total value to issue to households and then it establishes the shares for lower and upper-class households. In order to implement this monetary policy, the central bank decides to open a current account for each household in treatment 2, or each firm in treatment 3. We assume that the issuance happens only once and that the loan is never due to be repaid within the horizon of our simulations, in order to consider expansionary shocks only[16] (they are what Buetzer, 2022, calls "perpetual zero-coupon targeted long-term lending operations"). Therefore, both treatments qualify as instances of helicopter money.

In treatment 2, the policy shock generates two new accounting entries: the new stock of CBDC (households' deposits), which is the CBDC as a means of payment, and the loan to the recipient households, which is its accounting counterpart. The total size of the central bank's balance sheet grows exactly by this amount. After this shock, we assume that households consider the CBDC as a substitute for their bank deposits, and indeed they use bank money for consumption or other transactions and hoard the CBDC as much as they can, because following the literature we assume that the CBDC is perceived to be safer and more convenient than bank deposits (thence the risks for the stability of the banking system). The balance sheets before and after the policy shock are shown in appendix 1, figure A1.1.

In treatment 3, we assume that firms and their creditors (commercial banks) treat the CBDC, qua an infinite duration loan, as something not too different from a form of equity. Therefore, after the policy shock they perceive a reduction in firms' financial leverage (which in our model implies a reduction in the interest spread imposed on firms, and an increase in firms' desired level of capital). We further assume that firms use the CBDC to reduce their debt to banks, preferring instead the newly acquired non-interest bearing debt toward the central bank.[17] Finally, we assume that banks consider the CBDC as a perfect substitute for their other account(s) with the central bank, i.e. traditional reserves. Therefore, when they receive the CBDC from the firms, banks correspondingly decrease their demand for discretionary reserves with the central bank. As a consequence, the central bank's balance sheet does not increase by the full amount of the original shock. The balance sheets before and after the policy shock are shown in appendix 1, figure A1.2.

The last treatment considered deals with Quantitative Easing. In order to improve the comparability with the other treatments, we slightly modify Sawyer and Passarella's (2021) original QE scenario. In their model, the central bank sets the amount of government securities it wishes to buy from the upper-class households. When upper-class households reduce their holdings of government debt, they increase their bank deposits by the same extent, which in turn implies an increase in the banks' required reserves too. In our treatment, instead, we assume that when upper-class households see their government bonds decrease, they revise the allocation of their portfolio by partly increasing their bank deposits, and partly increasing their holdings of firms' equities (the only other financial asset in the model). This change to the original model (one of the very few ones) is meant to allow for more and larger transmission channels of this monetary policy to the real economy - therefore allowing for larger potential impacts on GDP. Yet, as shown in the next section, QE will emerge as the least effective treatment anyway.

As a result of upper-class households' increased demand for shares, asset inflation emerges. This both implies some capital gains for the holders of shares (upper-class households, again) and to some extent it stimulates firms' investments and their issuance of new shares. Notice that in this case the upper-class households' capital gains are unrealized profits: indeed, in this model only they hold shares, so any capital gain on this asset cannot imply a net transfer of resources from other sectors and at most it will result in a redistribution of wealth within this class. Including such asset inflation among the capital gains, and therefore in the change in upper class households' net wealth, leads to higher consumption spending due to higher (nominal) wealth.[18] The balance sheet representation of this treatment is shown in appendix 1, figure A1.3.

5. - Main results

As mentioned, rather than trying to replicate the economic dynamics of a specific country, we focus on comparing the various treatments and on highlighting what non-trivial findings emerge due to general equilibrium effects (i.e., indirect feedbacks, and stock-flow adjustments). In what follows we assess the effectiveness of a certain policy by its impact on nominal and real GDP; and we compare the respective implications for public and private finance. For all four treatments, we consider a shock worth 5% of previous quarter's GDP. Table A4.1 in appendix 4 reports additional results in terms of variables not considered here, and figures A4.1 to A4.8 report robustness checks under alternative assumptions.

5.1. - GDP dynamics

As shown in Fig. 1, all four treatments imply a positive impact on GDP in the short term, both in nominal and in real terms. This positive effect is a direct consequence of an increase in consumption, and then a multiplier and an accelerator effect. More specifically, an increase in transfers impacts on consumption via the propensity to spend out of income (MPSY, see e.g. Carroll et al., 2017), while QE and the CBDC to households have a direct effect on wealth and, consequently, on consumption via the propensity to spend out of wealth (MPSW, or

[14] In Appendix 4.3 we show how to account for the issuance of CBDC as a grant, in the balance sheets of the central bank and of the recipient households. In this case, the second entry in the central bank's balance sheet is a net loss (a reduction in own resources or equity, vcb)), and in the households' balance sheet, it is a capital gain (an increase in net worth). We do not further consider this case because the results are not qualitatively different from those considered here, with the additional complication that the central bank's capital might turn negative – a contentious possibility that, although perfectly compatible with stock-flow consistency, has caused debate e.g. during the eurozone crisis. Similarly, for the same reason we include the value of the open-ended loan among the central bank assets even though we do not consider repayment of the loan within the simulation horizon (see footnote 15).

[15] Given the desirability of a safe asset with the characteristics of a CBDC, described in Section 3.1, we assume that all households and/or firms who will be given the opportunity to hold a CBDC will decide to do so. In Appendix 4, figure A4.6, we discuss the case of targeting one class or the crediting of the CBDC with variable shares for the two classes of households.

[16] The case of a CBDC that is repaid gradually over time or in a one-shot instalment some periods after the original monetary expansion is not presented here because the main effects of the monetary restriction implied by the repayment are trivially specular to the effects of the original expansion. Further scenarios and main results are available from the authors upon request.

[17] This assumption is a choice concerning the composition of firms' liabilities and not their overall level: since firms are not liquidity constrained, they already had the desired level of liabilities before the shock. However, since the central bank charges a lower interest rate (zero, in our assumption), they prefer the central bank loan over the commercial banks' loans. And since firms do not have unused free cash flow, they use their CBDC account (an asset on their balance sheet) to repay their loans toward the commercial banks.

[18] The same occurs as a consequence of goods prices inflation, which in principle would have to imply a reduction in real disposable income due to a negative wealth effect (Godley and Lavoie, [2007] 2012, pp. 289-291; pp. 293-294), which is instead ignored here. Therefore, the model implies that households suffer from monetary illusion. We thank Marco Passarella for raising this point with us.

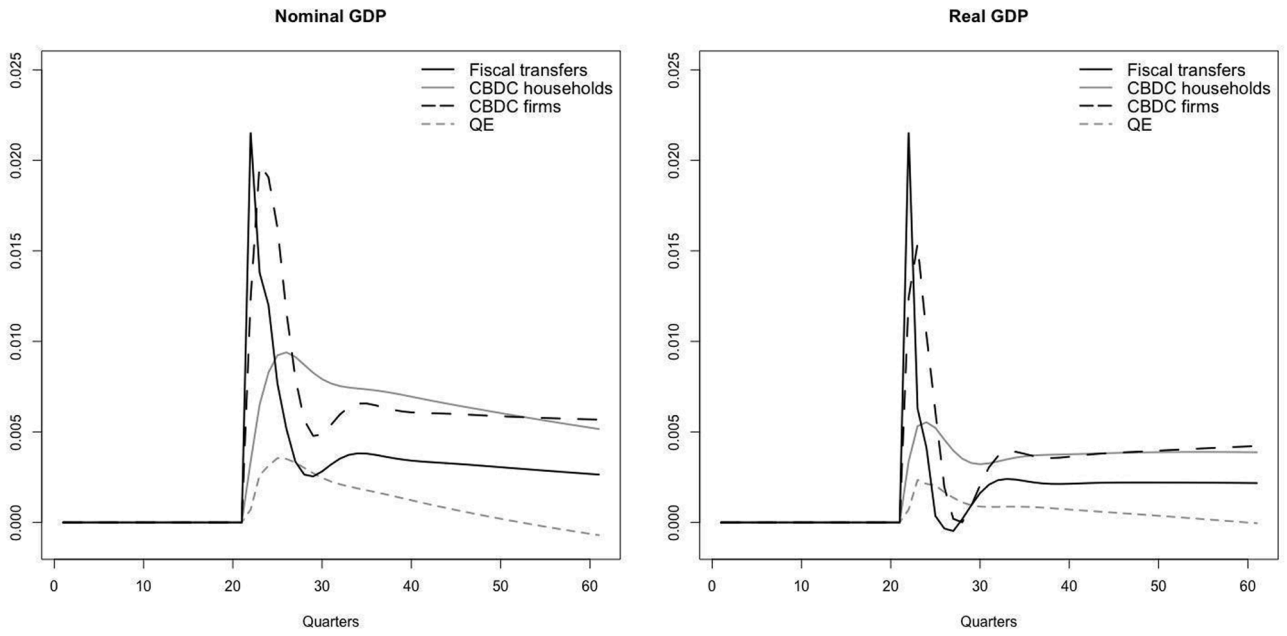

Fig. 1. Nominal and real GDP.
Notes: for each period, the values shown are ratios to the corresponding value in the baseline scenario minus 1.

specifically, the propensity to spend the CBDC, in the case of scenario 3, see e.g. Drescher et al., 2020). In the QE scenario, this phenomenon is led by asset inflation as a result of an increase in the demand for equities. In contrast, in treatment 3 (CBDC to firms), output growth is due principally to an increase in firm's investment triggered by firm's deleveraging (e.g. Roxburg et al., 2010).

Regarding the short-term impact on GDP (i.e. considering 20 quarters, or 5 years, after the shock), the two treatments that implement a CBDC perform better than both fiscal transfers and QE. In this sense, no substantial discrepancies emerge comparing the dynamics of nominal and real GDP.

Considering the long run effects (40 quarters, or 10 years, after the shock), expansionary fiscal policy stabilises real GDP at a higher level than the pre-shock value (that is, the model exhibits some long-term impacts of fiscal policy). The two scenarios based on the introduction of a CBDC exhibit even higher levels of production in both nominal and real terms. Instead, the QE's positive impact on real GDP fades away in the long run, realigning its level to that of the baseline scenario (with no shocks).[19] This behaviour arises because fewer government bills held by the private sector over time imply lower net public expenditure for interest payments (recalling that all central bank's profits are returned to the government) and therefore lower income and lower consumption of the upper-class households. Effectively, QE substitutes unrealized capital gains for realised capital incomes, with even a potentially negative impact in the long run.

To understand why the issuance of CBDC seems to result in a larger boost to GDP, in Appendix 4 we develop a sensitivity analysis specifically aimed at understanding to what degree our results depend on the specific parametrization used here.

Evidently, the behavioural assumptions about what firms and/or households do with the newly acquired CBDC are the most relevant candidate explanations. Concerning households, our approach of assuming that families value the CBDC more than bank money (deposits) represents a conservative approach, aimed at highlighting some of the risks for financial stability discussed in the literature (see section 4.3). However, there are no strong reasons to believe a priori that households would consume a given share of the CBDC they receive. The results shown in Fig. 1 are based on an assumed propensity to spend the CBDC of 5%, corresponding to the assumption that households consume the whole transfer from the central bank (arguably perceived as a transitory income) within 20 years. In figure A4.2 in the appendix 4 we report the simulation results assuming that households spend the CBDC in the same proportion as bank deposits (1%) as well as their propensity to spend the total wealth of upper-class (2%) and lower-class households (3%). We find that if households spend the CBDC in the same proportion as bank deposits, the GDP impact of this treatment is lower than public transfers, while if they spend at least 1.5% of the CBDC, the impact is higher both in the short and in the long term. Therefore, this parameter must certainly be regarded as the crucial variable on which the real-world effectiveness of this measure hinges. In certain contexts, policymakers could try to affect this variable by experimenting with an interest-bearing CBDC, or with one of limited time duration; however, predicting the precise impact of these design details is left for future research.

Concerning firms, we tested what would be the GDP impact if they used at least part of the CBDC loan from the central bank to increase their investments rather than to decrease their debts towards banks. As shown in figure A4.1 in Appendix 4, using the same percentages of CBDC invested as we assumed households would consume in the previous exercise (1%, 2%, and 3%), the results always denote an even (slightly) greater effectiveness of this policy tool than our main result in Fig. 1. However, while these increased investments provide a small short-run boost to GDP, in the long term no substantive changes are visible.[20, 21]

[19] The small difference between real and nominal dynamics can be attributed to low levels of inflation consistent with the secular stagnation hypothesis of Passarella and Sawyer's (2021) model.

[20] This is because in Passarella and Sawyer's (2021) model firms are not liquidity constrained in they can always obtain the funding for investments from banks. In the long term, banks will lend money charging a lower interest rate if firms have a lower financial leverage, so for firms deleveraging might be the best long-term strategy in this treatment (depending on a number of other parameters or emergent properties, e.g. the long-term growth stimulated by the short-run increase in investments).

[21] Given the GDP impact found for this treatment, one might suggest implementing a CBDC targeted to particularly indebted sectors (although not in the context of CBDCs, this topic has been explored by Roxburg et al., 2010).

Symmetrically, for the fourth treatment too we test the relevance of our behavioural assumptions in driving the result of a rather low GDP impact of QE. In figure A4.8 in Appendix 4 we consider a range of different portfolio shares allocated by the upper-class households in equities (rather than in saving deposits) following their selling of bonds to the central bank. When the demand for equities increases, their price increases too; this produces unrealized capital gains for the upper-class households, thereby increasing their consumption (Fratzscher et al., 2016). Therefore, in our analysis the greater the proportion of the portfolio reallocated to equities instead of saving deposits, the greater the positive impact of QE on GDP.

As a further robustness check we consider the possible role of some features in the design of the CBDC (namely the shares of recipients of the CBDC, in terms of the two classes of households), as well as different assumptions on the values of other values, characterising all treatments and the baseline, which could nonetheless affect the GDP impact of one or more treatments in a specific way (see Appendix 4). In all cases, the results are trivial and do not necessitate further analysis here, except to say that they do not imply a qualitative change in the main results commented on in this section.

5.2. Public sector finances

Concerning the financial performance of the public sector, in Fig. 2 we show the trends in the government debt and the size of the central bank's balance sheet in the four treatments, with respect to the baseline scenario. The effects of the first treatment are those traditionally produced by expansionary fiscal policies accompanied by some degree of monetization (Oh and Reis, 2012; Lavoie, [2014] 2022). We find an immediate increase in general government debt that is only partially reabsorbed over time by higher tax revenues and higher seigniorage income. Such partial compensation is due, to some extent, to the model assumption that government spending increases as a function of the previous quarter's GDP. The central bank's balance sheet shows a similar trend, peaking during the shock and then declining, because the central bank is a buyer of last resort of sovereign bonds (e.g. Caruana, 2012).

The second treatment implies a reduction in general government debt with respect to the baseline both in the short run and in the long run. Evidently, such dynamic is due to the fact that the stimulus (CBDC) is financed through an irredeemable loan from the central bank (not included within general government debt), while the increase in GDP results in higher public receipts and therefore lower deficit (e.g. Turner, 2015). The central bank's balance sheet rises exactly by the value of the CBDC issued, and then it constantly lowers down. Such reduction after the shock is mainly attributable to the lower stock of general government debt held by the central bank, and the lower banks' reserves due to reduced household demand for deposits (see next section).

Treatment 3 results in an immediate reduction of both general government debt and the size of the central bank's balance sheet, but both variables increase over time, and in the long run they grow above the baseline scenario. Such - not immediately intuitive - dynamic can be explained by firms' lower demand for loans after the shock, which forces commercial banks to reallocate their assets buying more public bonds, which in turn makes it necessary for the central bank to buy fewer of them (thus with a reduction of its own balance sheet).[22] However, a greater proportion of general government debt owned by the private sector implies lower seigniorage income for the government, triggering a growth in its deficit. In these respects, the deleveraging mechanism triggered by the CBDC issued to firms, as well as its effects on the banking system, differs substantially from the dynamics of firm's deleveraging normally observed in real contexts (e.g. Roxburg et al., 2010; Cuerpo et al., 2015).

Finally a short-run effect of QE, our fourth scenario, is the growth in the size of the central bank's balance sheet and a decrease in the stock of outstanding government debt with respect to the baseline (e.g. Federal Reserve, 2022b; Haldane et al., 2016). The latter is caused mainly by two factors: one is the increase in government revenues due to higher central bank profits, generated by the higher stock of debt owned by the central bank (both in the short run and in the long run); and the other depends on the higher tax revenues induced by the economic expansion caused by the QE (in the short run only). A lower public deficit, however, gradually produces a reduction in total general government debt, which results in a gradual reduction in the total size of the central bank's assets too.[23]

In summary, the analysis of public sector finance in the four treatments highlights a trade-off. On the one hand, if the goal of policy makers is to reduce general government debt, a CBDC targeted to households seems the most effective tool. On the other hand, if a policy objective (or a hard constraint) is to keep the size of the central bank's balance sheet under control, the issuance of a CBDC targeted to firms seems to provide the best tool among those considered here.

5.3. Effects on the banking sector

Concerning the impact of the four treatments on commercial banks' deposits and profits, we find that an expansionary fiscal policy (treatment 1) induces an increase in households' deposits and, consequently, an increase in the profits of the banking sector, as shown in Fig. 3. This increase is due to the wealth effect induced by the transfers and, for the upper-class households, it is also sustained by the increased profits of the firms and banks that they own.

With QE too we predict a higher demand for deposits (especially upper-class households' savings deposits) with respect to the baseline (e.g. Choulet, 2015). This is due to the lower amount of government bonds available for purchase by the private sector, once the central bank starts to buy more of them. Following the QE shock, the profits of the commercial banks decrease with respect to the baseline: on their liabilities side, this happens because of the higher aggregate costs of deposits; on the asset side, because of the lower return on government bonds.[24] However, the reduction in banks' profits is more than offset by banks' capital gains, generated by asset inflation on the public bonds they own (see table A4.1). The main difference is that these capital gains are unrealised.

As predicted by many scholars (e.g. Keister and Monnet, 2020; Kim and Kwon, 2021; Keister and Sanches, 2021), we find that a CBDC targeted to households (treatment 2) leads to a progressive reduction in bank deposits with respect to the baseline. Households prefer to hold the CBDC rather than bank deposits, and as banks loose a source of low-cost financing, they buy fewer bonds and therefore suffer from a reduction of their aggregate profits too.

[22] The results do not significantly change if we assume that banks demand more, or even exclusively, discretionary reserves instead of public bonds (further results are available from the authors upon request). Indeed, within this model it is rational for banks to demand as many bonds as possible, because they systematically yield a higher return.

[23] Appendix 4 reports the results of the sensitivity analysis in terms of government debt and central bank balance sheet.

[24] The negative impact of QE on banks' profitability might seem an unrealistic feature of the model. However, there is no consensus in the literature on the effect of QE on bank profits. For example, Demertzis and Wolff (2016) argue that an observed reduction in bank profits in the past few years is not attributable to QE since the main causes of low bank profitability are to be found in non-performing loans, legal risks, and other issues unrelated to net interest income. Altavilla et al. (2017), studying the European case, found no evidence of lower bank profits. Their empirical analysis shows that, despite the flattening of the yield curve, a positive effect on loan loss provisions and on non-interest income has largely offset the negative effect on net interest income.

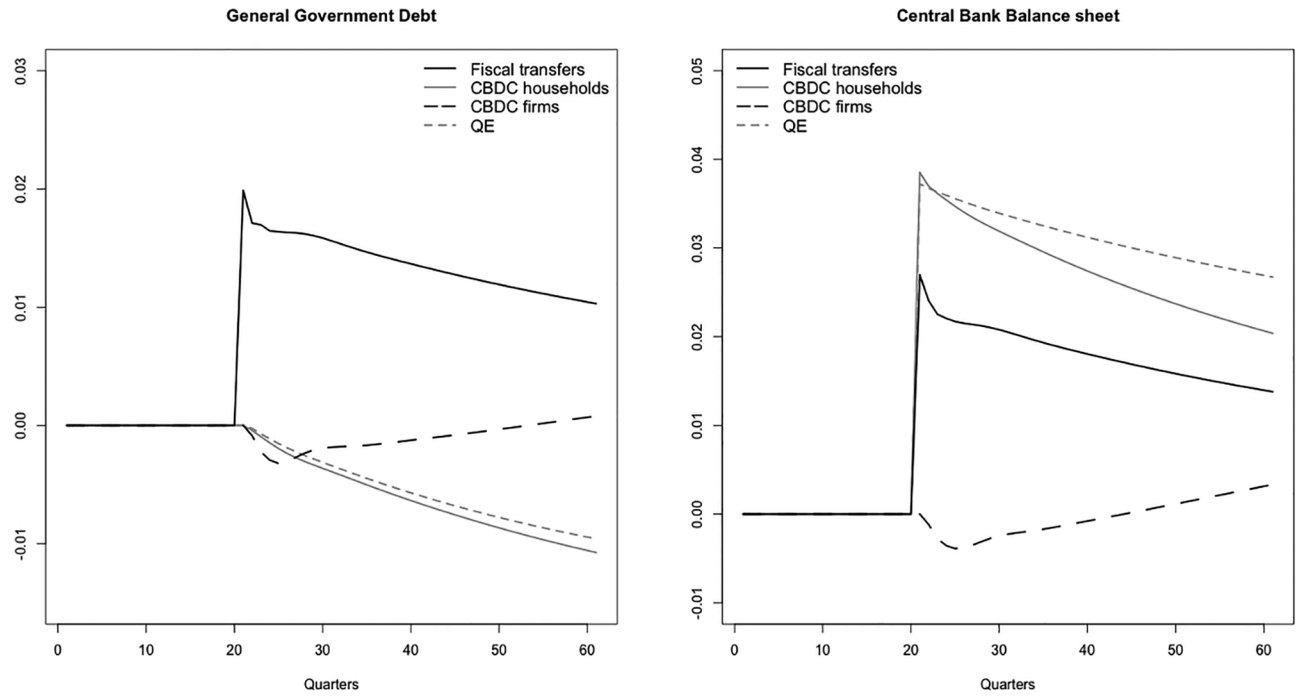

Fig. 2. General government debt and the central bank's balance sheet.
Notes: for each period, the values shown are ratios to the corresponding value in the baseline scenario minus 1.

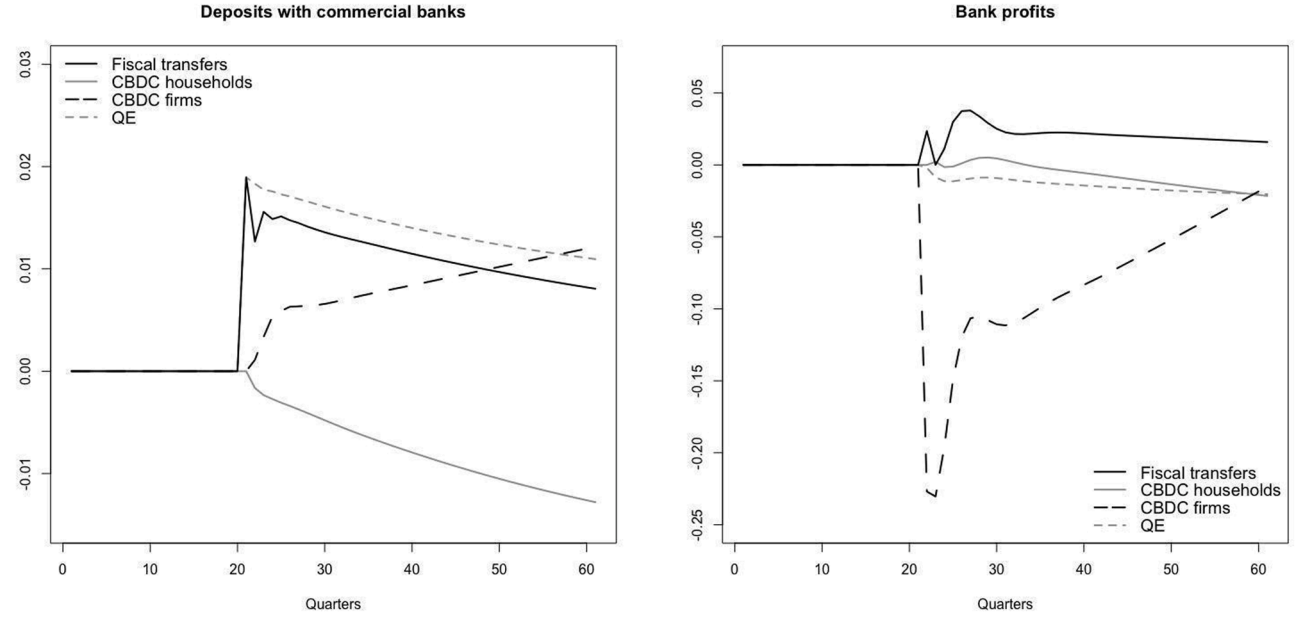

Fig. 3. Impact on the banking sector.
Notes: for each period, the values shown are ratios to the corresponding value in the baseline scenario minus 1.

In contrast, in treatment 3 (CBDC to firms), our simulations show a steady rise in the demand for deposits by households, originated by the increase in disposable incomes induced by the higher GDP. Yet, in this treatment bank profits drop even more than in the previous case, due to the lower indebtedness of firms towards the banking sector. In our model, this dynamic has a stronger negative impact on banks' profits than the reduction in households' deposits implied by the previous treatment, because of the model assumption that banks never face liquidity constraints. Should they ever need funding, they could always demand more advances from the central bank at a cost lower than the interest income on their assets. Therefore, the loss of profits in treatment 2 arises from the reduced opportunities for the banks to invest free cash on government bills, and it is proportional to the spread between the interest rate on saving deposits and that on bills. Instead, the loss in treatment 3 arises from the reduced opportunities to lend money, and it is (larger than the previous ones and) proportional to the spread between the interest rate on loans to firms and the alternative uses of liquidity for banks, namely government bills and discretionary reserves.

While the specific assumptions about these interest rate spreads may or may not fit the current situation in a specific country that is considering the introduction of a CBDC, we deem it relevant to highlight that potentially the reduced demand for loans – due to a desire to deleverage

instead of using the CBDC for additional expenditures – is at least as relevant a risk for financial stability as the reduced demand for deposits (Bindseil, 2020), even though the former has not yet been adequately discussed in the literature.

In our case, firms did not face liquidity constraints before the shock, and therefore they used the new resources to reduce other loans that they already had, independently of what the central bank intended. Notice that this result is related to the transfer of resources from the central bank, it is a by-product of helicopter money, and it is not a consequence of the transfer taking the form of a loan rather than a grant. This is evident when considering again Fig. 3: firms transfer their asset (the means of payment) to banks in order to repay their outstanding loans, and they keep the liability vis-à-vis the central bank (the irredeemable loan) on their balance sheet. Had they received the CBDC in the form of a grant, only the composition of the liabilities would have differed (with a higher net capital due to the capital gain from the central bank transfer), but not in the sense of a larger demand for commercial banks' loans, and the assets size would have been the same.

In conclusion, central banks (e.g. Panetta, 2021b) stress that they do not wish to enter into the business of commercial banks; but in so far as a CBDC is perceived to be a substitute for other financial assets or liabilities, this appears to be inevitable.

6. Conclusions

In times of economic and financial stress that make significant innovation often necessary on the side of fiscal and monetary authorities, the introduction of additional tools in the economic policy mix, and arguably policy tools that might leverage different transmission channels than what are currently used, might be advisable (Eichacker, 2022). In this paper we investigated one such possible tool, a CBDC, looking at its possible impact in a complex advanced economy, and comparing it to more traditional economic policies.

From a theoretical perspective, our SFC treatment allows to conceptualize and analyse different ways in which the central bank could exogenously change the supply of base money in a post-Keynesian model in which money supply remains endogenous; and more specifically, it allows us to show that from an accounting perspective these new liabilities of the central bank could be either a grant or a loan, with no substantial accounting differences.

We considered four kinds of policy: a fiscal transfer to households; the issuance by the central bank of a CBDC: targeted to households, or targeted to firms' accounts; and Quantitative Easing. Our analysis shows that issuing a CBDC has indeed the potential of activating a new transmission channel for monetary policy, whose effectiveness depends on behavioural patterns (such as firms' desire to reduce their leverage) and on different propagation mechanisms than usually activated by monetary or fiscal policy (namely, the sensibility of investments and of interest rates to firms' leverage).

Simulation analyses suggest that fiscal transfers might still have the highest immediate impact on GDP, but its comparative effectiveness crucially depends on how much the CBDC would be immediately spent. In the long run, the issuance of a CBDC targeted to households outperforms all treatments considered, in terms of impact on GDP, while it has no impact (or even a negative one) on general government debt. Yet, such effectiveness comes at the cost of a more sizeable expansion of the central bank's balance sheet than the other policies considered.

Whereas the impact of a CBDC targeted to households depends on its ability to stimulate consumption demand through wealth effects, the positive impact of QE on GDP (and on banks' profits) is entirely due to asset inflation. We see this as a clear advantage of helicopter money policies over QE.

Both QE and the CBDC targeted to households reduce banks' profits: the former by reducing interest rates, and the latter because of the lower demand for bank deposits. However, our simulations suggest that this impact is on the whole modest (and in the case of QE, it is more than offset by banks' unrealized capital gains). In contrast, the scenario of a CBDC targeted to firms too has a positive impact on GDP, both in the short and in the long run, but this is the scenario with the highest negative impact on commercial banks' profits. Such impact derives from firms' lower demand for loans, and risk to be such that might realistically pose financial stability challenges. In our analysis, this risk is larger in the case of a CBDC targeted to firms than one targeted to households, mostly because we assume that bank lending to firms is more profitable than alternative assets for banks. Besides these aspects, however, a main result that emerges from our analysis is that, for reasonable ranges, our results do not crucially depend on the model parametrization.

In our model, such a negative financial impact does not hamper economic growth in the long run, but more detailed models, tailored at gauging this specific aspect, are certainly needed. As opposed to the single case of an open-ended non-onerous loan to households or firms, that we consider in this work, CBDC injections could be fine-tuned, for example with the application of an interest rate and/or a time limit after which the monetary expansion could be reversed. The precise impact of these design details would better be captured by models calibrated on single countries or specific economies.

Some of the results we obtained are necessary, in the sense that they arise from accounting identities or near-identities, which a SFC model just makes evident.[25] Other results were obtained starting from behavioural assumptions that, however, seem to be widely shared in the literature. For example, the expectation is that households might find a CBDC more attractive than bank deposits because of the lower counterparty risk or other similar considerations. Similarly, we assumed that firms would prefer to owe a loan to the central bank than to private banks – which again seems reasonable, as long as the interest rate charged (zero, in our case) is lower than that charged by commercial banks. Therefore, a CBDC constitutes money in a much wider sense than just as a means of payment, and with helicopter money the central bank enters the business of commercial banks regardless of its stated or real intentions.

Moreover, our fairly large SFC model allowed us to show in a comparative way (across policy instruments) that for all policy tools considered here, the transmission channels could be many and sometimes indirect, i.e. involving a long causal chain and positive or negative feedbacks. In this light, a further advantage of CBDCs is the possibility to target specific sectors of the economy as recipients of a monetary injection – be it all or a class of households or firms. CBDCs can thus provide an opportunity e.g. for sterilisation of other policies.

In conclusion, while the risks for financial stability are real (Fernández-Villaverde et al., 2021), and in some cases possibly substantial, the debate around the possible introduction of CBDCs should explicitly consider the pros and cons of such move, instead of focusing on the 'defensive' need to pre-emptively tame private market initiatives or the financial innovations in "systemically competitor" countries such as China (Allen et al, 2022).

CRediT authorship contribution statement

Jacopo Temperini: Conceptualization, Methodology, Data curation, Formal analysis, Software, Writing – original draft, Project administration. **Carlo D'Ippoliti:** Supervision, Funding acquisition, Writing – review & editing. **Lucio Gobbi:** Conceptualization, Methodology, Writing – original draft.

[25] For example, except for specific design issues that might justify their demand (e.g. easiness of doing international transactions), in general it seems plausible to assume that from the commercial banks' perspective a CBDC is not too different from traditional reserves.

Data Availability

No data was used for the research described in the article.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.strueco.2023.11.003.

References

Allen, F., Gu, X., Jagtiani, J., 2022. Fintech, cryptocurrencies, and CBDC: financial structural transformation in China. J. Int. Money Finance 124 (C).

Altavilla, C., Boucinha, M., Peydró, J.L., 2017. Monetary policy and bank profitability in a low interest rate environment. In: CSEF Working Papers, 486. Centre for Studies in Economics and Finance (CSEF), University of, Naples, Italy.

Arauz, A., 2021. The international hierarchy of money in cross-border payment systems: developing countries' regulation for central bank digital currencies and Facebook's Stablecoin. Int. J. Polit. Econ. 50 (3), 226–243.

Auer, R., Böhme, R., 2020. The technology of retail central bank digital currency. BIS Qu. Rev. 85–110.

Bank of Canada, European central bank, Bank of Japan, Sveriges Riksbank, Swiss National Bank, Bank of England, Board of Governors of the Federal Reserve System, Bank for International Settlements, 2020. central bank Digital Currency: Foundational Principles and Core Functions. Bank for International Settlements, Basel. Report No. 1.

Bank for International Settlements (2020), "The digital economy and financial innovation", *BIS paper No. 109*, February.

Barrdear, J., Kumhof, M., 2016. The macroeconomics of central bank issued digital currencies. In: Staff Working Paper No. 605. Bank of England. See. https://www.bankofengland.co.uk/-/media/boe/files/working-paper/2016/the-macroeconomics-of-central-bank-issued-digital-currencies.pdf?la=en&hash=341B602838707E5D6FC26884588C912A721B1DC1.

Benigno, P. and S. Nistico (2020): "The economics of helicopter money," CEPR discussion paper No. 14555.

Bernanke, B. (2015)," Monetary policy and inequality". URL http://www.brookings.edu/blogs/ben-bernanke/posts/2015/06/01-monetary-policy-and-inequality.

Bilotta, N., Botti, F., 2021. The (Near) Future of central bank Digital Currencies – Risks and Opportunities for the Global Economy and Society. Peter Lang AG, International Academic Publisher, Bern. ISSN 2624-8905.

Bindseil, U., 2020. Tiered CBDC and the financial system". Eur. Central Bank. *Working Paper Series, No. 2351*, January 2020.

Boar, C., Wehrli, A., 2021. Ready, steady, go? - Results of the third BIS survey on central bank digital currency. In: BIS Papers. Bank for International Settlements number 11.

Bordo, M., Levin, A.T., 2017. central bank digital currency and the future of monetary policy. In: Economics Working Papers 17104. Hoover Institution, Stanford University.

Buetzer, S., 2022. Advancing the monetary policy toolkit through outright transfers. In: IMF Working Papers 2022/87. International Monetary Fund.

Buiter, W.H., 2014. The simple analytics of helicopter money: why it works — always. Economics 8, 1–45.

Carnevali, E., Deleidi, M., Pariboni, R., Passarella, M., 2019. Stock-flow consistent dynamic models: features, limitations and developments. In: Arestis, Philip, Sayers, Malcolm (Eds.), Frontiers of Heterodox Macroeconomics. Palgrave Macmillan, pp. 223–276.

Carroll, C., Slacalek, J., Tokuoka, K., White, M.N., 2017. The distribution of wealth and the marginal propensity to consume. Quant. Econ. 8 (3), 977–1020. November.

Carstens, A., Weidmann, J., Powell, J.H., 2021. How can central banks innovate in the digital age?. In: *BIS Innovation Summit* 2021. See https://www.youtube.com/watch?v=N-IaJUmkcV8&t=6s.

Caruana, J., 2012. Why central bank balance sheets matter. Bank for International Settlements. In: Are Central Bank Balance Sheets in Asia too Large?, 66. Bank for International Settlements, pp. 2–9.

Cecchetti, S. and Schoenholts, K. (2021), "Central bank digital currency: the battle for the soul of the financial system", VOX-EU - CEPR. See: https://voxeu.org/article/central-bank-digital-currency-battle-soul-financial-system.

Cesaratto, S., Febrero, E., 2023. "Central Bank Digital Currencies: a proper reaction to private digital money?". Review of Keynesian Economics 11 (4), 529–553.

Chen, H., Siklos, P., 2022. Central bank digital currency: A review and some macro-financial implications. J. Financ. Stabil. 60 forthcoming.

Chiu, J., M Davoodalhosseini, Jiang, J. and Zhu, Y. (2019), "Bank market power and central bank digital currency: theory and quantitative assessment", *Bank of Canada Staff Working Paper*, 2019-20, May.

Choulet, C., 2015. QE and bank balance sheets: the American experience. BNP Paribas Conjunct. Res.

Cuerpo, C., Drumond, I., Lendvai, J., Pontuch, P., Raciborski, R., 2015. Private sector deleveraging in Europe. Econ. Modell. 44, 372–383.

Cui, W., Sterk, V, 2021. Quantitative easing with heterogeneous agents. J. Monetary Econ. 123, 68–90.

De Bonis, R., Ferrero, G., 2020. Technology, finance, money and institutions. Rivista di Politica Economica 2020–2021.

Dafermos, Y., Nikolaidi, M., Galanis, G., 2017. A stock-flow-fund ecological macroeconomic model. Ecol. Econ. 131, 191–207.

Demertzis, M., Wolff, G.B., 2016. What impact does the ECB's quantitative easing policy have on bank profitability?. In: Policy Contributions, 17913 Bruegel.

Eichacker, N., 2022. Institutional constraints, liquidity provision, and endogenous money in the Eurozone core and periphery before and after crises: a preliminary comparison of the Eurozone Crisis and the Coronavirus Pandemic. PSL Q. Rev. 75 (303), 403–424.

European central bank (ECB) (2020), "Report on a digital euro", October 2020.

Fantacci, L., Gobbi, L., 2021. Stablecoins, central bank digital currencies and US dollar hegemony: the geopolitical stake of innovations in money and payments. Account. Econ. Law: A Convivium.

Fantacci, L., Gobbi, L., Luciani, D, 2022. Bene pubblico globale o arma finanziaria? L'egemonia del dollaro alla prova delle sanzioni. Moneta e Credito 75 (298).

Fatás, A, Summers, L.H, 2017. The permanent effects of fiscal consolidations. In: NBER Chapters, in: NBER International Seminar on Macroeconomics 2017. National Bureau of Economic Research, Inc.

Federal Reserve, 2022a. Money and Payments: The U.S.Dollar in the Age of Digital Transformation. Board of Governors of the Federal Reserve System, Research and Analysis.

Federal Reserve, 2022b. Principles for Reducing the Size of the Federal Reserve's Balance Sheet. Board of Governors of the Federal Reserve System see. https://www.federalreserve.gov/newsevents/pressreleases/monetary20220126c.htm.

Fernández-Villaverde, J., Sanches, D., Schilling, L., Uhlig, H., 2021. Central bank digital currency: Central banking for all? Rev. Econ. Dyn. 41, 225–242.

Fratzscher, M., Lo Duca, M., Straub, R., 2016. ECB unconventional monetary policy: market impact and international spillovers. IMF Econ. Rev. 64, 36–74.

Friedman, M., 1969. The optimum quantity of money. M. Friedman The Optimum Quantity of Money and Other Essays. Aldine, Chicago, pp. 1–50.

Fullwiler, S., 2013. An endogenous money perspective on the post-crisis monetary policy debate. Rev. Keynesian Econ. 1 (2), 171–194.

G7 Working Group on Stablecoins, 2019. Investigating the Impact of Global Stablecoins. Joint group of BIS, CPMI, IMF, and G7. See: https://www.bis.org/cpmi/publ/d187.pdf.

Gali, J., 2020. The effects of a money-financed fiscal stimulus. J. Monet. Econ. forthcoming.

Goodhart, C., D. Masciandaro, and S. Ugonini (2021): "Pandemic recession, helicopter money and central banking: Venice, 1630," CEPR Discussion Paper No. 15715.

Gornemann, N., Kuester, K., Nakajima, M., 2012. Monetary policy with heterogeneous agents.

Grenville, S. (2013), "Helicopter money", VOX - EU - CEPR. See: https://voxeu.org/article/helicopter-money.

Haldane, A., Roberts-Sklar, M., Young, C., Wieladek, T., 2016. QE: The Story so Far. Bank of.

Kappes, S.A., 2021. Monetary policy and personal income distribution: a survey of the empirical literature. Rev. Polit. Econ. forthcoming.

Keynes, J.M., 1930. A treatise on money. In: 1-2: The Applied Theory of Money. London: Macmillan In: J.M. Keynes (1971-1989). The collected writings of John Maynard Keynes, VI. Macmillan, London.

Keister, T. and Monnet, C. (2020), "Central bank digital currency: stability and information", Unpublished, Rutgers University and University of Bern.

Keister, T, Sanches, D.R, 2021. Should Central Banks Issue Digital Currency? Federal Reserve Bank of Philadelphia. Working Papers 21-37.

Kim, Y.S., Kwon, O., 2022. central bank digital currency, credit supply, and financial stability. J. Money, Credit Bank. Forthcoming.

Kregel, J., 2019. Alcune osservazioni sulla globalizzazione della finanza e delle valute digitali. Moneta e Credito 72 (285), 15–28.

Lavoie, M., 2022. Post-Keynesian Economics. Edward Elgar.

Meaning, J., Dyson, B., Barker, J., Clayton, E, 2018. Broadening narrow money: monetary policy with a central bank digital currency. In: Staff Working Paper No. 724. Bank of England. See. https://www.bankofengland.co.uk/-/media/boe/files/working-paper/2018/broadening-narrow-money-monetary-policy-with-a-central-bank-digital-currency.pdf.

Nikiforos, M., Zezza, G., 2017. Stock-flow consistent macroeconomic models: a survey. J. Econ. Surv. 1–36.

Oh, H., Reis, R., 2012. Targeted transfers and the fiscal response to the great recession. J. Monet. Econ. 59 (S), 50–64. Elsevier.

Palley, I.T., 2011. Quantitative easing: a Keynesian critique. Investigación económica 70 (277).

Panetta, F., 2021a. Central bank digital currencies: a monetary anchor for digital innovation. In: Introductory remarks to the Commission for Economic and Monetary Affairs of the European Parliament. Madrid. November. Available at: https://www.ecb.europa.eu/press/key/date/2021/html/ecb.sp211118~b36013b7c5.it.html.

Panetta, F., 2021b. Interview with Fabio Panetta, member of the executive board of the ECB, conducted by Tim Bartz. Der Spiegel available at. https://www.ecb.europa.eu/press/inter/date/2021/html/ecb.in210209~af9c628e30.en.html.

Panetta, F., 2022. The digital euro and the evolution of the financial system. In: Introductory statement by Fabio Panetta, Member of the Executive Board of the ECB, at the Committee on Economic and Monetary Affairs of the European Parliament. Brussels, 15 June 2022, available at. https://www.ecb.europa.eu/press/key/date/2022/html/ecb.sp220615~0b859eb8bc.en.html.

Reis, R., Tenreyro, S., 2022. Helicopter money: what is it and what does it do?. In: *CEPR Discussion Papers 17180,* C.E.P.R. Discussion Papers.

Rochon, L.P., 2016. In pursuit of the holy grail: monetary policy, the natural rate of interest, and quantitative easing. Stud. Polit. Econ. 97 (1), 87–94.

Rochon, L.P., Vallet, G., 2022. The institutions of the people, by the people and for the people? Addressing central banks' power and social responsibility in a democracy. PSL Q. Rev. 75 (301), 83–102.

Roxburg, C., Lund, S., Wimmer, T., Amar, E., Atkins, C., Kwek, J., Dobbs, R., Manyika, J., 2010. However, A Greater Proportion of Public Debt Owned by the Private Sector Implies Lower Seigniorage Income for the Government, Triggering a Growth in its Deficit. McKinsey Global Institute.

Ryan-Collins, J., Van Lerven, F., 2018. Bringing the helicopter to ground: A historical review of fiscal-monetary coordination to support economic growth in the 20th century. In: *UCL Institute for Innovation and Public Purpose Working Paper Series* (IIPP WP 2018-08). https://www.ucl.ac.uk/bartlett/public-purpose/wp2018-08.

Sawyer, M., Veronese Passarella, M., 2021. A comprehensive comparison of fiscal and monetary policies: a comparative dynamics approach. Struct. Change Econ. Dyn. 59, 384–404, 2021.

Shah, D., Arora, R., Du, H., Darbha, S., Miedema, J. and Minwalla, C. (2020), "Technology approach for a CBDC", Bank of Canada, Staff Analytical Notes, 2020-6.

Siu, R., 2023. Social, political and economic dimensions of the instituted process of central bank digital currency: the case of the digital Yuan. In: Presented at AFEE at ASSA 2023 Annual Meeting in New Orleans.

Soderberg, G., Bechara, M., Bossu, W., Che, N., Davidovic, N., Kiff, J., Lukonga, I., Mancini Griffoli, T., Sun, T., Yoshinaga, A, 2022. Behind the Scenes of Central Bank Digital Currency: Emerging Trends, Insights, and Policy Lessons. FinTech Notes. No 2022/004.

Temperini, J., Corsi, M., 2023. Democratizing money? The role of cryptocurrencies. PSL Q. Rev. 76 (304), 51–66. https://doi.org/10.13133/2037-3643/17967.

Turner, A., 2015. The case for monetary finance – an essentially political issue. In: 16th Jaques Polak Annual research conference November 5-6, Papers 386. Society for Economic Dynamics.