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- The problem of parity in Kumhof and Noone's design principles for Central Bank Digital Currencies

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Abstract:

This paper is a critical engagement with the four design principles for Central Bank Digital Currency (CBDC) recently proposed by Kumhof and Noone (KN). It is argued that the implicit notion of parity underlying KN's analysis is too narrow as it is only focused on the exchange rate between CBDC and bank deposits. Instead, we develop a three dimensional model of parity, which also includes the concepts of purchasing power parity and settlement parity. Applying this model to KN's proposal, the paper identifes four potential breaking points, where their principles provide a weaker defense of parity between CBDC and bank deposits than what is suggested by their analysis: Gilt traders may create a break of purchasing power parity as they respond to a crisis by quoting different gilt prices depending on whether payment is made in CBDC or bank deposits. Speculators may provoke a break of either purchasing power parity or exchange rate parity by buying gilts for bank deposits, thus forcing the central bank to buy gilts for CBDC, and then subsequently selling gilts for CBDC. The Treasury may find itself forced to break settlement parity, if citizens create a 'run' by using only bank deposits to make payments to the government, while demanding payments from the government in CBDC. And finally the central bank cannot use the interest rate on reserves as a separate policy tool to guide the risk-free interest rate in the economy as reserves carry the risk of a break of settlement parity in relation to CBDC.

Keywords: Central banks, money creation, digital currency, CBDC, monetary policy, parity

JEL: E40, E41, E42, E50, E51, E52, E58, E61, G21

Contents

Introduction

The debate about central bank digital currency (CBDC) is currently marked by a ketchup effect. For a long time the notion of central banks issuing their own digital currency was a fringe idea mostly debated among activists and academics at the margins of the mainstream. But over the course of the past two years the issue has rapidly picked up speed. This idea is now being researched and debated internationally by central banks and other stakeholders with new research reports and central bank statements coming out on a monthly if not on a weekly basis (Barrdear and Kumhof 2016; Bech and Garratt 2017; Blakstad and Allen 2018; Bordo and Levin 2017; Dyson and Hodgson 2016; Engert and Fung 2017; Fiedler et al. 2017; Ketterer et al. 2016; Meaning et al. 2018; Sandal et al. 2018; for overview see Prasad 2018).

CBDC is simultaneously an abstract theoretical idea and a concrete policy proposal. At the horizon of the academic debate is thus the political question of whether CBDC should be implemented CBDC or not (Skingsley 2016; Ingves 2017; Nicolaisen 2017; Gürtler et al. 2017; Bjerg and Nielsen 2018) As the debate about CBDC is progressing, we see more and more nuances added. Since CBDC may be implemented in a number of different ways, the question is not merely *whether* to implement or not but. Equally important is the question of *how* to implement a CBDC (Bjerg 2017; Meaning et al. 2018).

Working with different co-authors, Michael Kumhof has been at the very forefront of this debate for several years and his research figures as standard references in studies on CBDC (Benes and Kumhof 2012; Barrdear and Kumhof 2016). In a recent paper, Michael Kumhof and Clare Noone (KN) push the discussion of how to implement CBDC an important step further by opening a series of crucial design questions (2018). They also provide their own answer to these questions by listing four core principles for a design of a CBDC.

The current paper is a critical engagement with the proposal and analysis of KN. While KN's core principles are indeed expedient, the paper argues that the design principles provide a weaker defense of parity between CBDC and bank deposits than what is suggested by KN.

The paper begins with a presentation of the key points in the KN paper. Then follows a discussion and definition of the concept of parity as this is a key issue in KN's analysis. This leads into four consecutive analytical sections, where four potential breaking points of parity are identified. Each of the sections observe the problem of parity from a different perspective: the central bank, the market, the government and the banks, and it is investigated, how KN's design proposal respond to different types

of pressure. The paper concludes by summarizing the findings and discussing their policy implications.

CBDC design principles

A key concern in debate about CBDC is the potential impact on the functioning of the existing monetary system. The contribution of KN to this debate is the following:

> [I]f the introduction of CBDC follows a set of reasonable core principles, then the banking sector's two key functions, the provision of credit to borrowers and the provision of liquidity to depositors, are not necessarily curtailed. (2018, 5)

The concern with regards to the first of these key functions is that the introduction of CBDC may prevent banks from funding loans through the creation of new deposits thus limiting their capacity for credit provision (Broadbent 2016; Gürtler et al. 2017; Fiedler et al. 2018). The challenge is that if borrowers insist on having loans paid out in CBDC, banks can only lend out money to the extent that they can secure funding from savers. Banks would be fully or partially reduced to simple financial intermediaries rather than suppliers of money.

The concern with regards to the second of the two key functions is that the introduction of CBDC might facilitate a digital bank run thus causing financial instability (Carney 2016; Skingsley 2016). The challenge is that if money users are given the choice between holding risk-free CBDC and holding bank deposit money, which ultimately carries a credit risk, they may opt for the latter thus forcing banks to pay out CBDC in exchange for bank deposits. If this happens on a significant scale, banks would soon find their stock of CBDC depleted and they would turn to the central bank as CBDC lender of last resort. The central bank would in turn be obliged to supply the banks with CBDC in exchange for various kinds of more or less risky assets.

The core principles proposed by KN to counter these two challenges are:

> (i) CBDC pays an adjustable interest rate.
>
> (ii) CBDC and reserves are distinct, and not convertible into each other.
>
> (iii) No guaranteed, on-demand convertibility of bank deposits into CBDC (via an obligation on commercial banks or the central bank to guarantee convertibility).
>
> (iv) The central bank issues CBDC only against eligible securities (principally government securities).
>
> (2018, 5)

The most original contribution in KN's solution is probably principle (iii). It is based on the counterintuitive idea that parity between bank deposits and CBDC is best

secured by committing *neither* commercial banks *nor* central banks to converting the former into the latter at their nominal price. This sets KN apart from many other papers on CBDC that assume this convertibility as given (eg. Meaning et al. 2018). KN's reasoning is that rather than banks and central banks taking on a commitment, which they may not be able to honor under extreme circumstances, it is better to not take on the commitment at all. This way the credibility of banks is not impaired, if they cannot meet customers demand for CBDC, as they have never made such a promise in the first place.

Instead of maintaining parity through the commitment of banks and the central bank, KN propose a market solution combined with CBDC interest rate adjustments by the central bank. This is where principle (i) comes into play. The demand for conversion of bank deposits into CBDC and vice versa is met by non-bank private sector agents acting as CBDC exchanges. Assuming that bank deposits and CBDC have the same utility as a means of payment, their value will deviate according to the fact that CBDC is a risk-free store of value, while bank deposits carry a credit risk. In order to maintain parity between the two forms of money in spite of the difference in credit risk, the central bank adjusts the interest rate on CBDC to create a spread relative to the bank deposit rate. The central bank thus applies a quantity rule (fixing the quantity of CBDC and adjusting the price) to make sure that supply and demand in the market for CBDC/bank deposit conversion clears.

The point of leaving the conversion of bank deposits into CBDC and vice versa to non-bank market agents is that shifts in the portfolio preferences of money users do not affect the size of bank balance sheets or the overall stock of liquid money. The conversion of bank deposits into CBDC by one money user is only possible through a counter party accepting the inverse conversion, which offsets the macroeconomic implications of the transaction. This differs from a scenario, where banks perform the conversion. When a bank responds to the demand by a customer for the conversion of bank deposits into CBDC, it removes CBDC from the asset side of its balance sheet and destroys deposits from its liability side. This balance sheet contraction decreases the overall stock of liquid money in the economy.

Principle (ii) extends the non-convertibility between bank deposits and central bank money to also encompass reserves. One of the reasons for this principles is to prevent a bank run 'by the back door'. Such a scenario might occur if a narrow bank with access to a central bank reserve account and the central bank clearing system (RTGS in the UK) were to offer conversion of bank deposits for CBDC to customers. This narrow bank would then receive bank deposits from other banks thus obliging these banks to clear the transaction through the transfer of reserves into the narrow bank's account with the central bank. The narrow bank could then respond to customers' demand for

CBDC by exchanging reserves for CBDC at the central bank and paying this out to customers in return for deposits. The end result would be the same as in a regular bank run 'by the front door'. Banks losing deposits would ultimately run out of reserves and the central bank would be forced to either step in as lender of last resort or terminate conversion of reserves for CBDC.

Another argument for keeping reserves distinct from CBDC is that it allows the central bank to retain the policy rate as an independent monetary policy tool. While the rate on CBDC is adjusted to maintain parity with bank deposits and thus financial stability, the policy rate on reserves can be used separately to manage price stability in the economy.

The final principle (iv) provides the central bank with a second line of defense against pressure on the parity between CBDC and bank deposits. In addition to the above mentioned adjustment of the interest rate on CBDC (quantity rule), the central bank may also adjust its quantity by issuing CBDC against eligible asset (price rule). Such assets would normally be constituted by government bonds (gilts in the UK). Private sector agents such as CBDC exchanges would thus be able to respond to an excessive demand for CBDC by using bank deposits to purchase gilts in the market, which are then subsequently exchanged for CBDC with the central bank. This mechanism for CBDC issuance in exchange for gilts makes sure that no bank deposits are destroyed and thus aggregate bank funding is not affected in the process. The exception is of course if the seller of gilts for bank deposits is a bank, but this would only occur on the initiative of the bank itself. The mechanism also safeguards the central bank from having to fund commercial banks directly by being forced to accept their IOUs in exchange for CBDC.

The gist of the four principles, as proposed by KN, is that they allow for a largely market based solution to the maintenance of parity between CBDC and bank deposits, where the central bank is not directly committed to convertibility and is only obliged to accept government liabilities in exchange for CBDC. Parity between the two forms of money is crucial because it is key to making sure that banks can continue funding themselves through deposit creation and that deposits continue to circulate as liquid means of payment. In this manner, CBDC may be introduced without significantly altering the way that the money and banking system currently functions.

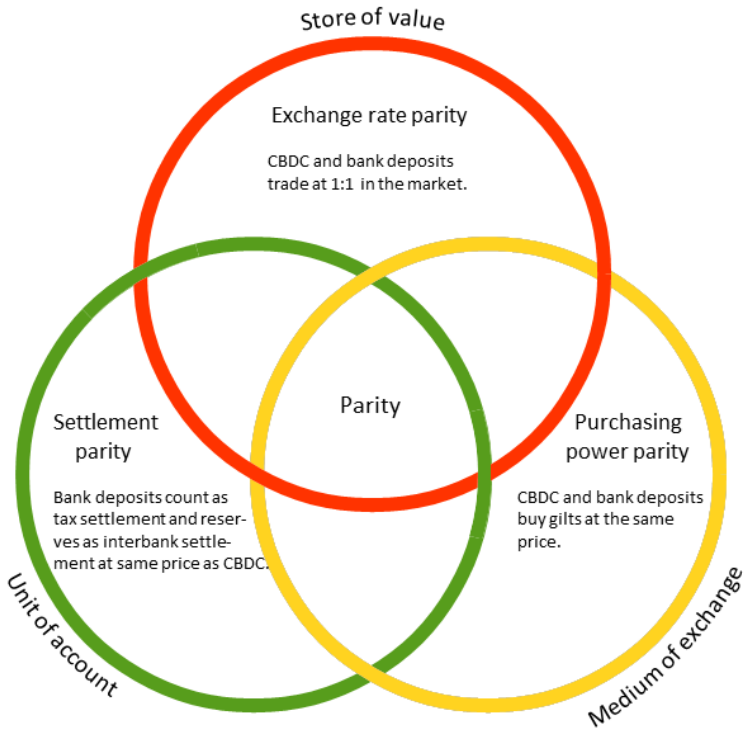
The Problem of Parity

We may conceive of the problem that KN is trying to solve by their four principles as a problem of parity. Our existing monetary system already consists of three different forms of money, which all count as units of the national currency: physical cash, central

bank reserves, and commercial bank deposits. It is the responsibility of the central bank and other monetary authorities to make sure that these three forms of money circulate at par. By implementing CBDC we are introducing a fourth kind of money into this system. This further complicates the task of managing parity. The concerns of KN quoted at the beginning of the previous section are essentially concerns that parity between CBDC and bank deposits breaks down thus upsetting the opportunities for commercial bank credit creation and liquidity provision.

What is parity? Before we venture into a review of the implications of KN's proposal, we shall take a philosophical step back to define and reflect on the concept of parity. As a first definition, parity simply just means equal or equivalent. In the context of monetary economics, this means that different forms of money circulate at equal value. The value of money, however, is always defined in relation to something else. Money has multiple functions and thus the value of money manifests itself along different dimensions. This also means that parity manifests itself along different dimensions. And by implication this finally means that parity can break down in different dimensions. It is common place to distinguish between three functions of money: store of value, medium of exchange and unit of account. We can use these three functions to develop a three dimensional definition of parity. The definition is illustrated in figure 1.

Figure 1: Three Dimensions of Parity



The most direct way of observing parity is when we use money to exchange for other kinds of money. It implies that different kinds of money are exchanged at their nominal value. In the context of our analysis this means that £100 of bank deposits may be exchanged for £100 of CBDC. They trade at 1:1. This kind of parity is related to the function of money as a *store of value*. The market prices money according to its quality as a store of value. When bank deposits and CBDC trade at par, the market has priced them as equal stores of value. We shall refer to this as *exchange rate parity*, which is represented by the red circle. Exchange rate parity is the kind of parity that KN is focused on in their analysis.

Obviously money is not only used to buy other forms of money but also to purchase goods, services and other kinds of assets in the economy. It functions as a *medium of exchange*. Along these lines parity exists when similar amounts of different kinds of money buy similar amounts of goods, services or assets. This implies, for instance, that when traders sell securities such as gilts, they quote only one price regardless of whether buyers pay in bank deposits or CBDC. We shall refer to this as *purchasing power parity*, which is represented by the yellow circle.

A third use of money is for the settlement of debt. We can connect this with the function of money as a *unit of account*. Money functions as a unit of account in so far as it constitutes an abstract measure of value. This allows us to quote prices in terms

of currencies such as Pounds or Kroner. But in order for a currency to function as an abstract unit of account it also has to designate a concrete unit of account. The currency has to define, what counts as a unit of the currency. What counts as a Pound? What counts as a Krone? A crucial element in the designation of the concrete unit of account of a currency is the definition of the units, which count as settlement of debts. This is what we find in legal tender laws. But even if a unit is not legally defined as legal tender, it may still de facto function to settle some forms of debt. When equal amounts of different forms of money settle equal amounts of debt, parity exists. We shall define this as *settlement parity*, which is represented by the green circle. Since the major creditors in our economy are banks and the government, their acceptance of CBDC, reserves and bank deposits in debt settlement is crucial to the designation of the concrete units of account and the maintenance of settlement parity.

The point of this three dimensional definition is that we should think of parity as a chain composed of several links. This is why figure 1 is composed of so-called Borromean rings. They are mutually overlayered in a way, where they keep each other together. But if one of the rings is broken, the other two can also drift apart. If one form of parity breaks down, the break transmits to the other two and parity as such breaks down. As mentioned, KN is only focused on exchange rate parity. This means that their analysis is not sufficiently sensitive to weaknesses in other links in the chain of parity. In the following, we shall identify four potential breaking points in the chain of parity.

Analysis

The following analysis proceeds to explore, how the three forms of parity are connected. In the first section we shall identify the limits of the central banks defense of exchange rate parity. In the second section we shall examine vulnerabilities in purchasing power parity, which may be exploited by traders looking for speculative profits. In the third section the role of the Treasury in the maintenance of settlement parity is discussed. And in the fourth section we shall imagine a scenario, where settlement parity between CBDC and reserves in the interbank market breaks down.

1. The Challenge to the Central Bank: How bad can you make good money?

From the history of economics, we know the phrase 'bad money drives out good' also referred to as Gresham's law. It originally refers to a situation, where different forms of commodity money circulate at the same nominal value, while there is a discrepancy between their respective commodity values. If, for instance, money users in an economy hold silver coins of unequal fineness but with the same denomination, they are likely to use the impurest coins for purchases and debt settlement while hoarding the purest coins as stores of value. The impure 'bad' coins thus eventually drive the 'good' fine coins out of circulation.

By virtue of being a claim on the central bank, CBDC carries no credit risk. In comparison to bank deposit money, this makes CBDC 'good' money with a better quality as store of value. The challenge facing central banks is then to prevent 'good' CBDC from driving out 'bad' bank deposits. This would happen, if money users where to hoard CBDC, while trying to convert all their bank deposits into CBDC. To prevent this, central banks should aim to make the good money as bad as the bad money. In this section, we shall test the limits of this strategy.

In KN's proposal the central bank first compensates for the difference in the value of the two forms of money by keeping the interest rate on CBDC lower than the interest rate on bank deposits:

> For example, if the central bank targets a CBDC-to-GDP ratio of, say, 15%, and at some point in time, and at prevailing CBDC interest rates, the market demands more CBDC than this target, the interest rate on CBDC must drop until the market clears at the desired quantity. An efficient mechanism needs to exist to facilitate this adjustment. (2018, 30)

As already noted by KN there are certain limits to this quantity rule. If the rate on bank deposits is low, which is the case in many economies today, the central bank may be forced to impose negative interest rates on CBDC in order to maintain a spread be-

tween the two forms of money, which is large enough to dissuade money users from converting into CBDC:

> [T]here are potential limits if this requires a highly negative interest rate, and if further reductions of the interest rate below this level become politically difficult. (2018, 34)

The political issue here is that negative interest rates are in effect a tax on money users to compensate for risk accumulated in the banking sector. If the market becomes concerned about solvency in the banking sector, it factors credit risk into the relative pricing of CBDC and bank deposits thus increasing the demand for CBDC. In order to defend exchange rate parity, the central bank reacts to this by taking a certain percentage of the CBDC held by general money users in negative interests. During the financial crisis of 2007-8 there was already a sense that 'tax payers' money' was used to 'bail out the banks'. It is questionable, whether the general public is going to accept this once again especially if it is done in the very direct fashion of imposing negative interest rates on ordinary people's CBDC accounts.

There is an additional problem in imposing negative interest rates on CBDC to defend exchange rate parity. While negative interest rates do indeed make CBDC less attractive to hold, they are also effectively shrinking the supply of CBDC. This creates an opposite price effect than the one desired by the central bank. As the supply of CBDC decreases, the price goes up and thus creates additional pressure on the exchange rate parity with bank deposits. To what extent this opposite price effect offsets the initial effect of lowering interest rates is difficult to estimate.

Now KN suggests that even when CBDC interest rates have been lowered to their political limit, there is an additional effect, which would re-balance exchange rate parity. In order to compensate for the decreasing demand for bank deposits, banks will increase deposit rates:

> Given the large reduction in demand for bank deposits at given interest rates, the interest rate on bank deposits is likely to increase relative to the policy rate and the CBDC rate, to incentivise households and firms to hold deposits. (2018, 34)

This reasoning involves a game theoretical problem. If the banks know, that the central bank is ultimately committed to the maintenance of parity between bank deposits and CBDC, why would they jeopardize their profit margin by increasing deposit rates. In turn, they could just sit back and wait for the central bank to cave in and restore exchange rate parity by whatever means necessary.

There is an additional twist to this problem of relying on interest rate adjustments to manage the relative demands for bank deposits and CBDC. In the quote above, KN refers to a need for an 'efficient mechanism' to 'facilitate this adjustment'. On the one

hand, such a mechanism would constitute a response to behavior in the market. On the other hand, it would also constitute a signal to the market, which would influence behavior. If, for instance, the central bank lowers the interest rate on CBDC in order to make markets clear in a situation with excess demand for CBDC, this lowering of the interest rate would itself feed back into the market as a signal that a concern about credit risk in the banking sector is justified. This would then trigger even more demand for CBDC, which would in turn compel the central bank to lower CBDC interest rates even more, and so on.

When central banks come up against the lower limit of interest rates on CBDC, they have the option of switching to the second line of defense against a break of exchange rate parity, which is the imposition of the price rule. By selling CBDC for eligible securities, the supply of CBDC may be increased to satisfy increasing demand and clear the market at par. The existence of such a market, where CBDC and bank deposits trade at par (possibly with a transaction fee), relies on the assumption of arbitrage opportunities:

> Say CBDC is trading at an exchange rate of 1-x to deposits, for x>0. Then a financial institution can lock in a riskless profit, by taking 1 unit of deposit inflow from a customer, buying 1 unit worth of gilts in the market, immediately selling the gilt to the central bank for 1 unit of CBDC, delivering 1-x of CBDC to the customer, and keeping x CBDC as riskless profit. Arbitrage will drive x to zero. Note that it is the central bank's commitment to pay 1 unit of CBDC for a gilt worth 1 unit of 'deposit-money' – that is, central bank's use of a parity exchange rate in its operations – that allows this strategy to work. (Kumhof and Noone 2018, 16 n17)

This assumption is crucial to KN's proposal. But it is also problematic. In order for the financial institution in question to buy '1 unit worth of gilts in the market' there has to be a seller of gilts willing to quote the same price regardless of whether payment is made in bank deposits or CBDC. KN's assumption thus ultimately relies on the willingness of this seller of gilts to absorb the costs of conversion necessary to maintain exchange rate parity. Or, in other words, the seller of gilts is assumed to provide the purchasing power parity necessary to defend exchange rate parity. But why would this private agent with no responsibility for financial stability do so? There is a tautology in KN's reasoning.

Since the central bank has switched to the price rule and thus engaged in the purchase of gilts, it is already responding to a situation, where the market values bank deposits lower than CBDC. In the words of KN 'CBDC is trading at an exchange rate of 1-x to deposits, for x>0.' This pressure on parity would, however, not only manifest itself in the direct exchange rate between CDBC and deposits, it would also be factored

into the pricing of securities and other objects of trade in the market. Pressure on exchange rate parity would transmit to a pressure on purchasing power parity.

For illustration, we can think of a classical bank run scenario such as the one we saw during the Greek debt crisis in 2015. The crisis not only caused banks to impose a cap on daily cash withdrawals. In response to the fear of a widespread collapse in the banking system, restaurant owners, filling stations and other merchants reacted by charging a higher price for credit card payments or by refusing to accept anything but cash payments. The pressure on exchange rate parity between cash and bank money manifested itself in a divergence in the prices of goods and services and thus a break in purchasing power parity.

In a situation, where there are doubts about the parity between CBDC and bank deposits, we should thus expect gilt traders to react in the same fashion as Greek restaurant owners. They have the option of selling their gilt in the open market for bank deposits or selling them directly to the central bank for CBDC. To the extent that they would even consider the former, we should expect them to charge a higher price for payment in bank deposits. If CBDC is trading at an exchange rate of 1-x for deposits, for $x>0$, the gilt trader is going to want a compensation of x in order to sell for deposits. Two prices of gilts will emerge and at that moment, the parity, which was supposed to be defended, breaks down.

The tautology in KN's reasoning is that they expect the gilt sellers to trust parity to be maintained and thus sell their gilts for bank deposits, while at the same time it is these very same gilt sellers, who are the ultimate bulwark against the break of parity, because they are expected to absorb the excess of bank deposits in the economy in exchange for gilts. The 'gilt standard' of CBDC proposed by KN therefore only works under the assumption that gilt traders are altruists, who are primarily concerned with the general stability of the financial system. This is hardly a reasonable assumption. In turn, we should expect them to factor the risk of a break of parity into gilt prices by charging a premium on payments in bank deposits.

Once the purchasing power parity is broken and gilt buyers have to pay a premium for payment in bank deposits an arbitrage opportunity emerges, which puts additional pressure on exchange rate partiy: First, you sell bank deposits for CBDC at par or close to it. Then you buy gilts for CBDC at a relatively low price. These gilts may then be sold for bank deposits at a nominally higher price. The bank deposits may then be exchanged for CBDC at par, and you can start all over again. As traders exploit this opportunity, exchange rate parity is eventually going to break and widen even more. Arbitrage opportunities thus move the market away from rather than towards parity.

The conclusion to this section is that neither the adjustable interest rate on CBDC nor the possibility for the central bank to increase the supply of CBDC in exchange for

eligible securities are sufficient tools to guarantee parity. The two tools may work nicely under normal conditions, when there are no concerns about the general health of the banking sector and the money users' preferences for holding CBDC or bank deposits are determined by matters of habit and convenience. But the robustness of a money system should not be measured on its performance under normal conditions but rather on its performance in a crisis. A key purpose of the four core principles proposed by KN was to avoid:

> open[ing] the door to aggregate bank runs, with a counterpart in the central bank becoming a large, and potentially partly unsecured, creditor of the banking system. (2018, 31)

This is achieved by making sure that

> [c]onvertibility of bank deposits into CBDC does ... not have to be ensured by banks themselves, and the central bank ... does not need to stand ready to accept bank IOUs as an eligible asset when issuing CBDC. (2018, 32)

What we have demonstrated is that both the first (quantity rule) and the second (price rule) line of defense against a break of exchange rate parity are weaker than suggested by KN. This means that in a crisis the central bank is ultimately going to end up in a situation, where it is indeed compelled 'to stand ready to accept bank IOUs as an eligible asset when issuing CBDC' and therefore ends up exactly as 'a large, and potentially partly unsecured, creditor of the banking system'. The only other option is for the central bank to accept the break of parity and thus an ensuing drop in bank funding, liquidity and eventually solvency. In more popular terms, the central bank will be faced with the choice between either saving the banks or sticking to its initial monetary policy principles.

2. The Opportunity in the Market: What would Soros do?

In 1992 financier George Soros became famous by making a successful bet on a devaluation of the British Pound. Two years prior, Britain had joined the European Exchange Rate Mechanism thus pegging the Pound to a basket of European currencies including most prominently the German Mark. Since Britain had joined at a high exchange rate relative to the Mark and was suffering from high inflation and high interest rates, Soros judged that Britain would not be able to stay within the band of the ERM. By borrowing Pounds and subsequently buying Marks and Francs, he was not only setting himself up for a profit in the case of devaluation. His trading was also creating additional pressure on the value of the Pound to decrease. In the end, the British monetary authorities had to give in to the pressure and allow the exchange rate of the Pound to fall be-

low the stipulated limits of the ERM, enabling Soros to make an estimated profit of £1bn by liquidating his positions.

One of the reasons, why Soros' move on the British Pound has become famous, is because not only was he betting on a certain future event (Britain leaving the ERM). His own trading was at least partially instrumental in eventually bringing about this event. In similar fashion, it is worth considering, to what extent the KN proposal for CBDC implementation is vulnerable to deliberate trading strategies aimed at exploiting weaknesses in the system. As we have seen, KN assumes that the exploitation of arbitrage opportunities actually helps to stabilize the system as it pushes divergences in exchange rate between CBDC and bank deposits towards zero. In this section, we shall argue that this is not necessarily the case, by analyzing the effects of a trading strategy aimed at exploiting the central bank commitment to parity. We thus shift our perspective from the central bank to the market, where we find agents looking for speculative profits.

The executing agent of our trading strategy is a bank with the possibility of expanding the money supply by creating new deposits. It might also be a hedge fund with extensive credit lines at a bank. Since the strategy ultimately trades against the central bank, a number of banks, funds or other market agents acting in concert may create synergies to increase profits for everyone involved. For simplicity, however, we here imagine the case of an individual, albeit major, bank triggering the following chain of events:

1) The bank starts buying up gilts and paying in newly created bank deposits. If the bank comes up against liquidity restraints as payments in bank deposits come back as claims for settlement, it may use the gilts as collateral in repos to borrow reserves at the central bank to make these settlements.

2) The trading increases the ratio of bank deposits to CBDC resulting in a demand for conversion from the former to the latter as gilt sellers re-balance their portfolio of money.

3) As a first line of defense the central bank compensates for this increasing demand by lowering the interest rates on CBDC. If, however, interest rates are already close to zero, as is the case today, and our bank is able to keep the pressure by purchasing enough gilts, the central bank is ultimately compelled to shift to a price rule and start increasing the supply of CBDC by buying gilts.

4) The bank has now pushed the central bank into a situation comparable to our current Quantitative Easing scheme, where central bank demand for gilts puts an upward pressure on prices.

5) This should be a signal for the bank to accelerate its trading and buy even more gilts for bank deposits. The effect of this trading is double. First, it pushes up gilt

prices even further, which allows the bank to increase the value of its existing position. Second, it increases the supply of bank deposits even more thus forcing central banks to buy even more gilts for CBDC to defend exchange rate parity thus again increasing gilt prices even more. (At this stage we are accepting the assumption, which was refuted in the previous section, that gilt sellers in the market remain indifferent as to whether gilt buyers pay in CBDC or bank deposits and purchasing power parity does not break). The bank cannot create CBDC and the central bank will not accept bank deposits, so the two parties do not trade directly with each other. In turn, the gilt market becomes the venue for their proxy struggle. But since their respective trading behaviors do not offset but rather reinforce each other, the market is pushed away from, rather than towards, equilibrium. The ensuing result is increasing gilt prices.

The profitability of the bank's trading strategy does not necessarily depend on its ability to eventually break exchange rate parity between CBDC and bank deposits. It is able to cash in regardless of whether parity breaks or not. We shall explore each of these scenarios in turn:

6a - parity maintained) The bank may cash in by liquidating its position in gilts. As long as exchange rate parity is maintained it should sell gilts for CBDC. By doing so it can maintain the pressure on parity between CBDC and bank deposits even in the process of liquidating its position. The bank may have ceased increasing the supply of bank deposits but it still maintains the existing supply. Furthermore, it is increasing the demand for CBDC. The point of this tactic is to compel the central bank to keep purchasing gilts for CBDC, while the bank is selling, thus preventing gilt prices to fall in the process and allowing the bank to lock in the profit from the inflation in gilt prices. In this trade the two parties may actually become direct counter parties. At some point the bank may have to use the incoming flow of CBDC to purchase reserves at parity in the interbank market to redeem its repos thus unlocking even more gilts to be sold into the market.

7a - parity maintained) Once the bank has converted all gilts into CBDC, it may also want to restore its balance sheet to its original size by using its excess amount of CBDC to redeem its excess amount of bank deposit liabilities. This may be done by settling directly with customers or by selling CBDC into the market for exchange. Since the central bank will still be committed to the maintenance of exchange rate parity, this final conversion can also be expected to be risk free. The bank thus ends up with a profit in the form of a remaining surplus amount of CBDC on its balance sheet. Having profited on this trading strategy, the bank may decide to go back to 1) and repeat the trade all over again.

6b - parity broken) Another scenario is that exchange rate parity between CBDC and bank deposits breaks before the bank has liquidated its trading position. This may hap-

pen if the central bank gives up trying to supply enough CBDC for gilts to satisfy demand in the market thus allowing the exchange rate between CBDC and bank deposits to float. It may also happen in the manner already touched upon previously if gilt sellers start quoting different prices depending on whether buyers pay in CBDC or in bank deposits thus breaking purchasing power parity. In any case, the result is that the bank deposit price of gilts increases, which allows the bank to profit by selling its stock of gilts for bank deposits.

7b - parity broken) As the bank receives bank deposits in exchange for gilts, it is able to settle its own outstanding balance of bank deposit liabilities incurred in the initial process of purchasing gilts. As these balances are settled the bank also receives an inflow of reserves, which it can use to settle repos and thus unlock more gilts for selling. Ultimately this restores the balance sheet of the bank to its original size, while also providing the bank with a net profit due to it having bought gilts for bank deposits, when parity was still intact, and now selling, when parity is broken.

The funding costs of executing the strategy is constituted by the interests paid on the surplus amount of deposits, the interests paid on repos required to make settlements, as well as possible negative interest rates paid on CBDC. These costs are partially offset by interests received on gilts and CBDC, if the latter are not negative. The amount of these costs of course depend on the time it takes to execute the strategy. Since the strategy is likely to be more effective the faster it is executed, the profitability of the trade should not be significantly affected by these costs.

In the previous section, we have seen how concerns about solvency and credit risk in the banking sector may trigger a pressure on parity between CBDC and bank deposits, which the central bank is ultimately unable to defend without relinquishing one or more of KN's core principles. The point of this section is that speculative trading strategies may deliberately provoke a similar situation. If parity is not broken (6a and 7a), there is nothing preventing the bank as well as other agents in the market, who have caught on to the strategy, from repeating the trade over and over again. As long as the central bank remains committed to maintaining parity by buying gilts for CBDC, the bank may claim an arbitrage profit by buying gilts for bank deposits and selling for CBDC. Since this is obviously not sustainable, the central bank will ultimately find itself faced with the same dilemma as in the previous section: give up on the initial core principles by accepting other assets than gilts and eventually bank IOUs in exchange for CBDC, or give up the defense of parity by allowing exchange rates to float.

While KN assume that speculative trading in the market means that '[a]rbitrage will drive x to zero' and thus reestablish parity, the above analysis suggests that the central bank commitment to parity, even if it is not executed through direct convertibility,

provides arbitrage opportunities for speculative traders that will drive x away from zero and thus exacerbate rather than alleviate pressure on parity.

3. The Role of the Treasury: How should we pay our taxes?

Our third issue about the consistency and efficiency of KN's core principles for the implementation of CBDC regards the role of the state in the form of the Treasury. While the Treasury has no direct responsibility for money creation and monetary policy, it still plays a vital role in the constitution of a currency as a unit of account. This is related to the concept of settlement parity. While KN fails to discuss this aspect of parity, it is an issue that has to be considered in the design of CBDC.

As the mediator of economic transactions between the citizens and the government the Treasury collects taxes and manages public expenditure. In advanced economies this constitutes a very significant portion of the total flow of money in the economy. The Treasury, on behalf of the government, constitutes the largest and most significant money user in the economy. Practically all money users in the economy will ultimately have to use some of their money to settle tax bills and other forms of debt to the government. This means that the designation of the concrete units, which money users can use to settle their tax debts, plays a decisive role in determining, what counts as money in the economy at large.

The fact that taxes and other payments to the government today can be paid in bank deposits at the nominal value helps sustain settlement parity of this kind of money. One of the reasons, why £100 of bank deposits is worth exactly £100 is because it can be used to settle a debt of £100 with the government. This further helps constitute bank deposits as a concrete unit of account in the economy. One pound of bank deposits *is* one pound.

The issue at stake here is how the Treasury manages the different kinds of money as they flow through the state budget. As we have seen, the gist of KN's proposal is that neither commercial banks nor central banks should be directly responsible for the conversion of bank deposits into CBDC. Instead, exchange rate parity is supposed to be maintained in the market. But as we have also seen, pressure on exchange rate parity may propagate into a pressure on purchasing power parity as gilt sellers may no longer accept bank deposits at parity in exchange for gilts. Furthermore, the idea of closing the doors of commercial banks and the central bank to potential bank runners may just redirect the pressure on parity towards the Treasury. This would constitute a pressure on settlement parity.

Today we take it for granted that taxes can be paid in bank deposits, since this is the only form of digital money, which is accessible to all money users. With the imple-

mentation of CBDC, however, this arrangement becomes much less self-evident. In an economy with both CBDC and bank deposits, the role of the Treasury has to be defined with regards to the following question: Which kind(s) of money can citizens use to pay their taxes? Ignoring the role of cash, which currently plays a negligible role in the administration of public finances, there are three possible answers to this question:

1) Treasury accepts both bank deposits and CBDC at the discretion of money users in the payment of taxes.
2) The Treasury accepts only bank deposits in the payment of taxes.
3) The Treasury accepts only CBDC in the payment of taxes.

We shall explore these three options in turn with regards to their implications for the maintenance of parity:

(1) In order to support the continued circulation of bank deposits, the Treasury may decide to leave it up to the citizens, whether they want to settle their tax and other payments to the government in bank deposits or CBDC. This is a commitment to settlement parity. As the Treasury receives an inflow of CBDC and bank deposits it has to subsequently balance its portfolio of the two kinds of money. There are two ways of doing this: It can manage its outflow of expenditures to match the ratio between bank deposits and CBDC in the inflow of revenue, or it can exchange bank deposits for CBDC and vice versa with private agents in the market. In this respect, the Treasury manages its portfolio of bank deposits and CBDC just like any other non-financial agent in the economy.

As long as the banking system and the financial markets operate under normal, stable conditions, this balancing should not constitute a problem. If, however, a crisis emerges and there is pressure on the parity between bank deposits and CBDC, money users may decide to use only bank deposits for their payments to the government. This would be a version of Gresham's Law, where 'bad' bank deposit money drives 'good' CBDC out of circulation. While other agents in the economy are in a position to refuse payments in bank deposits, the Treasury is committed to settlement parity and thus obliged to accept bank deposits at the nominal value.

Conversely, the opportunities for the Treasury to compensate for the excessive inflow of bank deposits relative to CBDC by rebalancing its outflow are probably limited both politically and legally. It is hardly conceivable that the Treasury can force public employees, recipients of social benefits, government contractors, etc. to accept bank deposits as payments from the state, if there is a public alternative in the form of CBDC. The Treasury may turn to the open market for conversion of bank deposits into CBDC. But assuming that parity is already under pressure, the Treasury's demand for conversion is just going to increase this pressure in the open market and possibly trigger the kind of situation described in the previous sections, where purchasing power

parity is eventually broken as gilt sellers no longer accept bank deposits as payment at parity with CBDC.

The point here is that if the Treasury can control neither the CBDC/bank deposit ratio of its inflow of money nor the CBDC/bank deposits ratio of its outflow of money, it also cannot control the ratio of its stock of money. This will be determined by the preferences of money users. In a crisis, the Treasury may be forced to absorb bank deposits, which money users do not want, while at the same time having to pay out CBDC. In effect, the Treasury is thus forced to perform the kind of conversion of bank deposits into CBDC, which neither commercial banks nor the central bank is obliged to do. The situation is a kind of 'run on the Treasury'. Such a run would be slower than a bank run insofar as money users can only offload bank deposits at the Treasury to the extent that they owe taxes or other debts to the government. The run would last until the Treasury's stock of CBDC is exhausted at which point it ends up in a liquidity crisis. At this point it may have to abandon settlement parity by only accepting CBDC in payment of taxes.

Since the Treasury has an account with the central bank, it has the option of holding reserve money. The Treasury may thus allow money users to decide, how they want to make and receive payments to and from the government, but as soon as payments in bank deposits are made, they are cleared and converted into reserves in the Treasury's central bank account. This complication, however, would not solve the underlying problem.

First, the Treasury still remains committed to settlement parity and thus obliged to accept bank deposits as payments at the nominal value even in a situation of crisis. Second, the Treasury is faced with the challenge of finding agents in the market, who are willing to buy reserves in exchange for the CBDC, which it needs to make its payments. According to KN's principle (ii) 'reserves and CBDC are distinct and not convertible into each other on demand'. This means that the central bank is not going to help the Treasury make this trade.

Instead, the Treasury has to approach sellers of CBDC in the open market. But in order for these sellers to receive central bank reserves as payment, the trade has to go through a commercial bank. The Treasury would transfer central bank reserves to the commercial bank and the commercial bank would credit the account of the CBDC seller accordingly. But this means that the seller of CBDC would receive bank deposits in exchange for his CBDC. Since we are assuming a situation of crisis, where parity is under pressure, the CBDC seller is unlikely to accept payment in bank deposits at the nominal value. This means that the Treasury would have to pay a premium in reserves to receive CBDC. Not only does this premium represents a loss between the value of the money received in taxes and the value of the money used for public expenditure

but the Treasury's demand for conversion of reserves into CBDC further contributes to the pressure on exchange rate parity, which constitutes the crisis in the first place, because it eventually amounts to a supply of bank deposits and a demand for CBDC.
(2) To avoid the challenge of having to match the inflow and outflow of CBDC and bank deposits respectively, the Treasury may then opt for the second model, which is to accept only bank deposits in tax payments. Obviously, this would force money users receiving payments from the government to also accept payment in bank deposits. This comes up against the limitations that we have already touched upon in the previous scenario.

If the purpose of CBDC implementation is to provide money users with a genuine option to choose between two forms of money, a refusal of the Treasury to use CBDC would defy this purpose as it forces bank deposits onto money users. Especially in a situation of crisis, it is highly questionable that public employees, recipients of social benefits, government contractors, etc. would accept payment in bank deposits if there is a safer alternative. Furthermore, one of the arguments sometimes put forward in favor of CBDC is the potential for financial inclusion of unbanked marginalized groups of people. Since such groups tend to rely heavily on social benefits, the payment of social benefits in bank deposits would prevent CBDC from being of much use to these people.
(3) The third option is then for the Treasury to manage the public budget exclusively in CBDC. This would remove any problems of cash flow management and would also relinquish the Treasury from assuming monetary policy responsibility by having to guarantee settlement parity. At the same time it would also make it much more difficult for the central bank to manage parity between CBDC and bank deposits. If bank deposits cannot be used to pay taxes, their utility as means of payment is decreased. The general ratio of CBDC to bank deposits in the money supply would also have to be maintained at a relatively high level as money users would constantly demand CBDC to pay taxes. Bank deposits would now not only carry a credit risk as liabilities of commercial enterprises but also the additional risk, that if parity is broken, citizens holding bank deposits would have to pay a premium in order to pay their taxes. We might even ask the question, if bank deposits could be maintained as a concrete unit of account, that is as money, if they are not supported by the Treasury. If the Treasury does not support settlement parity between bank deposits and CBDC, how may the rest of the economy be expected to do so.

There is a further twist to the role of the Treasury in the constitution of a currency. Not only does the Treasury manage the inflow and outflow of money through the public budget. It is also the issuer and primary seller of gilts and other government bonds. In KN's proposal, the function of gilts is not only to finance government deficit spending. Gilts are also the exclusive kinds of assets, which the central bank may purchase as

it supplies CBDC into the economy. In addition to deciding, which kinds of money are accepted in payments of taxes, the implementation CBDC would also force the Treasury to consider, in which kind of money government debt should be managed. Due to the technical nature of this issue, it is beyond the scope of this paper to provide anything but the questions, which would have to be considered with regards to gilt issuance.

When the Treasury initially sells gilts, it has to decide, whether buyers should pay in CBDC, bank deposits, reserves or any of the three. At the same time it also has to decide, how these gilts are denominated. A gilt is a promise to pay certain amounts of money at certain points in time. With the implementation of CBDC, it would have to be specified, which kind of money the gilt owner is entitled to receive: CBDC, bank deposits or reserves. Since the selling of gilts is often used to finance repayment of older gilts, which have reached maturity, the inflow of money from the sell and the commitment to pay would have to be somehow matched.

As the issuance of CBDC in exchange for gilts under KN's proposal would cause a lot of gilts to sit on the balance sheet of the central bank, the denomination of gilts also has consequences for the kind of assets, which may ultimately end up in the central bank. If gilts are redeemed in bank deposits, the central bank would end up holding the bank IOUs, which KN aims to prevent. If gilts are redeemed in reserves, CBDC and reserves are no longer as distinct and separate, as KN is aiming to make them. If gilts are redeemed in CBDC, the Treasury would largely also have to sell them for CBDC, which brings us back to the parity issues mentioned under option (3) above.

In conclusion to this section, we see how the implementation of CBDC forces the Treasury into a very difficult situation. A key idea in KN's proposal is to relieve both commercial banks and the central bank from the direct commitment to exchange rate parity through conversion of bank deposits into CBDC. Invariably, this merely passes the buck onto the Treasury, which is faced with questions of how to deal with settlement parity. If the Treasury adopts the first option and accepts both bank deposits and CBDC in payment of taxes and other forms of debt to the government, it assumes responsibility for settlement parity and thus absorbs some of the risk from the monetary system. If it adopts the second option and accepts only bank deposits, it transmits this risk onto money users. And if it adopts the third option it pushes the risk and also the responsibility for parity maintenance back onto the banks and the central bank.

4. The Debt of the Banks: Who wants reserves?

So far we have only considered parity in the relation between CBDC and bank deposits. In this section, we shall be turning to the relation between CBDC and central

bank reserves. Since the primary function of reserves is in the settlement of debts among banks, this issue is also related to settlement parity.

KN address the relation between CBDC and central bank reserves in their second design principle. According to this principle 'reserves and CBDC are distinct, and not convertible into each other on demand.' We have already discussed, how one of the objectives of this principle is to prevent bank runs 'by the back door' through reserve-backed narrow banks. KN also state a second objective of keeping CBDC and reserves distinct, which is to allow the central bank to maintain the rate on reserves as separate monetary policy tool. While KN's principle may indeed make sense on the grounds of this first objective, we shall question, whether it is going to achieve the second objective stated by KN. Here is how KN present this second objective of principle (ii):

> [T]his principle enables reserves and CBDC to have a separate core purpose, in particular CBDC does not have to function as the interbank settlement asset or be bound by the same rules as RTGS. This allows the central bank to operate a second policy instrument, specifically the quantity of or the interest rate on CBDC. This could be used as a tool for monetary policy or for financial stability, while enabling the central bank to retain control over the quantity of reserves in the financial system, which has traditionally been a key mechanism through which central banks control the rate on reserves. Retaining control over reserves allows the central bank to continue to influence the risk-free interest rate in the economy, the key rate for real investment decisions and intertemporal allocation decisions. (2018, 9)

There is a flaw in the reasoning of KN here. On the one hand, they argue that CBDC and reserves are two distinct forms of money. On the other hand, they fail to see how this distinction will present a risk to parity between the two forms of money. The flaw is derived from a failure to regard the differences between CBDC and reserves not only in terms of their function as means of exchange and stores of value but also in terms of their function as units of account. The difference between CBDC and reserves in terms of their function as units of account means that in the event of a crisis, it is not only the parity between CBDC and bank deposits that comes under pressure. There will also be a pressure on the parity between CBDC and reserves. And in the event that parity breaks down, reserves will end up following the price of bank deposits rather than the price of CBDC. We shall expand on the reasoning behind such a scenario by reviewing CBDC and reserves in terms of the three functions of money (see Bjerg 2017):

As *means of exchange* there is an obvious difference between CBDC and reserves. While reserves are only accessible to banks and certain other agents with an account at

the central bank, CBDC are universally accessible to all money users. The superior functionality of CBDC makes it more valuable as a means of exchange. KN invokes the concept of 'convenience yield' to account for this difference.

As *stores of value* CBDC and reserves are in the first instance similar. Both are issued by the central bank and by definition they carry no credit risk. The proposal of KN, however, allows the central bank to pay different interest rates on CBDC and reserves. If the interest rate on reserves is higher than on CBDC, the former is a superior store of value. The convenience yield and the interest rate spread between CBDC and reserves establish a balance between the two. CBDC has more value as means of exchange and reserves has more value as a store of value.

Now we turn to the third function of money, which is not considered by KN. As *units of account* there is a crucial difference between CBDC and reserves. CBDC can be used to settle all kinds of debt in the economy at the nominal value. £100 of CBDC settles any form of debt of £100. Reserves, however, can only be used to settle debts between banks or debts to the central bank. This is what happens in interbank clearing systems such as the RTGS (Depending on the design of the role of the Treasury, as discussed in the previous section, banks might also be able to settle their debts with the government using reserves. For simplicity, we disregard this option in the current discussion). The value of reserves as concrete units of account is that they function as settlement for debts incurred by the processing of payments in bank deposits. £100 of reserves allow the bank to settle a payment of £100 of bank deposits on behalf of one of the bank's customers.

Under normal circumstances, when the monetary system is in a stable condition and there is no more pressure on parity than what the central bank can manage through interest rate adjustments and gilt purchases, the above mentioned balance established by the convenience yield and the interest spread will maintain settlement parity and cause CBDC and reserves to count equally as units of account.

But now imagine a situation of crisis, when there is pressure on the exchange rate parity in the market. We assume that it takes £110 of bank deposits to buy £100 of CBDC. Which units would count as concrete units of account in this situation and what would be the price of reserves in this situation?

Imagine a Bank A, which has a balance sheet consisting of CBDC and reserves on its asset side and bank deposits on its liability side. A customer in Bank A, Alan, now wants to buy a car. He has a deposit of £11.000 in Bank A. The seller of the car is Benny, who is a customer in Bank B. Since exchange rate parity is broken, Benny quotes two prices for his car. If Alan pays in CBDC the price is £10.000 and if Alan pays in bank deposits the price is £11.000. Since Alan has no CBDC, he pays in bank

deposits and asks his bank to make the transfer to Benny. In order to settle the transaction, Bank A has to transfer £11.000 of reserves to Bank B.

Bank A may also offer another solution to Alan. Instead of making the payment through Bank B, Bank A offers to make the payment in CBDC directly to Benny. Alan would still be charged £11.000 of bank deposits but Bank A would only have to transfer £10.000 of CBDC to Benny. In this scenario, we would soon see a very clear manifestation of the break down of parity as banks would offer each other the opportunity to settle payments in CBDC rather reserves at a discount. It would, in other words, take only £10.000 of CBDC to settle a debt of £11.000 reserves. Settlement parity between CBDC and reserves has broken down. While £100 of CBDC would still be £100, £100 of reserves are no longer £100.

Just like the difference in credit risk between CBDC and bank deposits would be factored into the market price of the two forms of money even before any crisis emerged, so would the difference in settlement parity risk be factored into the relative pricing of CBDC and reserves. The problem here is not the same as in the relation between CBDC and bank deposits, where the central bank has to prevent mass conversion of the latter into the former. If banks were to switch into using CBDC instead of reserves in their mutual settlements, this would not necessarily be a threat to financial stability. In fact this is the model proposed in several other papers, where CBDC simply constitutes universal access to reserves (Bordo and Levin 2017; Meaning et al. 2018; Niepelt 2018).

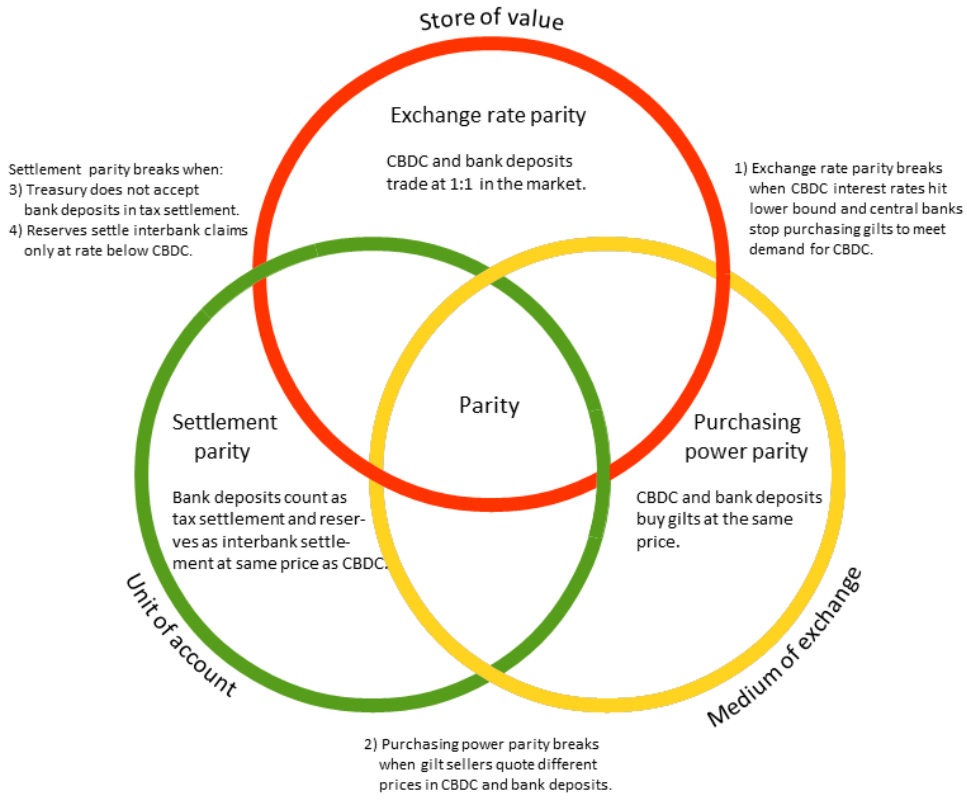
The argument here is rather that the principle of keeping reserves and CBDC distinct is not going to achieve the objective of allowing the central bank to maintain the reserve rate as a separate monetary policy tool to 'influence the risk-free interest rate in the economy'. Reserves may be free of credit risk. But as we have seen, this does not make them free of the risk of a break of parity. The interest rate on reserves would no longer be a proxy for the risk-free interest rate in the economy. Since CBDC is the only digital unit of account, which would remain a concrete unit of account in the event of a crisis, the interest rate on CBDC and not the reserve rate would be the risk-free interest rate in the economy and thus also 'the key rate for real investment decisions and intertemporal allocation decisions'. The policy rate on reserves may indeed be adjusted separately from the rate on CBDC but it would have little macroeconomic significance and thus be a blunt monetary policy tool.

Conclusion

The purpose of the four design principles proposed by Kumhof and Noone is to enable an introduction of CBDC, which does not curtail the two key functions of the banking section: provision of credit to borrowers and provision of liquidity to depositors. This means that the introduction of CBDC would not upset the functioning of the existing monetary system, where bank deposits constitute the primary form of money. CBDC and bank deposits would be able to circulate in parallel and at parity.

The conclusion to the analysis is that the design principles provide a weaker defense of parity that what is suggested by KN. The analysis has identified four different potential breaking points in the chain of parity. These breaking points are added to the figure presented previously. Figure 2 thus serves to summarize the argument of the paper. The numbers in the figure roughly refer to the breaking points explored in each of the analytical sections. As we have seen, the different dimensions of parity are intimately connected, which means that there are several overlaps in the analyses.

Figure 2: Breaking Points in the Chain of Parity



Even though KN's proposal relieves the commercial banks as well as the central bank from the commitment to provide direct convertibility between bank deposits and CBDC, the central bank still remains ultimately responsible for the maintenance of parity between the two kinds of money. The argument of the paper is that neither the adjustable interest rate on CBDC nor the possibility for the central bank to increase the supply of CBDC in exchange for gilts are sufficient tools to guarantee parity in the event of a crisis. As a first line of defense, the lowering of interest rates on CBDC eventually comes up against a lower bound. As a second line of defense, the selling of CBDC in exchange for gilts only works as long as traders are willing to quote the same price for gilts regardless of whether payment is made in bank deposits or CBDC. Since the reason, why the central bank is selling CBDC in the first place, is that CBDC does not trade at par with bank deposits, gilt traders would hardly be willing to accept bank deposits in exchange for gilts without a premium. Rather than reestablishing parity, the central bank's selling of CBDC for gilts would merely function to transmit pressure on exchange rate parity onto purchasing power parity.

A foreseeable side effect of the central bank's defense of parity through the selling of CBDC for gilts is an upward pressure on gilt prices. The analysis has demonstrated how this opens up the possibility of speculative trading exploiting arbitrage opportunities that increase rather than settle pressure on parity. When banks or affiliated speculative agents buy gilts using newly created bank deposits, they put pressure on parity, as gilt sellers re-balance their portfolio of money by selling bank deposits for CBDC. This may eventually compel the central bank to defend parity by selling CBDC for gilts. If speculators keep buying gilts for bank deposits, they can drive drive up gilt prices even more. When the speculators wish to lock in their profits, they can either begin selling gilts for CBDC, thus retaining an excess of bank deposits in the economy forcing the central bank to keep buying gilts, or, in case parity breaks, they can sell gilts at a premium for bank deposits. Contrary to KN's assumption, that speculative trading will drive price differences between CBDC and bank deposits to zero, this paper argues that the central bank commitment to parity may be exploited by speculators to create and profit from arbitrage opportunities that drive prices away from parity.

The implementation of CBDC in parallel circulation with bank deposits raises crucial questions of how to manage the in- and outflow of money through the public budget. The analysis has shown how these questions force the Treasury into a dilemma. If it accepts any kind of money in settlement of taxes and other payments from citizens, it may find itself in the position of being forced to absorb bank deposits from money users in a situation of crisis. While KN's design principles do protect commercial banks and the central bank from bank runs, we might instead see a kind of 'run on the Trea-

sury'. If, on the other hand, the Treasury refuses to accept anything but CBDC in settlement of taxes and other payments from citizens, it would counteract the effort of the central bank to maintain parity, as the utility of bank deposits would be significantly decreased. In addition to this dilemma, the Treasury would also be faced with complicated questions about whether to sell and settle gilts in CBDC or bank deposits.

In the final section of our analysis, we have questioned the assumption that by keeping CBDC separate from reserves, the central bank may retain the reserve rate as a distinct monetary policy tool. The only utility of reserves is the settlement of interbank debts created by the transfer of bank deposits. This means that in the event of a crisis, where parity between CBDC and bank deposits is broken, the price of reserves would follow bank deposits rather than CBDC. CBDC rather than reserves is thus the true risk-free form of money and the interest rate on CBDC rather than the interest rate on reserves will be the risk-free interest in the economy, which will serve as the key rate for investment and asset allocation decisions. While the reserve rate may indeed be adjusted independently from the rate on CBDC, the former would have little macroeconomic significance.

Policy Implications

In the introduction, we touched upon the way that the debate about CBDC involves both the question of *whether* to implement and also *how* to implement CBDC. KN's paper is primarily concerned with the latter question. Even though the analysis has shown that KN's design principles may not be as effective in guaranteeing parity between bank deposits and CBDC as suggested by the two authors, this does not imply that the implementation of CBDC is necessarily a bad idea. The reason, why the problem of parity emerges in the first place, is because a CBDC is a more stable form of money than bank deposits as it does not carry any credit risk. If implemented correctly, CBDC may thus add stability to the financial system as well as to the general economy. It may also provide the central bank with a more effective monetary policy tool than what is currently at its disposal.

The analysis also does not imply that the four design principles proposed by KN are necessarily bad ideas. The most novel contribution of KN's proposal to the debate about CBDC is probably the principle (iii) of relieving commercial banks as well as the central bank from the obligation to guarantee direct convertibility between bank deposits and CBDC. This is referred to as a market based solution to the problem of parity as it the price of CBDC relative to bank deposits is to be settled by private agents buying and selling. The central bank only intervenes indirectly in the markets by adjusting the CBDC interest rate and by buying gilts for CBDC.

What we have seen in the analysis, however, is that the other three principles do not suffice to make this market based solution work properly. I thus propose to supplement KN's proposal with an additional two principles: (v) The central bank is not only relieved of the obligation of direct convertibility but even the very responsibility for parity between CBDC and bank deposits. The central bank shall thus refrain from monetary policy interventions in the market to support parity as well as from the issuance of explicit or implicit guarantees of deposit insurance. (vi) The Treasury does not accept bank deposits in taxes and other payments to the government. The purpose of these two principles is to pave the way for a truly market based solution to the problem of parity.

As the central bank and the government relinquish responsibility for the price of bank deposits, the exchange rate to CBDC will be determined in the market without any form of state intervention. Rather than bank money being treated at par with central bank money, commercial banks would now be treated at par with other forms of private enterprises, which receive no state support for the maintenance of the value of their liabilities. In turn, the price of bank deposits would be determined by the evaluation of the solidity of the issuing bank by markets and money users. This is no different than the way that stocks, corporate bonds and many other securities are currently priced. The benchmark against which bank deposits and other securities would be priced would be CBDC, which would *de jure* as well as *de facto* be the only concrete unit of account (besides cash) of the national currency.

The starting point of KN's proposal was to design and implement CBDC in a way, which would not curtail the two key functions of the existing banking system: 'provision of credit to borrowers and the provision of liquidity to depositors.' The conclusion to this paper is that KN's four principles are only a halfway solution, which may eventually prove to be fragile in the event of a crisis. A question for further research is whether the addition of the above two principles would indeed create a more robust system without curtailing the provision of credit and liquidity. If the central bank and the Treasury relinquish responsibility for the maintenance of parity, it would be bestowed on the banking sector itself to either attract enough deposits of CBDC to meet the demand for CBDC credit from borrowers or to make sure that bank deposits would remain generally accepted as liquid payments despite the lack of state support. I hope to address this problem in a subsequent paper.

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