Central Bank Digital Currencies in a World with Negative Nominal Interest Rates

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1 Introduction

Both academics and central banks have recently started to analyze merits and dangers of introducing central bank digital currencies (CBDC), i.e., some form of central bank money handled through electronic means and accessible to the broad public. CBDC could be considered a third form of base money, next to (i) overnight deposits with the central bank, currently available only to banks, specific non-bank financial firms, and some official sector depositors; (ii) banknotes, being universally accessible but arguably of limited efficiency and relying on old[1] technology. This chapter discusses issues relating to the remuneration of generally accessible CBDC, in particular in a negative interest rate environment such as prevailing in the euro area and Japan. A number of quite diverse benefits of CBDC have been put forward in the literature (see e.g., Bindseil, 2020 for an overview). This chapter focuses on one specific dimension of CBDC, namely its remuneration. Some authors have noted that CBDC could be designed to have cash-like properties, including a zero remuneration. However, a zero remuneration of CBDC means very different things depending on the interest rate environment, i.e. depending on whether short-term nominal interest rates are at 10%, 3%, 0%, or −0.5%. Central bankers and holders of central bank money got used to the fact that banknotes represent a risk-free short-term financial asset offering a zero nominal yield regardless of the structural and cyclical level of nominal interest rate in an economy. While some consider this feature of banknotes an anomaly which could precisely be solved with CBDC (and the discontinuation of banknotes), others have argued the opposite, namely that it is important to preserve this feature of banknotes

[1] Of course, modern banknotes are at the same time based on modern technology in terms of material and security features.

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in the design of CBDC such as to provide an as much as possible banknote-like electronic means of payments.

In this chapter, it is argued that for currency areas with presently negative risk-free nominal interest rates, or with this possibility being somewhat likely for the future, the ability to remunerate CBDC, and also to remunerate it negatively, will be necessary. More specifically, it is proposed to solve the tension between the desire to offer CBDC to citizens (at a reasonable quantity needed for its use as a means of payment) at interest rates never worse than the ones on banknotes (i.e., never below zero), with the need to preserve financial stability and the effectiveness of monetary policy, by having a two-tier remuneration approach to CBDC. This approach allows offering CBDC in an elastic and unconstrained way to other potential holders, such as corporates or foreigners. It would thereby also overcome the perceived dichotomy between "retail" and "wholesale" CBDC.

Section 2 will review the potential risk of a structural and cyclical (i.e., crisis-related) bank disintermediation. Section 3 will look at the problem of preserving, with CBDC, a very accommodating stance of monetary policy, i.e., one with even negative remuneration. Section 4 proposes tiered remuneration of CBDC as solution to both problems, while keeping CBDC attractive for citizens in comparison to banknotes, and being able to offer it without constraints to other holders. Section 5 concludes the chapter.

2 The Risk of Structural and Cyclical Bank Disintermediation Through CBDC

CBDC has both found support, and caused strong concerns, with regard to its impact on the structure and scale of bank intermediation. Advocates of "sovereign money" see bank disintermediation as precisely the goal of CBDC. Others have strongly rejected the idea of CBDC inflating the central bank balance sheet at the expense of deposit funding of banks. For example, Alex J. Pollock, in testimony to the Subcommittee on Monetary Policy and Trade of the Committee on Financial Services United States House of Representatives,[2] argues that CBDC would lead to various distortions precisely because of bank disintermediation: on one side the central bank would benefit from an unfair competitive advantage in deposit collection and amass undue power and market share (also likely misusing its regulatory powers to further strengthen its unfair advantages), on the other hand it would have competitive disadvantages in credit provision, which it would however ignore, leading to inefficiency, conflicts of interest and financial losses that eventually the taxpayer would have to bear. Carstens (2019) reiterates such worries (see also Mancini-Griffoli et al., 2018). Finally, the Committee on Payments and Market Infrastructures and Markets Committee (CPMI-MC) of the Bank for International Settlements (2018) emphasizes the cross-border issues that CBDC may create. Indeed, also for banknotes, foreign

[2] https://www.govinfo.gov/content/pkg/CHRG-115hhrg31510/pdf/CHRG-115hhrg31510.pdf.

demand has been a major factor in recent decades (e.g., Jobst & Stix, 2017). CBDC, if offered in the same perfectly elastic way as banknotes, could facilitate further the cross-border access to central bank money.

Below the creation of CBDC is captured in a financial account system, which very broadly replicates the euro area financial accounts as of Q2 2018 provided in the ECB Statistics Warehouse or the ECB Economic Bulletin (see Table 1). The accounts are simplified in particular with regard to netting and that the non-bank financial sectors (OFIs and ICPFs, i.e., "other financial institutions" and "insurance companies and

Table 1 Financial accounts representation of CBDC, compensating securities purchases by the central bank, and possible bank deleveraging (numbers in trillions of Euro broadly illustrating euro area accounts)

Households, Pension and Investment Funds, Insurance Companies					
Real assets	20		Household equity	44	
Sight deposits	5	**−CBDC2**			
Savings deposits	4		Bank loans	5	
CBDC		**+CBDC1+CBDC2**			
Banknotes	1	**−CBDC1**			
Bank bonds	4	**+S1**			
Bonds	7	**−S1**			
Equity	8				
Corporates					
Real assets	13		Bonds issued	3	
Sight deposits	2		Loans	8	
Savings deposits	1		Shares/equity	5	
Government					
Real assets	11		Bonds issued	9	
			Loans	2	
Commercial Banks					
Loans to corporates	8		Sight deposits	7	**−CBDC2**
Loans to govt	2		Savings deposits	5	
Loans to HH	5	**−S2**	Bonds issued	4	**+S1**
Bonds	5		Equity	3	
Deposits with CB	0		Central bank credit	1	**+CBDC2 −S1−S2**
Central Bank					
Credit to banks	1	**+CBDC2 −S1−S2**	Banknotes	1	**−CBDC1**
Bonds	0	**+S1+S2**	Bank deposits	0	
			CBDC		**+CBDC1+CBDC2**

Source by the author

pension funds") have been omitted or been broadly integrated into the household sector. Also, the ECB's asset purchase program is not reflected.

If households substitute banknotes with CBDC, then central bank and commercial bank balance sheets do not really change. However, if households substitute commercial bank deposits with CBDC, then this would imply a funding loss for commercial banks and could lead to "disintermediation" of the banking sector. In particular sight deposits with low remuneration could be expected to shift at least to some extent into riskless CBDC, leading to a loss of commercial banks' funding of equal size. Banks would have to try to offer better conditions on their deposits in order to protect their deposit base as much as possible—but this would imply higher funding costs for banks and a loss of commercial bank "seignorage". Below, the creation of CBDC has thus been split into two parts: **CBDC1** which substitute banknotes and **CBDC2** which substitute deposits with banks. It seems most likely that indeed CBDC would do both of those, but it is unclear with what weights. The effect of CBDC1 on the rest of the financial accounts is neutral, but the effects of CBDC2 are not: CBDC2 lengthens the central bank balance sheet as central bank credit will have to fill the funding gaps of the banks. The central bank may want to avoid this effect by purchasing government and corporate bonds, whereby the source of the bonds could be either households or banks, being captured in the financial accounts by **S1** and **S2**, respectively. In the former case, it has been assumed here that the households will not keep the money obtained in the form of bank deposits, but would purchase bank bonds that the banks would in addition issue (however, from a financial account perspective, it makes no difference if the purchases of bonds by the central bank from households imply additional deposits with banks or additional capital market investments of households into bank bonds).

While CBDC1 appears uncontroversial as it merely substitutes one form of central bank money into another without changing the rest of the financial system, CBDC2 increases the dependence of banks on central bank credit and decreases sight deposits with the banking system. Both S1 and S2 have positive effects in the sense that they reduce again the dependence of banks on central bank credit. CBDC2 will obviously have effects on funding costs of the banking system, as typically central bank credit and bond issuance are more expensive than the remuneration rate of sight deposits (except in unusual circumstances, as the ones prevailing, e.g., in the euro area since 2014, in which obtaining credit from the central bank was partially possible for banks at negative rates, while sight deposits of households with banks remained non-negative). Moreover, a larger recourse to central bank credit could lead to collateral scarcity issues and the question whether the central bank collateral framework becomes so crucial from a credit allocation perspective that one would observe an effective centralization of the credit provision process. Both effects will be analyzed further in the next two subsections.

2.1 Effects on Bank Funding Costs of CBDC2

Following Juks (2018), one needs to understand what impact CBDC will have on average funding costs of banks, and therefore on bank lending rates (see also, e.g., Engert & Fung, 2017). In addition, it should be understood how this may impact monetary policy interest rate setting of the central bank and the seignorage income of the central bank. Bank funding costs will obviously increase because a cheap funding source (sight deposits) decreases, and more expensive funding sources (central bank credit or bank bond issuance) have to take over. The central bank would have to compensate the implied tightening of financial conditions caused by a decrease of cheap sight deposit financing of banks by *lowering* the monetary policy rate. The extent of the required lowering of short-term interest rates would depend on the size of CBDC2, on the relative share of bank funding in the economy, and on the spread between the other bank funding rates and the monetary policy operations rate. Moreover, substitution effects from bank-based to capital market-based financing of the economy would impact on the overall needed adjustment of central bank rates. The fact that bank funding is only one part of overall funding of the economy implies that the central bank will not reduce the short-term interest rates in a way that bank funding costs are stabilized, but only partially so. Therefore, in the new equilibrium, banks will have lost competitiveness and will lose some market share relative to other forms of funding (through capital markets and non-bank intermediaries).

Tables 2 and 3 provide the average levels of the relevant shares and interest rates for the period 2003–2008, and 2009–2018, respectively.

The largest share in bank funding came from deposits with residual maturity of less than two years and redeemable at three- or less-month notice, i.e. the types of deposits contained in the monetary aggregate M3. This is also the cheapest funding source in the first period, while in the second period, central bank funding becomes even cheaper. Actually, overnight deposits contribute 50–65% of these deposits, and have a significantly lower interest rate. For example, in December 2005, new overnight deposits were remunerated on average at 0.71% with up to one-year term deposits at 2.15%.

Table 2 Euro area bank funding costs across different instruments, 2003–2008

	Share in bank funding (%)	Average interest rate (%)
Deposits (in M3)	44	1.83
Other deposits	13	3.25
Bonds issued	30	4.10
Equity issued	10	8.47
Central bank credit (MRO rate)	3	2.79

Source author's calculation. Bond yields data (Merrill Lynch); all other data ECB

Table 3 Euro area bank funding costs across different instruments, 2009–2018

	Share in bank funding (%)	Average interest rate (%)
Deposits (in M3)	47	0.78
Other deposits	14	2.39
Bonds issued	23	2.15
Equity issued	12	10.54
Central bank credit (MRO rate)	4	0.50

Source author's calculation. Bond yields data (Merrill Lynch); all other data ECB

For example, assume that the 2003–2008 data apply, and that 10 percentage points of M3-deposits of banks are substituted with CBDC2, and that CBDC is not remunerated. If everything else remains unchanged, then the funding costs of banks increase by 0.1 × (2.79%–1.83%), i.e., around 10 basis points. If the central bank wants to keep financial conditions unchanged, it needs now to lower the general interest rate level. If bank funding is 50% of total funding of the economy, the rest being capital market based, then the central bank will have to lower the interest rate level by 5 basis points if it wants to achieve that the average funding costs of the real economy stay unchanged (and if one ignores secondary effects). Average funding costs of banks will have increased by 5 basis points, and costs of capital market financing will have decreased by the same amount, implying some loss of competitiveness of banking.

2.2 Increase of Banks' Reliance on Central Bank Credit, Collateral Constraints, and Credit Centralization?

To what extent could CBDC undermine the decentralized, market-based financing of the real economy by increasing massively the central bank balance sheet, and thereby making it, either via increased central bank securities holdings, or via an increased funding of banks through central bank credit, an important (but potentially inefficient) element of the credit allocation process? State liabilities can be stores of value for households, in particular if they are matched, in the state balance sheet, by *real* assets that the state owns. However, probably the state would not want to become a *financial* intermediary for household savings, which would happen if the state re-invested proceeds from issuing debt to households in the form of financial assets, or in the form of real assets not linked to state tasks, just for the sake of re-investment. This logic may also be applied to central banks in a somewhat different way as central banking starts from the liability side: to the extent they issue means of payment, they need to re-invest the proceeds from doing so. However, the central bank probably does not want central bank money to become a large-scale store of value, i.e., investment vehicle, as this would mean that the central bank would become a

financial intermediary. Turning to the asset side of the central bank balance sheet, one may note different views of central banks on what is the best match with its monetary liabilities: The Fed and the Bank of England systematically invested the proceeds from the issuance of banknotes into government paper. The Deutsche Bundesbank in contrast traditionally considered exposures of the central bank to the government as problematic and therefore preferred assets in the form of loans to banks collateralized with high-quality securities or bills of exchange.

In view of the outstanding levels of government debt in developed economies, and the much lower level of cash in circulation so far [around 10% of GDP for advanced economies,[3] and 8% for emerging economies (Sveriges Riksbank, 2018)] it would appear that there would be some scope for CBDC2 to be matched on the central bank asset side with higher holdings of government bonds, such that neither (i) the reliance of banks on central bank credit would need to increase, nor (ii) would the central bank have to hold a credit-risk-intense portfolio of securities. In any case, currently at least the central banks of the UK, Japan and the euro area hold large quantitative easing (QE) related portfolios that created large amounts of excess reserves of banks, that would provide scope for CBDC2 of at least the size of banknotes in circulation before reserve scarcity would emerge (without any further purchases of government bonds). Moreover, once the potential for matching CBDC with government exposures had been exhausted, the central bank could still try to minimize the impact of the lengthening of the central bank balance sheet on the credit allocation process by aiming at diversified exposures to the private sector (e.g., outright holdings of various securities types and issuers proportional to market capitalization; credit operations with banks against a broad collateral set). In so far, it could be argued that there is some scope for CBDC2 before the central banks would have to accept really credit-intense exposures to the private sector, and thereby play a potentially larger role in the credit allocation of the economy, which may eventually be negative for the overall efficiency of the economy.

2.3 Bank Runs and Cyclical Bank Disintermediation Through CBDC

Mersch (2018) and Panetta (2018), amongst others, have emphasized the potentially destabilizing effects of CBDC in a financial crisis, namely its facilitation of a run on the banking system. CPMI–MC (2018) also supports the view that CBDC could worsen bank run dynamics in a crisis. Mancini–Griffoli et al. (2018) also discuss this aspect of CBDC, but conclude that overall, these effects are likely to be muted. While a run into banknotes has limitations resulting from the risks and costs of storing larger amounts of banknotes at home or at some safe places, no such limitations would arise if everyone would have an unlimited ability to hold CBDC. Also, a crisis-related

[3] Japan is an interesting outlier and has a much higher share of cash in circulation (see, Ministry of Internal Affairs and Communications, 2020).

run into safe financial assets (gold-related assets, highly rated government debt) is different: although being possible in "electronic" form and therefore not creating security issues (except for physical gold), it is (i) dis-incentivized through the price mechanism, i.e., the secure assets will become very expensive in a crisis; (ii) on aggregate such a run does not reduce per se deposits with banks. Therefore, it is plausible that CBDC could worsen bank runs, as it would neither create physical security issues, nor be subject to scarcity-related price dis-incentives, as it would be supplied in a fully elastic way (like banknotes). The financial flow representation of a bank run into CBDC is identical to the one of CBDC2 in Table 1.

3 NIRP and CBDC[4]

A number of central banks have implemented negative interest rate policies (NIRP), notably in Denmark, Switzerland, the euro area, Sweden, and last but not least, Japan. Moreover, long-term nominal interest rates suggest that NIRP could have a significant probability of re-occurring in future decades, and maybe even in monetary areas not applying it currently.

Issuing unremunerated CBDC without access and quantity constraints would however imply the end of NIRP. As it would also imply that NIRP would no longer be considered possible in the future, long-term nominal yields—even those currently in positive territory —would tend to increase as NIRP scenarios would no longer be factored into expectations.

Indeed, if the most liquid and risk-free asset—central bank overnight liabilities in domestic currency—offers a return rate of zero, no other financial instrument should yield a negative rate any longer as its holders would otherwise substitute it with CBDC. Therefore, effective access- and/or quantitative constraints on CBDC holdings would be necessary to preserve the ability to conduct NIRP under a future issuance of *zero-remunerated* CBDC. However, such constraints reduce the scale and scope of usage of CBDC and therefore its effectiveness and usefulness as means of payment.

4 A Two-Tier Remuneration System for CBDC

Some authors (e.g., Kumhof & Noone, 2018) note the possibility of addressing CBDC's potential structural and cyclical bank disintermediation through applying unattractive and/or negative interest rates on CBDC. However, they are skeptical that the tool of negative interest rates will always be sufficiently effective in crisis times, also because of political acceptance problems. Indeed, central banks will prefer to be able to promise to citizens that CBDC will be at least as attractive as banknotes on

[4] See also the chapter by Yamaoka in this volume.

all relevant aspects, i.e., excluding that a household's holdings of CBDC of the size of normal holdings of banknotes could be subject to negative remuneration, even during a crisis. In this section, a solution, namely tiered remuneration of CBDC, is proposed to solve the potential problems explained in the preceding two sections, while allowing central banks to achieve this objective. Panetta (2018) was first to hint at the idea of a tiering system for CBDC to address the bank run problem (italics added), whereby he does not go as far as to envisage negative remuneration for the second tier:

> in bad times, depositors could switch rapidly and at no cost from their bank account to the CBDC. The central bank could limit such risks—for example by setting a ceiling on the amount of CBDC that each individual investor can hold, or by bringing the remuneration to zero for holdings of CBDCs *above a certain threshold*. (p. 29)

Actually, reserve tiering systems have often been applied by central banks for the remuneration of deposits, and exactly for the purpose to control the total amount of deposits while being forthcoming toward moderate levels of deposits. Under such a system, a relatively attractive remuneration rate is applied up to some quantitative ceiling, while a lower interest rate is applied for amounts beyond the threshold. The Eurosystem has applied such tiering systems for deposit accounts of public sector institutions, notably of domestic government and foreign central banks or sovereign wealth funds. Regarding the remuneration of *government deposits*, for example, Article 5 of the Eurosystem's DALM guideline[5] specifies that a two-tier remuneration system applies. Similarly, the Eurosystem reserve management services (ERMS[6]), granting accounts to foreign central banks and public sector funds, also typically foresee the differentiation between a more attractive rate applying up to some limit, and a less attractive one without limits. If the remuneration rate for tier two deposits is sufficiently unattractive, then the amount of such deposits should be low, or even zero. The central bank should also be able to counter, through an as aggressive as needed lowering of tier two remuneration rates, the inflow of additional deposits in a financial crisis context.

One may also note that some central banks (DK, SE, CH, JP) have collected experience over the last years with a differentiated remuneration of bank deposits with the central bank. For example, the Bank of Japan introduced on 29 January 2016 a three-tier system (Press release of the Bank of Japan dated 29 January 2016) following the existence of two-tier approaches in other central banks. The size of the better remunerated tiers is calculated by the Bank of Japan for each bank essentially in proportion to the bank's required reserves, which itself are calculated proportionally to the short-term liabilities of the bank to non-banks.

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[5] GUIDELINE OF THE EUROPEAN CENTRAL BANK of 20 February 2014 on domestic asset and liability management operations by the national central banks (ECB/2014/9), as amended by GUIDELINE OF THE EUROPEAN CENTRAL BANK of 5 June 2014 amending Guideline ECB/2014/9 on domestic asset and liability management operations by the national central banks (ECB/2014/22).

[6] https://www.ecb.europa.eu/paym/erms/html/index.en.html.

In sum: central banks have ample experience with tiered remuneration systems. These could be readily applied to deposit-based CBDC and could address the structural and the financial crises-related bank disintermediation issues without exposing households using CBDC for payment purposes to (perceived) financial repression. Of course, an undue structural or transitionary increase in CBDC at the expense of banks could also be addressed by a single tier system in which the interest rate applied to the entire CBDC deposits would be sufficiently low (or temporarily lowered). However, a two-tier system seems to have important advantages:

- It allows assigning the **payment function of money to tier one CBDC**, while the **store of value function would be assigned to tier two**, and would essentially be dis-incentivized through a less attractive remuneration rate. Indeed, central bank money should probably not become a large-scale store of value (or investment vehicle), i.e., a major form of investment of households, as this eventually implies that the central bank would become an investment intermediary of the economy (for which it has no particular qualification).
- It ensures that **CBDC is attractive** to have in principle for all households, **as reliance on tier one CBDC never needs to be dis-incentivized by a particularly low remuneration rate**.
- A two-tier system allows **better steering of the amount of CBDC**, which provides additional confidence into the manageability of the introduction of CBDC.
- As mentioned above, it avoids that in a crisis situation, one would need to push into negative territory the remuneration of *all* CBDC. Thereby **tiering decisively reduces the scope for popular criticism of the central bank (e.g., of financial repression, expropriation of money holders, etc.)**. The central bank would need to communicate clearly at an early stage that the remuneration of tier two CBDC is not meant to be attractive, and may be made particularly unattractive in a crisis, as needed. For tier one CBDC, the central bank can commit to never charging negative rates.
- In case it is wished to be combined with abolishing bank notes, it allows overcoming the zero lower bound (ZLB) for monetary policy reasons when needed, without implying that tier one remuneration needs ever to fall below zero, which appears fair for low-wealth individuals and toward the payment function of central bank money more generally.

The central bank can also provide a **commitment with regard to the quantity of tier one CBDC**. For example, it could promise to always provide per capita a tier one quota of e.g. EUR 3000, implying an amount of total tier one CBDC for households of around EUR 1 trillion (assuming an eligible euro area population of 340 million; the allowances of minors could be either set to zero or they could be allocated to a parent's CBDC account). To recall: banknotes in circulation in the euro area are somewhat above EUR 3000 per capita (summing up currently to around EUR 1.2 trillion); securities holdings of the Eurosystem (including both investment and policy portfolios) are currently around EUR 3 trillion; and the banking system has excess reserves close to EUR 2 trillion. Everything else unchanged, there would thus still be no need for large scale credit operations with banks if CBDC of a total amount of EUR

1 trillion would be issued now. The central bank could moreover commit to increase the tier one CBDC quota when the amount of banknote in circulation decreases. An amount of EUR 3000 for tier one CBDC could be interpreted as covering the average monthly net income of euro area households, such that the normal payment function of money would be covered. CBDC tier one allowances for companies would not necessarily have to be high, as it could be argued that the main objective of CBDC is to serve citizens. When estimating how tier one CBDC allowances would be translated into total CBDC volumes, it should on one side be taken into account that not all CBDC accounts will be opened rapidly, and maybe some households will never open an account, or will not hold the full tier one allowance on the account. On the other side, some households will be willing to hold tier two allowances.

For corporates (financial non-banks and non-financials), the tier one allowance could be set to zero, or alternatively it could be calculated to be proportional to some measure of their size and thereby presumed payment needs. Simplicity and controllability of the assignments would be essential. Foreigners, if allowed to open accounts, should have a tier one ceiling of zero. Finally, a deposit based CBDC framework could in principle be complemented by an anonymous token-based CBDC. If so, then the anonymous token-based part would be remunerated at the same level as account-based tier two CBDC. Simple solutions (such as a stored-value card like the London Oyster card) could be sufficient for instance to allow tourists to use CBDC without having an account. Again, those cards should be subject to the tier two remuneration rate.

The tier one remuneration rate r_1 could be set in principle at a relatively attractive level, up to the rate of remuneration of banks' excess reserves, and it would in addition be specified that it could never fall below zero. The tier two remuneration rate would be set such that tier two deposits are rather unattractive as store of value, i.e., less attractive than bank deposits or other short-term financial assets, even when taking into account risk premia. The two rates would co-move in parallel with policy interest rates, with in addition some special provision when the zero lower bound territory is approached. The rates would themselves not be regarded as policy rates. Moving the rates would simply serve keeping a similar spread over time to other central bank rates, and thus in principle to other market rates. The objective would be to sufficiently stabilize and control over time the incentives to hold CBDC. Of course, the existence of banknotes, which are invariably remunerated at zero, creates a variable spread between the remuneration of banknotes and CBDC, which may also have quantitative effects on both.

Initially, for example the following remuneration could be considered by the ECB for tier one CBDC (DFR is the rate of the ECB's deposit facility):

$$r_1 = max(0, DFR - 1\%) \tag{1}$$

For tier two CBDC, the remuneration formula could be:

$$r_2 = min(0, DFR - 1\%) \tag{2}$$

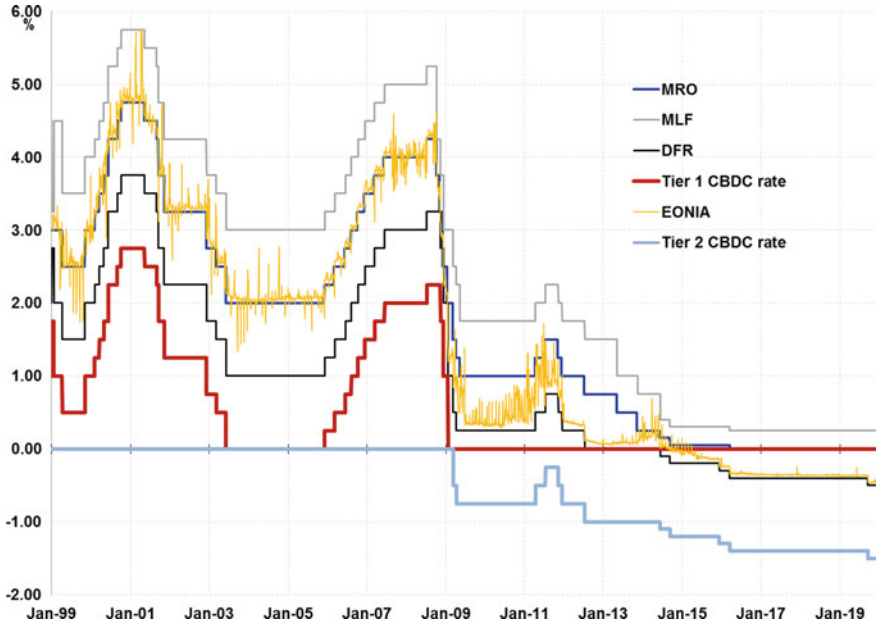

Fig. 1 An example of CBDC remuneration rates relative to historical ECB official interest rates *Note* tier one CBDC rate $r_1 = max(0, DFR - 1\%)$ and tier two CBDC rate $r_2 = min(0, DFR - 1\%)$. DFR: Deposit facility rate; MLF: Marginal lending facility; MRO: Main refinancing operations; EONIA: Euro overnight index average

In words: r_1 would equal the rate of ECB deposit facility minus 1%, with however a zero lower bound applying, while r_2 would be the rate of the ECB deposit facility minus 1%, however with zero as a ceiling. Figure 1 shows the relationship of remuneration rate r_1 and r_2 with the ECB's official interest rates.

Of course, alternative formulas for remuneration of the two tiers could be imagined and applied.

5 Conclusion

This chapter proposes a way to achieve simultaneously four key objectives related to the introduction of CBDC:

1. Offering CBDC as means of payments to households at conditions at least as attractive as banknotes, implying a non-negative remuneration of some relatively significant amount of CBDC per household.
2. Offering CBDC in a quantitatively unconstrained manner to *any* holder, also beyond citizens, i.e., including corporates, foreigners, institutional investors, etc., such as to ensure that CBDC can achieve maximum scale, scope, and

effectiveness as means of payment, including internationally, and serve both as "retail" and "wholesale" CBDC.
3. Being able to control the risks of structural or cyclical bank disintermediation through CBDC, in particular in a low-interest-rate environment (including NIRP).
4. Preserving the ability to conduct NIRP and thereby preserve the current accommodative stance of monetary policy, such as it currently prevails in a number of advanced economies (including Japan and the euro area).

The solution relies on a tiered remuneration of CBDC, in line with long-tested central bank logic and practice. Tiered remuneration is probably not needed when nominal short-term risk-free interest rates are far above zero, as they have been e.g. in G7 countries in the early 1980s. In such circumstances, where nominal interest rates would be, e.g., close to 10%, a zero-remuneration of CBDC would be effective to prevent an extensive use of CBDC as a store of value (i.e. as a large-scale investment), probably even in financial crisis situations. For economies with moderately positive nominal interest rates, the technical ability to introduce a tiered remuneration may also be desirable, in particular for the risk of crisis-related bank dis-intermediation. Moreover, CBDC issuance which would technically exclude future NIRP would not only, by definition, constrain future policy options, but it would also tend to increase long-term interest rates today, i.e., tighten the stance of monetary policy, because of expectations effects.

Offering unremunerated CBDC to households can achieve either objectives 1 and 2 but not 3 and 4, or, in case of quantity and access constraints, 1, 3, and 4, but obviously not 2. Offering CBDC with a single remuneration rate can achieve in addition 2, 3, and 4, if it sacrifices 1. Therefore, tiering appears as the only solution to achieve all four objectives.

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