FEDS Notes

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Central Bank Digital Currency: A Literature Review

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Technological advances in recent years have led to a growing number of fast, electronic means of payment available to consumers for everyday transactions, raising questions for policymakers about the role of the public sector in providing a digital payment instrument for the modern economy. From a theoretical standpoint, the introduction of a central bank digital currency (CBDC) raises long-standing questions relating to the provision of public and private money (Gurley and Shaw 1960), and the ability of the central bank to use CBDC as a means for transmitting monetary policy directly to households (Tobin 1985). The theoretical literature on CBDC to date relates to these questions by focusing on the effect of introducing a CBDC (i) on commercial banks, and (ii) on monetary policy and financial stability, and the resulting welfare implications. Policymakers have also taken a keen interest in these questions, among others (Bank for International Settlements 2018).

Broadly, the literature that studies CBDC considers it to be a means of payment that can pay interest and that does not necessarily need to be held in an account at a commercial bank. Though there is no universally agreed-upon definition of CBDC by policymakers or academics, thus far the literature has studied the implications of a central bank liability held directly by the public[1]. The models and assumptions in the literature so far provide streamlined frameworks to answer questions about the effects of CBDC at the micro- and macro-levels, while abstracting from many of the complex design issues of interest to policymakers.[2]

CBDC's Effect on Commercial Banks

The first strand of the literature asks how CBDC will affect commercial banks. Fundamentally, CBDC can serve as an interest-bearing substitute to commercial bank deposits. Faced with such a substitute, commercial banks may respond by changing the deposit rates they offer to savers and, because of the resulting impact on banks' funding cost, the terms of the loans they offer to borrowers. As a result, both the quantity of bank deposits and the volume of bank-intermediated lending may change with the introduction of a CBDC. In this respect, this strand of the literature can speak to the concern of some policymakers that the introduction of CBDC may replace banks' main source of funding and cause disintermediation of commercial banks, which in turn may lead to a decrease in their lending.

Andolfatto (2018) studies these effects on a monopoly bank. In his paper, when the CBDC is interest-bearing, the bank, which makes positive profits in equilibrium, raises the equilibrium deposit rate to be equal to the interest rate on CBDC, thus making depositors indifferent. An

important result is that because CBDC induces more favorable contractual terms for depositors, it increases the demand for deposits, both through an intensive margin (existing depositors are encouraged to save more) and an extensive margin (individuals who otherwise would choose to be unbanked are encouraged to pay the cost of accessing the banking sector). Hence, the competitive pressure exerted by CBDC could actually end up expanding banks' depositor base. It is, however, possible that CBDC remuneration erodes "banks' franchise value" (profits) but this does not necessarily result in higher loan rates. To this point, Andolfatto argues that as long as banks are able to borrow reserves from the central bank, which in any corridor system is done via the central bank's lending facility, disintermediation can be avoided as banks can still make loans.[3]

Similar ideas to those in Andolfatto (2018) are further developed by Chiu et al. (2020), who also study the impact of CBDC on bank lending and model CBDC as an interest-bearing asset that competes with banks' deposits. The economic mechanism driving their baseline results is similar to that in Andolfatto (2018), as banks in their model are also imperfectly competitive. From a theoretical perspective, Chiu et al. (2020) go beyond Andolfatto (2018) in that they analyze the case where banks can hold CBDC to meet their reserve requirements and CBDC designs that consider policy tools different from fixing the rate of interest it pays. Calibrating their model to the US, Chiu et al. (2020) quantify the magnitude of the effect on lending from the introduction of a CBDC, finding it can increase by as much as 3.55% with a properly chosen remuneration rate. The specific change in lending depends on the region of the parameter space considered: if the interest rate on CBDC is below that on checkable deposits, there is no effect on banks' activities. If the interest rate on CBDC is higher than that on deposits, but not too high, then banks respond by increasing deposit rates and lending, as higher deposit rates result in a larger deposit base. If, however, the interest rate on CBDC is too high, banks scale down their deposits and loans.

Brunnermeier and Niepelt (2019) also consider CBDC as an asset with the same liquidity properties as bank deposits. As in Andolfatto (2018), assuming the central bank lends to commercial banks, the introduction of a CBDC need not affect the equilibrium allocation. They show that if households' deposits are exchanged for CBDC, then there is no effect on the equilibrium allocation as long as (i) deposit liabilities are replaced by central bank loans to commercial banks and (ii) there is no effect on the constraints faced by households or the wealth distribution across households. Intuitively, if CBDC does not affect households' payoffs nor relaxes or tightens the constraints they face, the portfolio choices of each household, and in turn the distribution of wealth across households, will be unaffected. From the perspective of private banks, the equilibrium is unaffected only if the level of liabilities is unchanged. Thus, the authors state that this could be achieved by "render[ing] the central bank's implicit lender-of-last-resort guarantee explicit."

Fernandez-Villaverde et al. (2020a) build a model of bank runs in the spirit of Diamond and Dybvig (1983) to derive a related equivalence result. The authors characterize conditions such that CBDC replaces banks' deposits entirely, and show that in normal times the set of allocations achieved under private bank deposits is the same as that achieved under CBDC.

Differently, in times of bank runs, they show that if the central bank is able to commit not to liquidate its long-term assets, the presence of CBDC can decrease the likelihood of runs, leading all depositors to hold CBDC instead of deposits in equilibrium. Under the assumptions of their model, despite the elimination of commercial bank deposits, the presence of CBDC does not lead to a decrease in lending as the central bank is assumed to have (indirect) access to the same investment technology as commercial banks.

Keister and Sanches (2019) explore the trade-off introduced by a CBDC between reduced lending by commercial banks and increased trade in a model of decentralized exchange in the spirit of Lagos and Wright (2005). They show that if CBDC is widely accepted for transactions, buyers will hold more of it, increasing trade between buyers and sellers, leading to higher quantities exchanged, and in turn, higher consumption. At the same time, consumers' portfolio choice implies lower deposit balances and in turn lower lending by banks, reducing investment. If the consumption effect through increased acceptance is larger than the investment effect through decreased lending, the introduction of a CBDC will increase welfare.

CBDC's Effect on Monetary Policy and Financial Stability

The second strand of the literature asks what will be the effect of a CBDC on monetary policy and financial stability, and the resulting welfare implications. As a new form of central bank money, CBDC has the potential to affect central banks' wider policy objectives, either by acting as a new monetary policy tool or through its effects on the portfolio choices of households and the probability of bank runs. Crucial to these mechanisms is the flexibility provided by CBDC in responding to macroeconomic shocks.

Barrdear and Kumhof (2016) build a dynamic stochastic general equilibrium (DSGE) model with sticky prices and adjustment costs to study the long-run and cyclical effects of CBDC for the macroeconomy. Under the assumption that newly issued CBDC is exchanged one-for-one with government debt, they find that the introduction of CBDC decreases interest rates and distortionary taxes, thus increasing long-run GDP. Over the business cycle, counter-cyclical CBDC issuance can lead to a smaller fall in GDP in response to a liquidity demand shock. This shock leads to a flight to safety in which households demand more CBDC. If the central bank can increase the quantity of CBDC to satisfy this demand, the reduction in real economic activity is less severe, attenuating the decline in spending and therefore welfare.

Subsequent work by Fernandez-Villaverde et al. (2020b) considers a model of bank runs a la Diamond and Dybvig (1983) in which banks can offer nominal contracts.[4] In their paper, CBDC is modeled as deposits held at the central bank. Their framework highlights an important trade-off: if a run on CBDC occurs, the central bank internalizes the effect on prices, and thus real consumption, from liquidating its assets to pay depositors. By increasing the price level in the case of a run, the central bank can effectively reduce the real value of withdrawals, thus preventing bank runs from occurring. This increase in the price level, however, comes at the cost of sacrificing inflation targeting. Even if the central bank is mandated to maintain price stability, it cannot do so in the case of a large enough run. In this case, the authors show that

there is a positive probability of runs, and that a negative interest rate on CBDC during financial panics is optimal to keep inflation in check.

Williamson (2019) studies the role of a CBDC not only as an interest-bearing asset, but also as a means of payment alternative to cash, which is subject to theft, and to bank deposits, which are subject to limited commitment of the bank to honor deposit repayment. When households endogenously select into banked (i.e. deposit users) and unbanked (i.e. cash users), the introduction of a CBDC, which pays interest and is assumed to be immune to theft, can be Pareto improving and always increases welfare of at least unbanked households. The economic mechanism driving the welfare implications focuses on the interaction between the new monetary policy tool introduced by an interest-bearing CBDC and banks' limited commitment. Because banks' assets serve as collateral to secure deposit liabilities and relax their commitment friction, collateral assets play a key role in limiting the amount of liquidity banks can offer households. Interest payments on CBDC which are financed by an open market purchase of government bonds effectively reduce the availability of collateral assets to banks, tightening their collateral constraint and reducing their ability to issue payment instruments in the form of deposits. Thus, despite increasing the welfare of unbanked households, who, by assumption, are no longer subject to theft, CBDC decreases the welfare of banked households unless they also choose to hold CBDC in their portfolios. With at least some households switching to CBDC, some of the transactions which were carried out with deposits and required banks to hold collateral are now carried out with CBDC. Banks' collateral assets are still available to issue deposits, hence, overall, the aggregate stock of collateral can support more transactions.

While also focusing on the liquidity properties of CBDC as a means of payment, Keister and Monnet (2020) study its effects on the set of feasible policies available to the government in periods of financial distress. If the financial conditions of banks are private information to each bank and its depositors, the introduction of a CBDC as an alternative means of payment to bank deposits but immune from the risk of bank runs (as the central bank does not perform maturity transformation) results in depositors withdrawing their funds from banks in times of stress and reallocating them into CBDC. By observing a large and sudden inflow of funds into its digital currency, the central bank can then infer the financial conditions of banks. This information might be crucial in designing an appropriate policy response in times of stress, the more so the faster a response is needed to be effective. By appropriately choosing the interest rate on CBDC to make it more attractive in times of stress, the central bank can more quickly infer the state of the financial system and respond more effectively. This allows the government to adopt policies that are welfare-improving over the best policies feasible without a CBDC.

Considerations for future research

As with any new literature, many questions remain. We believe the most crucial question is which intrinsic features of CBDC as a means of payment and a store of value are important for households' portfolio choices as to which monies to use. Indeed, empirical studies of consumer payment choice such as Koulayev et al. (2016) show that individuals' preferences across means of payment are heterogeneous and not fully explained by demographic characteristics such as income and age. In order to fully understand the macroeconomic and microeconomic effects of

introducing a CBDC in a theoretical framework, it is imperative to first understand consumer payment choice as CBDC will, first and foremost, expand the set of payment and savings options available to households.

To understand how heterogeneity in consumers' choices across means of payment determines the adoption of CBDC, it is crucial to identify whether CBDC could be a substitute for physical currency, deposits, or both. Cash and deposits share several characteristics, such as (near) immediate settlement upon payment; however, they differ in the level of anonymity and privacy of transactions and the risks involved in holding each. Williamson (2019) highlights one such trade-off between cash and deposits: the risk that a bank absconds with deposits and the risk of theft for physical cash. Andolfatto (2018) considers a fixed cost of opening an interest-bearing deposit account, while the use of cash is free but pays no interest. Given these trade-offs, Andolfatto and Williamson, respectively, allow for heterogeneity in income or preferences as a driver of payment choice, leading to a share of the population to be unbanked, that is, to hold only cash. In these models, the introduction of a CBDC can lead to greater financial inclusion by making deposits, either at commercial banks or in CBDC, more attractive, lowering the share of unbanked. Chiu et al. (2020) and Keister and Sanches (2019) consider heterogeneity across sellers -- some accept only cash (say, for small purchases) while others accept only deposits (for larger purchases) -- leading buyers to hold different means of payment depending on which type of purchase they will make.

Avenues for future work include further exploring how the intrinsic features of CBDC as a means of payment and store of value affect the set of feasible allocations in the economy and, in turn, affect its value to heterogeneous households.

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1. See Adrian and Mancini Griffoli (2019) for a description of an alternative design, the "synthetic CBDC". Return to text

2. These include, but are not limited to, the choice between token and account-based CBDCs, ledger design and access, programmability, privacy, and handling of offline transactions. Return to text

3. In monetary policy implementation frameworks based on a corridor system, the target for the short-term interest rate is typically set within the corridor established by the discount rate (or interest rate charged by the central bank's lending facility) as the ceiling and the interest rate on reserves deposited at the central bank as the floor (or interest rate paid by the central bank's deposit facility). Return to text

4. Nominal contracts are promises to pay a future amount that is not indexed to the price level. Return to text

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