

Digital Currency (DC)

Design principles supportive of a shift from bankmoney to DC

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Meaning of DC

Digital currency – DC for short – is a now widely discussed concept of a new form of central bank money. It is meant to circulate side-by-side with bankmoney (i.e. bank deposit money = sight or demand deposits), in parallel and competition with bankmoney, similar to the still familiar co-existence of cash with bankmoney.

First design studies on DC were put forward by the Bank of England, the Swedish Riksbank and the BIS, but also from academic researchers and earlier on from monetary reform initiatives.¹ Ever since, the number of central banks who have expressed their interest in such an approach has been steadily growing.²

Initially, DC was imagined to come in the form of cryptocurrency based on DL or blockchain technology. The new technology, however, is still in its infancy.³ By comparison, tried and tested ways of how to manage money-on-account and payments from and to accounts are fully suited for implementing DC. For the foreseeable future, DC is very likely to come in the form of money-on-account – which does not exclude the future application of cryptographic technology to managing DC.

Firms and people would chose to maintain a bankmoney account (a bank giro account), or a currency account, or both in parallel, depending on preferences and conditions.

Motives behind and advantages of DC

The reason for wanting to introduce DC given in Sweden is providing a modern successor token to traditional cash. Cash has fallen there almost into disuse. An

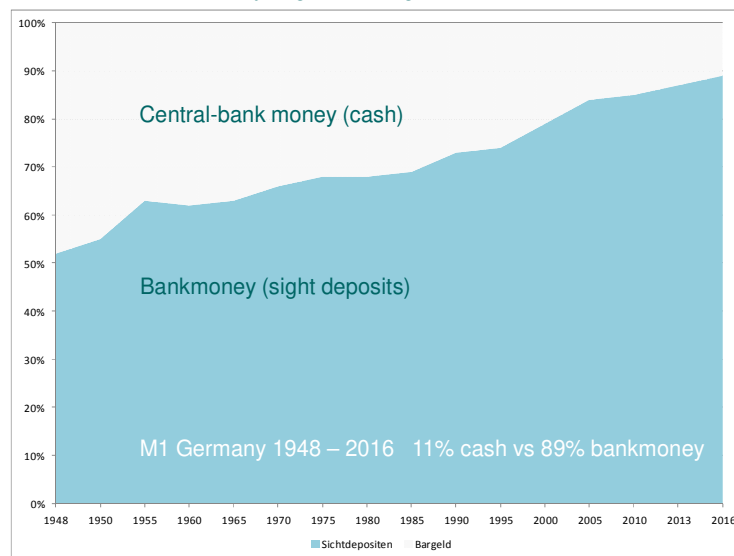
¹ Barrdear/Kumhof 2016 3–18, Kumhof/Noone 2018 4–22, 35–37, Sveriges Riksbank 2017, Dyson/ Meaning 2018, BIS 2015, 2018, Bech/Garratt (BIS) 2017, Niepelt (SNB) 2015. Other academic and institutional supporters of digital currency include Bordo/Levin 2017, Bordo 2018, Eichengreen 2017, Roubini 2018. Pioneering inputs on the part of the IMMR were made by Dyson/Hodgson 2016, Wortmann 2016, Yamaguchi/Yamaguchi 2016, Huber 2017 188–190, 2018 [first ed. 2014].

² Contributions of late also include Central Bank of Iceland 2018 and IMF 2018.

³ Among related problems is the high volatility of cryptocurrencies, due to their being used as speculative casino tokens rather than a means of payment. Transferring crypto coins is not fast enough for now, is much too energy-intensive and is thus comparatively expensive. Crypto trading platforms are vulnerable to hacker attacks. There is no guarantee of safeguarding, and legal questions of liability and identifiability are not entirely settled.

unspoken worry related to this is that a central bank with no more central bank money in public circulation might look somewhat redundant, sort of King Lackland.

Rise of the bankmoney regime, marginalisation of central-bank money



Daten: Deutsche Bundesbank, Monatsberichte, Tabellen zur bankstatistischen Gesamtrechnung, 1954-2017.

The fact is that down to the present day bankmoney has marginalized central bank money in all advanced countries, presently to a proportion of about 80–95% bankmoney to 20–5% cash; not to speak of MMF shares, largely based on bankmoney, that represent an amount of 2.4 times M1 in the US and 1/3 in Europe, still. That proportion indicates the dwindling influence of central bank money and monetary policy on the creation of bankmoney. If, however, that shift could be reverted, so that there would again be more central bank money in proportion to bankmoney, then the transmission lever of interest-rate policy could correspondingly be expected to be more effective again.

In this sense another working paper by the Bank of England, written by Dyson and Meaning, emphasizes the potential of DC for making conventional instruments of monetary policy more effective again.⁴ That would restore a good deal more central-bank control over money creation and the existing stock of money. Improved effectiveness of conventional monetary policies is reason enough to introduce DC.

Another advantage is absolute safety of DC in contrast to bankmoney that is inherently unsafe and must be backed by a number of auxiliary constructions which themselves are of dubious reliability (such as e.g. equity ratios, deposit insurance, government bail for bankmoney). In making DC payments directly from the payer's to the payee's account, the counterparty risk (aka default risk) in this regard is eliminated. DC would thus be trusted and accepted.

⁴ Dyson/Meaning 2018.

The safer money is, and the more stable the monetary system is, the more this will contribute to financial and economic stability.

In a crisis, and as far as DC is concerned, there is no need to save banks in order to save the nation's money and maintain payment transactions. Even as far as bankmoney is still concerned, backing it by state guarantees would be much less urgent.

As for the comfort and costs, the handling of DC is likely to cost much the same as the handling of bankmoney and reserves today. The relatively high costs of handling cash cease to exist.

Regarding the banks' costs of financing DC, the situation is comparable to the banks' financing of cash. For long times banks had no problems to get along with a cash-to-bankmoney ratio of 30, 50, 70 per cent. Why would they have problems dealing with comparable ratios of DC? Should there be somewhat reduced profit margins from bank lending and security purchases, this simply reflects a corresponding reduction in today's bankmoney privilege.

Another advantage, particularly for the public purse, is increased seigniorage in proportion to the stock of DC. No matter how DC enters circulation, banks will have to finance that money in full, like cash. Even under conditions of still predominant bankmoney this will result in an increased amount of seigniorage.

Problems with DC and bankmoney coexisting side-by-side

Some authors – supporters as well as sceptics – have given advice about certain problems that could arise with the introduction of DC. I will mention here just three of these problems.

Impaired ability of banks to lend and invest?

A concern expressed, also by central bankers, is that with a growing share of DC 'deposit-funded bank credit might be undermined'⁵ and that 'with too widespread a CBDC, it might threaten the banks' lending activity, if banks cannot use deposits for that purpose'.⁶ Such statements are misleading from the outset. Under fractional reserve banking, deposits are not loanable funds and banks are not financial intermediaries, but creators, de- and re-activators as well as extinguishers of bankmoney.

The proposals published so far do not intend to strip banks of the privilege to create themselves the money on which they operate in their business with nonbanks. The bankmoney privilege is supposed to exist further on. Accordingly, the banks' almost unlimited ability to create bankmoney at their discretion will fully be maintained, thus *not* impaired. The problem that actually exists here is the continued bankmoney privilege.

⁵ Niepelt 2015.

⁶ Broadbent 2016 5.

A new problem, however, that could arise is a temporary shortage of central bank-eligible securities, if, due to customer demand, too much bankmoney has to be converted into DC in too short a time. This is about the same problem as a bankrun, that is, the problem of basically insufficient bank liquidity in any bankmoney regime based on fractional reserves.

Fractional reserve banking and bankruns

So, not surprisingly, the biggest fear of DC designers is mass migration from bankmoney accounts to currency accounts, thus a veritable bankrun. This remains a problem indeed – not, however, a problem of DC (i.e. central bank money = sovereign money), but the fundamental problem of bankmoney, inherent in fractional reserve banking. It is irritating when the bankrun problem is attributed to the introduction of DC while in actual fact it is a persistent threat inherent in bankmoney.

Continued bankmoney creation as such will remain a major source of instability. DC in important volumes can mitigate the dynamics of monetary overshoot and proneness to crisis inherent in the bankmoney regime, but DC cannot stop those dynamics, the less so because – in the current proposals – it is not the central bank, but the banks who in the first instance decide on whether and how much money is created.

The bankrun problem is normally much played down, whereas in the context of discussing DC it is unduly exaggerated. Bankruns do not occur in a situation of business-as-usual. They occur when banks get into trouble. Sovereign money and bankmoney have coexisted for over 300 years; at first in the form of precious metal coins coexisting with private banknotes, subsequently in the form of central bank cash (notes and coins) coexisting with bankmoney-on-account (deposit money). What would be different if that problem-ridden coexistence continues with bankmoney side-by-side with DC? Not too much in the first place.

Crises of various kinds will recur. The demand for cash and safe DC then will go up accordingly, and the banking sector – in the short run and in a regular way – will not be able to procure enough eligible securities for taking up enough money so as to fulfil its largely 'empty' promise to convert bankmoney into cash or DC. Such a situation would indeed be destabilising. Central banks would have little choice but to resort to QE again. However, with currency accounts being available they could do it in a more effective and sensible way than was the case with *QE for finance* during the 2010s.

The parity question and state guarantees of bankmoney

Another question relates to the 1:1 parity of bankmoney with central bank money. In a side-by-side constellation of DC and bankmoney, would the present 1:1 parity between the two endure? Or might a new type of Gresham situation arise, with bankmoney in the role of the less valued means of payment while DC, that is, high-powered central bank money, would be valued higher? Such an expectation is not as obvious as it

would appear. In Chile, for example, many goods are sold at a higher price when paid in cash, and cheaper when paid in bankmoney via credit cards or bank transfer.

The question of parity is a quite intriguing question, examined of late particularly by Ole Bjerg.⁷ The 1:1 parity depends on the following conditions:

- that bankmoney, in fact a private means of payment, is allowed to be denominated in the domestic currency (the national unit of account)
- that the central bank accounts for both monies at a rate of 1:1, thereby in actual fact administering the 1:1 parity
- that all state bodies accept and use bankmoney
- that the state gives extensive guarantees for bankmoney, for example,
 - by the central-bank almost unconditionally acting as the banks lender of last resort, within the frame of QE even as the banks' securities dealer of last resort (providing for the banks 'whatever it takes' according to a now proverbial statement by ECB President Draghi), and also
 - by the government standing bail for banks or
 - recapitalising banks if need be, and
 - by warranting bankmoney, each account up to 100–200 thousand euros.⁸

The answer to the parity question largely depends on whether or to what degree central banks and governments are going to maintain those auxiliary constructions for stabilising the inherently unstable bankmoney regime. Equally, this will also decide on the extent to which firms and people will want to use DC instead of or in addition to bankmoney.

At a crossroads

It is widely assumed that as soon as DC is available there would be strong migration from bankmoney to DC. However, DC is not the fast-selling position it is supposed to be and the advantages of DC will not materialise automatically.

For example,

- under conditions of business-as-usual when there is no sentiment of heightened uncertainty or overt crisis,
- if central banks and governments maintain far-reaching state guarantees for bankmoney, and
- if banks pay some decent deposit interest on bankmoney, but none or much less is paid on DC,

⁷ The problem of parity between different monies from different originators, especially parity between bankmoney and sovereign money, is discussed in much detail in Bjerg 2017 and 2018 6ff, 9ff, 18.

⁸ The pivotal role of state guarantees for bankmoney as a decisive system element is particularly emphasised in Wortmann 2016, 2017a+b. Equally emphasized is cancellation of those guarantees as a precondition for establishing a sovereign money system

one would not expect firms and people to feel urged to switch accounts. Under such conditions it remains unclear whether a significant shift from bankmoney to DC would take place at all.

As long as we continue to have a dominant bankmoney regime on a small base of cash and a tiny base of excess reserves, the advantages of DC will fail to materialise. Conversely, though, the more there is a critical and growing mass of DC, the more the positive impact on the stability of money, banking and finance would become apparent – opening up the perspective of a future sovereign money system.

Some would say, just let's wait for the next big crisis. Severe crises, however, lead to everything but rational and orderly change, and they are certainly not a welcome opportunity for change. Rather, the introduction of DC should be seen as a way to reduce the severity of coming crises, a way to restore greater effectiveness to monetary policy and expand the room for manoeuvre.

Design principles that make the difference

What then are the conditions and design principles that can be expected to be supportive of a gradual switchover from bankmoney to DC, so that over time central bank money would again be the dominant and system-defining means of payment?

No restrictions on access to and relative quantities of DC

The first principle is to secure countrywide access to currency accounts according to customer demand. This involves an expansion of the payment infrastructure so as to include currency accounts and making payments in DC.

Unrestricted access to currency accounts itself is part of the wider principle not to restrict access to DC, neither by actor group nor by the quantity of DC available. For example, in one model variant access to DC is reserved for financial institutions only. It might also be restricted to retail payments, or to wholesale transactions, respectively. In an earlier concept paper the quantity of DC was restricted to 30% of GDP.⁹

However, in most proposals put forward so far, DC is rightly intended to be a *universal* means of payment. Limiting the available amount of DC would clearly contradict that claim, and should the non-financial public be excluded from using DC, the whole project would in fact be pointless.

Merging DC and interbank reserves into one circuit

The next principle then is merging DC and interbank reserves into one circuit. So far, the English and Swedish proposals keep reserves and DC apart from one another. This is another arbitrary and implausible design feature. The terms 'reserves' and 'digital currency' do express different functions and owners, but all of this is about the same

⁹ Kumhof/Noone 2018 pp.18, Barrdear/Kumhof 2016 3, 50.

kind of central bank money-on-account. There is no difference regarding the form and quality of the central bank money involved.

The desirable design principle thus is to treat excess reserves like DC in general. This means

- to merge the banks' excess reserves and their DC, and
- moreover, to maintain free exchange between the banks' and non-banks' DC, thereby creating a single DC circuit, involving banks as much as nonbanks.

This does not mean blurring the difference between a pure DC transaction account and a bank's central-bank refinancing account, and does not impair monetary policy either.

Full convertibility between bankmoney and DC

A subsequent principle is full convertibility between bankmoney and DC. Bankmoney must be freely convertible into DC, as DC must be re-convertible into bankmoney. Technically, this poses no problem at all as can be seen with the example of payments between central-bank transaction accounts of state bodies and bank giro accounts of nonbanks.

Central bank guarantee of converting bankmoney into DC, particularly in a bankrun

Convertibility of bankmoney must be ensured, particularly in a bankrun situation. In actual fact, warranted convertibility of bankmoney is the definite response to the bankrun problem. This is to say that in a bankrun situation, central banks should stabilise banking and finance *not* by trying to stop the bankrun, *but*: by supporting the conversion of bankmoney into DC.

To this end, central banks should practice QE by granting special credit to banks, exactly for the conversion of bankmoney into DC. In a state of financial emergency this might involve a degree of unsecured book credit, involving a heightened risk for the central banks as far as banks would go bankrupt. However, the measure by itself would effectively prevent banks from going bust.

Gradually reducing and ultimately removing state warranties of bankmoney

Moreover, there is the question of retaining or withdrawing state warranty of bankmoney. As long as said guarantees are kept up, combined with basically unrestricted pro-active bankmoney creation, one cannot seriously expect the introduction of DC to eventually lead to a situation in which sovereign money would again be dominant and system-defining. Therefrom, another design principle is to reduce and finally remove the state guarantees of bankmoney. The bigger the share of DC has become, the more the state guarantees of bankmoney can be withdrawn.

Public bodies gradually increasing the use of currency accounts

Payment transactions of public bodies are carried out today for one part via transaction accounts with the central bank, the other part via bankmoney accounts. It

is among the absurdities of the present bankmoney regime that state bodies require to be paid in private bankmoney rather than in the sovereign currency of the state's central bank.

Public bodies should thus be obliged to transact via currency accounts. It has to be considered, however, that the state's acceptance of bankmoney is a key pillar in the state's warranty of bankmoney. Should that pillar be taken away too fast, with public expenditure at 35–55 per cent of GDP depending on the country, bankmoney would be undermined in a way similar to a run on bankmoney. Nevertheless, public bodies can begin to use currency accounts in addition to bank giro accounts, slowly but steadily increasing their use of DC.

Central-bank credit to banks not the only channel of issuance of DC

The Swedish and English concepts of DC continue the practice of issuing central bank money by way of credit to banks against collateral – the Swedish model by converting bankmoney into e-krona (which presupposes the central bank to sell or lend e-kronas to the banks), the English model by way of central bank purchases of sovereign bonds from financial institutions (which presupposes the financial institutions to have acquired the larger part those bonds with bankmoney rather than reserves). Either way, it is not the central bank, but the banks that in the first instance decide on whether and how much money is created, while the central bank accommodates the facts the banks have created beforehand.

DC, however, can and ought to be issued in a direct way too. That direct way would include measures like helicopter money. It might also include revising Art. 123 (1) and (2) TFEU (aka Lisbon Treaty). In its present form this Article is overtly inconsistent, in that the first clause of it prohibits direct monetary financing of government expenditure, while the second clause indirectly permits monetary financing of sovereign bonds.

Central bank deposit interest on DC equal to deposit interest on bankmoney

In the English concept variants, DC is interest-bearing. In the Swedish concept, by contrast, the e-krona does not yield interest. Why after all would DC be interest-bearing? Interest is paid on credit and debt positions, or say, on promissory items. DC, however, is *not* a promissory position. It *is* fully existing sovereign fiat money in its own right, high-powered base money that does not need coverage by another kind of money or collateral. (That's, by the way, why the Bundesbank in its time has always refused to pay deposit interest on bank reserves).

What then is the reason for DC be interest-bearing? One reason given is 'to clear the market'.¹⁰ Whether this refers to the market *demand* for DC or the central bank *supply* of DC is not explained. The idea of market equilibrium is hard to substantiate

¹⁰ Kumhof/Noone 2018 pp.8.

empirically anyway. Notwithstanding, it is quite obvious what deposit interest *on DC* actually can do: complementing the deposit interest *on bankmoney* that banks are likely to pay.

In a shift from bank giro accounts towards currency accounts, banks would certainly not fail to offer high-enough deposit interest (as was formerly paid on private banknotes) to prevent deposits from draining away. In the same way, central-bank deposit interest on DC can be set higher or lower than the banks' deposit interest on bankmoney. This would allow for exerting influence on customers' preferences for the one or the other.

So, even if paying interest on holdings of base money is not substantiated, the situation is this: If there would be deposit interest on bankmoney, but none on DC, this would importantly contribute to an undesirable effect of pro-cyclical fluctuation: into safe DC in times of heightened uncertainty, back to interest-bearing bankmoney in times of business-as-usual. In this regard, paying deposit interest on DC can be a neutralising measure if the interest rate paid on DC is equal to the interest rate on bankmoney. This will create a level playing field and counteract the undesirable pro-cyclical shifting back and forth.

Ruling out 'negative interest'

A special reason for introducing DC is to impose so-called negative interest.¹¹ The question of negative interest is not specifically related to DC, but is relevant to DC too. The term as such is misconceived, following the already problematic definition of 'real interest' defined as the actual interest rate minus the inflation rate. This in turn follows the difference between nominal and real growth of income. The problem here is that abstract arithmetic does not necessarily fit the real world.

For example, you can have more or less income, or no income at all, not however negative income. Less than nothing does not exist. Breaking through below the 'lower bound' is possible in the world of numbers, but not in the real world. What really can happen is incurring a loss of purchasing power and wealth, or incurring debt. Therefrom – it has rightly been said often enough – negative interest is an unnatural concept. It refers to something which in actual fact does not exist. You pay interest to someone who has lent money to you, but you do not agree to pay interest to someone who has borrowed from you. Similarly, it might be nice to go shopping and having the shopkeeper to pay you the price for the purchase. Apparently, some such thing is turning the real world upside down.

Negative interest is an inappropriately expanded and thereby distorted measure of conventional interest rate policy, in a desperate attempt to regain the latter's

¹¹ For example in Bordo/Levin 2017 3, Bordo 2018 3.

effectiveness that has got lost in the present bankmoney regime. What actually happens when 'negative interest' is imposed, is this:

Negative interest payments *on bankmoney* reduce the liabilities of banks to their customers and add to a bank's profit account. This is tantamount to an illegal private tax on deposit money to the benefit of the banks. At the same time, the stock of bankmoney is reduced.

In much the same way, and according to present accountancy rules, negative interest *on DC*, if it were to go to the central bank, would reduce the central bank's liabilities and reduce the publicly available stock of money. As far as this adds to the central bank's surplus, this then would indeed be a tax on holdings of DC, benefitting the public purse – without therefore becoming more sensible.

Deletion of liabilities on the banks' and the central bank's balance sheets, that is, deletion of money, would certainly contribute to reducing the existing overhang of money which is the inheritance of the bankmoney regime. But a reduction in this way would be wrongly targeted, hitting where there is the mass purchasing power: the income and savings of the broad middle classes.

What is more, negative interest misses its aim to stimulate expenditure (for fear of negative interest) that would result in demand-induced growth. It remains open to question under which conditions this kind of economic policy by monetary policy might be reasonable at all. Independently, most people react differently anyway. Negative interest, rather than spurring additional expenditure, triggers compensatory spending cuts. If money is confiscated from people they do not hurry to spend what is left, but they will try to make up for what has been taken away (except for conditions of runaway inflation). Negative interest is a technocratic folly born from unworldly model economics. If one wished to help spread populism, implementing nationwide negative interest at a possibly high rate would do the trick.

Imposing negative 'interest' is actually neither about interest nor fees, rather about overt expropriation of money, partly perhaps an unwise tax on money. As an instrument of monetary and economic policy, negative interest is counter-productive and unjust, perhaps even unlawful, and should thus generally be ruled out, also in connection with DC.

Concluding remark

When reading central bank statements on DC, one is left with an ambivalent impression, as if central bankers were running ahead of their convictions. The envisaged coexistence of bankmoney and DC certainly raises a number of questions. In some respects, watertight answers cannot be given yet. But it is not necessary to know all answers and details in advance. The modern world has been living now for 150–300

years with the conflicting situation constituted by the coexistence of sovereign money and bankmoney; at first in the form of private banknotes side-by-side with sovereign coin; subsequently in the form of bank deposit money side-by-side with central bank money (legal-tender banknotes and reserves). The equally conflicting situation constituted by the coexistence of bankmoney and DC will basically not be too different from that.

Introducing DC in parallel with bankmoney, in whatsoever variant, is at all events a step forward, coming to a degree with the advantages mentioned above. By comparison, the problems inherent to the present near-complete rule of bankmoney are still much bigger than problems relating to DC might be.

References

- Barrdear, John / Kumhof, Michael. 2016. The macroeconomics of central bank issued digital currencies, Bank of England, Staff Research Paper No. 605, July 2016.
- Bech, Morten / Garratt, Rodney. 2017. Central bank cryptocurrencies, Basel Bank for International Settlements, Quarterly Review, September 2017, 55–70.
- BIS. 2015. Digital currencies, prep. by the BIS Committee on Payments and Market Infrastructures, Basel: Bank for International Settlements. November 2015.
- BIS. 2018. Central bank digital currencies, prep. by the BIS Committee on Payments and Market Infrastructures, Basel: Bank for International Settlements, March 2018.
- Bjerg, Ole. 2017. Designing New Money – The Policy Trilemma of Central Bank Digital Currency, Copenhagen Business School Working Paper, June 2017.
- Bjerg, Ole. 2018. Breaking the gilt standard. The problem of parity in Kumhof and Noone's design principles for Central Bank Digital Currencies, Copenhagen Business School Working Paper, August 2018.
- Bordo, Michael D. / Levin, Andrew T. 2017. Central bank digital currency and the future of monetary policy, NBER Working Paper Series, no. 23711, Aug 2017.
- Bordo, Michael D. 2018. Central Bank Digital Currency. The Future Direction for Monetary Policy? Shadow Open Market Committee, E21 Manhattan Institute, March 9, 2018, <http://shadowfed.org/wp-content/uploads/2018/03/BordoSOMC-March2018.pdf>.
- Broadbent, Ben. 2016. Central Banks and Digital Currencies, Bank of England, 2 March 2016. www.bankofengland.co.uk/publications/Pages/speeches/2016/886.aspx.
- Central Bank of Iceland. 2018. Rafkróna? Central bank digital currency, Special Publication No.12, September 2018.
- Dyson, Ben / Hodgson, Graham. 2016. Accounting for sovereign money. Why state-issued money is not 'debt', London: Positive Money, January 2016.
- Dyson, Ben / Meaning, Jack. 2018. Would a Central Bank Digital Currency disrupt monetary policy? Bank Underground, 30 May 2018.
- Eichengreen, Barry. 2017. Central bank-issued digital currency is the future, not cryptocurrency, CNBC The Fintech Effect, 30 Oct 2017.
- Huber, Joseph. 2017. Sovereign Money - beyond reserve banking, London: Palgrave Macmillan.

- Huber, Joseph. 2018. Digital Currency. Retaining or overcoming the bankmoney regime? Design principles that make the difference, www.sovereignmoney.eu/digital-currency.
- IMF. 2018. Casting Light on Central Bank Digital Currency, IMF Staff Discussion Note, written by T. Mancini-Griffoli et al., Washington D.C.: International Monetary Fund.
- Kumhof, Michael / Noone, Clare. 2018. Central bank digital currencies – design principles and balance sheet implications, Staff Working Paper No. 725, May 2018, London: Bank of England.
- Meaning, Jack / Dyson, Ben / Barker, James / Clayton, Emily. 2018. Broadening narrow money: monetary policy with a central bank digital currency, Bank of England Staff Working Paper No. 724, May 2018.
- Niepelt, Dirk. 2015. Reserves for everyone – towards a new monetary regime?, VOX Policy Portal, 21 Jan 2015, <http://voxeu.org/article/keep-cash-let-public-hold-centralbank-reserves>.
- Roubini, Nouriel. 2018. Why central bank digital currencies will destroy Bitcoin, The Guardian, 19 Nov 2018, <https://www.theguardian.com/business/2018/nov/19/why-central-bank-digital-currencies-will-destroy-bitcoin>.
- Sveriges Riksbank. 2017. The Riksbank's E-Krona Project, Report 1, Stockholm, September 2017.
- Wortmann, Edgar. 2016. A proposal for radical monetary reform, Amsterdam: Ons Geld.
- Wortmann, Edgar. 2017a. Deleveraging without a crunch, Ons Geld Working Paper, Utrecht, https://onsgeld.nu/onsgeld/2017/deleverage_without_crunch.pdf.
- Wortmann, Edgar. 2017b. The virtual euro, Ons Geld Working Paper, Utrecht, https://onsgeld.nu/onsgeld/2017/the_virtual_euro.pdf.
- Yamaguchi, Kaoru/Yamaguchi, Yokei. 2016. *Peer-to-Peer Public Money System*, Japan Futures Research Center, Working Paper No. 02-2016, Nov 2016.