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Central Bank Digital Currency: When Price and Bank Stability (Don't) Collide

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Abstract

In a recent influential paper, Schilling, Fernández-Villaverde and Uhlig (2024) caution that the introduction of a central bank digital currency gives rise to a central bank trilemma in a nominal version of the quintessential Diamond and Dybvig (1983) model of bank-runs. We show that there is a natural policy tool that can be introduced into their environment to solve this trilemma.

Keywords: Central bank digital currency, financial stability, price-level stability
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1 Introduction

In a recent influential paper, Schilling, Fernández-Villaverde and Uhlig (2024) (henceforth SFVU) caution that the introduction of a CBDC gives rise to a central bank trilemma in a nominal version of the quintessential Diamond and Dybvig (1983) model of bank-runs. Specifically, the central bank can achieve at most two out of three policy objectives: attaining the socially efficient allocation, financial stability, and price stability. Their paper offers a warning about the limits of what a central bank can achieve when it issues a CBDC.[1] In this paper, we argue that there is a natural policy tool that a central bank can implement that solves the trilemma, alleviating these concerns about the adoption of a CBDC.

We begin by providing intuition for SFVU's trilemma. Suppose that households lose faith in the future value of their CBDC account (that is, there is a lack of financial stability) and wish to withdraw. By assumption in SFVU, they can only purchase goods. The central bank in such a circumstance is left with a decision: allow prices to rise with this increased demand, or liquidate investments in order to flood the market with more consumer goods. Under the former choice, price level stability is violated, while in the latter case, there is inefficient liquidation of investment. Hence, a trilemma: protecting financial stability necessarily violates one of the other two goals.

The policy tool we suggest to resolve the trilemma relies on relaxing the feature of their model whereby households must spend their CBDC on goods in order to draw down their CBDC account. Patient households who withdraw do not want to spend immediately on goods: they want to consume in the future. Providing them with an opportunity to purchase assets in lieu of goods can potentially solve the alleged trilemma. If patient households who run can use their CBDC to buy assets (i.e., save for the future), the price level need not rise when there is a run on the CBDC, even if there is no liquidation.

In particular, we allow the central bank to sell bonds backed by assets to solve the alleged trilemma. The central bank creates these bonds with a precommitment not

[1] Concerns about the viability of a CBDC are more widespread. For example, CBDCs were recently out by Executive Order 14178 arguing that the introduction of a CBDC threatens the stability of the financial system (The White House, 2025). Similarly, there is a proposed law to ban CBDCs pending (U.S. Congress, 2025).

to liquidate any investment that is backing them.[2] The central bank then sells bonds collateralized by these assets to the public during a run, and for every bond sold it moves investment into the account backing the bonds. Patient households who want to spend are willing to purchase these bonds and refrain from spending on goods, solving the trilemma.[3]

The introduction of a bond backed by real assets is natural given the environment in SFVU. The patient part of the public has lost faith in the CBDC and is looking for assets that will allow them to store value, which such bonds permit. Our innovation over SFVU is that we offer the central bank a new policy through which it can accommodate the public's demand for safe assets and thus solve the proposed trilemma. We focus on this particular bond as it is a natural departing point from the environment of SFVU. However, in Section 4, we describe the conditions under which this policy is actually equivalent to the central bank selling treasuries to maintain price level stability.

Having established our main result that the trilemma in SFVU can be reasonably resolved in the environment they use, we delve into a further comparison with the literature. Barlevy et al. (2024) (henceforth BBFW) find that there is no trilemma in a decentralized economy without a CBDC. Specifically, they find that a central bank can print during a run and lend to commercial banks, without causing inflation. How is it possible that centralizing the economy with a CBDC *restricts* the set of options the central bank can achieve? As we discuss in Section 4, this is the result of modeling choices that SFVU make rather than a necessary aspect of CBDCs. In particular, we show that introducing a CBDC into an environment such as in BBFW expands, rather than contracts, the set of obtainable outcomes for the central bank rather than creates a trilemma, even if the central bank is restricted to the tools analyzed in SFVU.

To understand why introducing a CBDC in general expands the set of options for a central bank, consider the source of value for currency, CBDC or otherwise. In SFVU currency is only valued for its cash-in-advance properties. In reality, currency gets its value in other ways, such as permitting trade (Allen, Carletti and Gale, 2014), or as it is

[2]The central bank's immunity from forced liquidation has already been explored in the CBDC literature, see e.g., Schilling et al. (2021).

[3]SFVU also consider the potential of asset sales to solve the trilemma, but find that it cannot do so. As we argue in Section 3.2, this is because they only consider assets backed by the same CBDC that the public has lost faith in. In order to demonstrate this point, we use the model analyzed in SFVU and add our proposed tool to their setting.

backed by taxes and thus a form of government debt (Cochrane, 2023). One can think of replacing the use of bonds backed by investments with currency that is government debt backed by other real resources, such as taxes, as in BBFW. BBFW find that there is no trilemma in a world where money has intrinsic value and there is no CBDC. The intuition is simple: when the central bank prints money during a run, it is given as a loan to commercial banks who then pays the patient runners. The interest rate that the central bank sets on this loan thus determines how much (if any) dilution is done to the value of currency, and thus whether the policy is inflationary or even deflationary (as in BBFW). Below, we argue that introducing a CBDC into the BBFW environment *expands* the set of options available to the central bank, rather than creates a trilemma. Intuitively, creating a CBDC under the central bank expands its options as it becomes easier for the central bank to be creative with policy with no commercial banks acting as intermediaries between the central bank and the public. We conclude that policy makers can rest assured that the adoption of a CBDC does not introduce a trilemma.

Related Literature

Our paper relates to a large literature on financial stability. Skeie (2008) considers a model in which households that withdraw money must use it to buy goods from banks. Banks thus never run out of money, even in a run: any money households withdraw simply returns to the bank as spending on goods. While runs are possible, there is no need for the central bank to bail out banks if a run occurs. SFVU apply the model of Skeie (2008) to a CBDC world to find a trilemma. Similarly, BBFW take a world similar to Skeie (2008) but add in the ability to store money outside of the financial system, as well as currency having value, to find that there is no trilemma without a CBDC.

A separate branch of the literature studies scenarios in which commercial banks may experience liquidity stress, and require money created by the central bank. Examples of such models include Antinolfi, Huybens and Keister (2001), Carapella (2012), Robatto (2019), Andolfatto, Berentsen and Martin (2020), and Altermatt, van Buggenum and Voellmy (2022). This paper focuses on a different mechanism for the impact of liquidity provision on financial stability and prices than the ones studied in this literature. However, the main contribution is to emphasize how the transition from a decentralized

economy to one where banking is done through a CBDC affects the central bank's set of options.

Finally, our paper is related to a growing literature on CBDCs. One set of the literature is concerned with both whether a CBDC will cause disintermediation of commercial banks as well as the welfare consequences of such disintermediation (Andolfatto, 2021; Schilling et al., 2021; Agur, Ari and Dell'Ariccia, 2022; Piazzesi and Schneider, 2022; Williamson, 2022; Chiu et al., 2023; Whited, Wu and Xiao, 2023; Keister and Sanches, 2023). Along with SFVU, we are agnostic on this debate. Similarly, there is a literature on how the introduction of a CBDC affects financial stability Ahnert et al. (2023); Carapella et al. (2024). The mechanisms they study are different than that studied here and in SFVU. Another strand looks at how the introduction of a CBDC could impact monetary policy (Barrdear and Kumhof, 2022; Davoodalhosseini, 2022; Burlon, Muñoz and Smets, 2024; Paul, Ulate and Wu, 2025). Here, we focus on different aspects of monetary policy, in particular stabilization in a Diamond-Dybvig style run, with the introduction of new policy tools to prevent a monetary trilemma. Niepelt (2024) considers how the interest rate on reserves and the CBDC might differ. This point is related to our contention that the introduction of CBDC increases the set of options available to the central bank, rather than limits them, though we do not explicitly examine setting different interest rates on reserves rather than the CBDC, nor do we model the liquidity difference between reserves and CBDC as in Niepelt (2024).

We proceed as follows. Section 2 recreates the model introduced by SFVU, and presents their trilemma. Section 3 shows that we can resolve their trilemma with the policy tool discussed above, both in their benchmark economy as well as in their extensions. Then in Section 4 we revisit the notion of currency having innate value beyond that of a medium of exchange, as in BBFW. We first revisit their main result of no monetary trilemma in an economy without a CBDC, and then show how the introduction of a CBDC expands the set of options available to the central bank. We conclude in Section 5.

2 Model

Our model builds on the model studied in SFVU.[4] The model features three periods: $t \in \{0, 1, 2\}$, and two types of agents: households and a central bank.

Households are risk-averse and ex-ante symmetric. The mass of households is normalized to 1. In period 0, each household is endowed with 1 unit of a good. With probability λ a household is impatient and values consumption only in period 1, and with probability $1 - \lambda$ it is patient and values consumption only in period 2. Utility from consumption in the relevant period is given by a utility function $u(\cdot)$ that is strictly increasing, twice differentiable, and features a relative risk aversion coefficient that is strictly greater than unity; that is, for all $c > 0$, $-cu''(c) > u'(c)$. Households privately learn their type at the beginning of period 1.

There are two technologies available. The first is a production technology that converts 1 unit of goods invested in period 0 into $R > 1$ units of goods in period 2. It is possible to liquidate part of this investment in period 1. The second technology is a storage technology, that yields 1 unit of goods in period 2 for every unit stored in period 1.

Optimal risk sharing A social planner with the ability to invest and allocate resources on behalf of the households would choose a consumption bundle (x_1, x_2) to maximize households' period 0 expected utility $W = \lambda u(x_1) + (1 - \lambda)u(x_2)$. The bundle must be feasible, i.e., $\lambda x_1 \leq 1$ and satisfy the resource constraint of $(1 - \lambda)x_2 \leq R(1 - \lambda x_1)$. The solution $(x_1^\star, x_2^\star)$ must satisfy the first order condition $u'(x_1^\star) = Ru'(x_2^\star)$ as well as the resource constraint $R(1 - \lambda x_1^\star) = (1 - \lambda)x_2^\star$. From Diamond and Dybvig (1983), the solution is unique and satisfies $1 < x_1^\star < x_2^\star < R$.

The central bank There is a central bank that offers households a nominal, interest-bearing demand-deposit contract, which can be interpreted as a CBDC. This contract replaces commercial bank deposits. In addition, the central bank sets a nominal interest rate between periods 1 and 2, as well as a liquidation strategy. Central bank policies can depend on the mass of households who want to spend their CBDC in period 1. Let n denote the fraction of households who want to spend their CBDC account in period 1.

[4]The model in SFVU is closely related to that of Skeie (2008) and Diamond and Dybvig (1983).

What is novel in our approach, relative to SFVU, is that we allow the central bank to create additional assets, in particular debt backed by investments the central bank owns. We assume that the central bank provides this debt elastically, and normalizes its price so that each household can buy exactly one bond. Each unit of debt sold will come with a promise of a certain amount of goods provided in period 2, this (real) coupon is denoted by S. This debt is in essence a real bond, and we will refer to it below as the central bank selling bonds in period 1. For the central bank to be able to pay this coupon, we impose a joint constraint on the bank's liquidation policy and sale of assets. In particular, we require that the bank is able to pay the coupon from the non-liquidated assets even if all patient households that withdraw early elect to buy the asset.

Definition 1. *[Central Bank Policy] A central bank policy is a tuple* $(M, y(\cdot), i(\cdot), S(\cdot))$*, where* M *is the money supply in* $t = 0, y : [0,1] \to (0,1]$ *is the central bank's liquidation policy,* $i : [0,1] \to [-1, \infty)$ *is the nominal interest rate paid on deposits between* $t = 1$ *and* $t = 2$*, and* S *is the consumption provided in period 2 per unit of bonds purchased in period 1.*

The central bank's policy is feasible: $(n - \lambda)S(n) \leq R(1 - y(n))$.

The central bank announces and commits to a certain policy at the beginning of $t = 0$. Households in period 0 engage in a contract with the central bank. They sell the central bank their endowment, and receive in return a commitment from the central bank to have either P_0 dollars of CBDC (which is the price of the good in period 0) should they choose to spend in period 1 or $P_0(1 + i(n))$ dollars of CBDC if they choose to spend in period 2.[5] We assume that households cannot store on their own in period 0. As such, the decision to deposit is trivial, and $M = \int_{[0,1]} P_0 di = P_0$. Finally, since there are no liquidation costs, the central bank invests all of the endowment provided by households.

At the beginning of period 1, all households observe their type and announce their intention to spend their CBDC account. Impatient households trivially spend their CBDC account on consumption goods. Patient households choose between leaving their CBDC account untouched, spending on consumption goods (which they then store until period 2), or spending on the bonds that the central bank may offer. To simplify

[5] As explained in Footnote 5 of SFVU, an interest rate between period 0 and period 1 would not affect the analysis.

exposition, we assume that households either spend all of their CBDC or none of it, and should they spend, it is either entirely on goods or entirely on bonds. Moreover, households cannot hold a negative CBDC balance. Households who choose to spend on goods do so by purchasing in a competitive market where goods are sold according to the central bank liquidation strategy $y(\cdot)$. Let n_g denote the mass of households who spend on goods, and n_b denote the mass of households who spend on bonds, such that $n_g + n_b = n$. The price of goods in period 1 depends on demand for goods, which is set by n_g, and the supply of goods from the central bank's liquidation strategy, which depends on n. The price level in period 1 is thus denoted

$$P_1(n_g, n) = \frac{P_0 n_g}{y(n)}.$$

At the beginning of period 2 the central bank pays the nominal interest $i(n)$ to any households who did not redeem their CBDC account in period 1. Next, it redeems the bonds it issued from the account holding the assets backing the bonds. Finally, there is a competitive market in which the remaining central bank investment, $R(1 - y(n)) - S(n)n_b$, is sold against the remaining CBDC balances. The price level in period 2 is thus given by

$$P_2(n_b, n) = \frac{P_0(1 + i(n))(1 - n)}{R(1 - y(n)) - S(n)n_b}.$$

Definition 2. *[Equilibrium] An equilibrium consists of a feasible central bank policy $\langle M, y(\cdot), i(\cdot), S(\cdot)\rangle$, aggregate spending on goods n_g, aggregate spending on bonds n_b, and price levels (P_1, P_2) such that:*

1. *The spending decisions of each household on goods and bonds are optimal given aggregate spending decisions, the central bank policy, and price levels.*
2. *Prices P_1 and P_2 clear the markets in each time period.*

2.1 Central Bank Objectives

We assume that the goals of the central bank are:

1. Price stability: There exists $\overline{P}$ such that $P_1(n_g, n) = P_2(n_b, n) = \overline{P}$, for all n_b, n_g.
2. Efficient allocation: Impatient households consume $x_1^\star$ and patient ones consume $x_2^\star$.
3. Financial stability: It is suboptimal for patient households to spend their CBDC on goods in period 1.

We require all three of these conditions for *all* potential equilibria. These objectives are identical to the central bank's objectives SFVU, albeit, with two minor differences.

First, we impose the strictest of the four notions of price stability that SFVU propose. Namely, we require what they call "price-stable at target level $\overline{P}$."

Second, purchasing bonds in their setting is always a dominated action since it is implicitly assumed that $S = 0$. Hence, SFVU requirement of financial stability (their Definition 4) is equivalent to requiring that holding the CBDC account is a dominant strategy for patient households in period 1. In our setting, households may want to spend on assets, and so this equivalence does not hold. Instead, we require explicitly that purchasing goods is a dominated action in period 1 for patient households, and add the requirement that holding the CBDC account is *an* optimal strategy for patient households, regardless of the choices of other households. The latter requirement rules out the degenerate case where it is strictly optimal for patient household to buy assets from the central bank.

The main result of SFVU is that a central bank trying to achieve all three of its above goals will "see its desires foiled." Formally, they show this by the combination of Corollaries 5, 8, and 11.

The intuition for their result is as follows. The only way to withdraw a CBDC account is by spending on goods. Should households withdraw their CBDC account in period 1, the central bank will have a choice: it can either allow prices to rise due to increased spending or it can liquidate investment to keep prices low. The former breaks price stability and the later breaks efficiency (as liquidating investment is inefficient). Furthermore, it is possible to liquidate so much investment that it becomes optimal for households to spend in period 1, causing financial instability.

We note that this intuition need not extend to the case where $S > 0$. In particular, if patient households that withdraw their CBDC account choose to spend on assets, the central bank does not need liquidate additional assets in order to prevent prices from increasing. Indeed, it is the implicit assumption that households must spend their CBDC account on goods in order to liquidate their account the creates the trilemma. Crucially, we allow households to exchange their CBDC account for other financial assets that the central bank creates in period 1, namely bonds. Our policy instrument allows patient households to continue waiting until period 2 to spend, and thus prevents demand for goods to rise in period 1.

3 There Is No Trilemma

In this section we begin by discussing how the sale of bonds by the central bank can solve the SFVU trilemma. We then discuss how their various model extensions can be addressed with similar logic.

3.1 Basic Environment

We now discuss how issuing bonds (backed by investments that the central bank commits to not liquidate) enables the central bank to obtain all three of it's goals. We begin by discussing the implementation of the "good" equilibrium in which patient households do not withdraw in period 1.

The "good" equilibrium occurs when $n_g = \lambda$, specifically, the λ impatient households spend on goods in period 1, and $n_b = 0$. The central bank liquidates $y(\lambda) = \lambda x_1^\star$, which provides exactly the efficient consumption for the impatient households. For a CBDC with a nominal value of M, the nominal price level in period 1 is $P_1(\lambda, \lambda) = \frac{M}{x_1^\star}$. In order to maintain price stability between periods 1 and 2, the interest rate set by the central bank must solve $P_2(0, \lambda) = \frac{M(1+i(\lambda))}{x_2^\star}$. That is, the interest rate is $i(\lambda) = \frac{x_2^\star}{x_1^\star} - 1$. If $S(\lambda) \leq x_2^\star$, then patient households find it optimal to hold their CBDC account, and hence this is an equilibrium.

We next turn to a policy that the central bank can implement if $n > \lambda$.[6] To induce the efficient allocation, the terms of the bonds need to be such that patient households that spend their M units of CBDC in period 1, will receive $x_2^\star$ units of goods in period 2. To obtain this, the central bank can set $S(n) = x_2^\star$ for all $n > \lambda$. The amount of investment moved to the account (per unit of bonds purchased) is $\frac{x_2^\star}{R}$. When offering such bonds to the public in period 1, the central bank also sets the liquidation strategy to be $y(\cdot) = \lambda x_1^\star$, that is, it liquidates the exact amount needed to provide the efficient consumption for the impatient households. This liquidation strategy is regardless of the number of households who want to spend in period 1 or their choice on what to spend (goods or bonds). Note that this is a feasible policy for the central bank. Finally, the central bank maintains the interest rate $i(\cdot) = \frac{x_2^\star}{x_1^\star} - 1$ for price stability.

Lemma 1. *If $S = x_2^\star$ and $y = \lambda x_1^\star$, then buying goods is dominated by buying bonds for patient households that spend their CBDC in period 1. Hence, if μ patient households spend their CBDC in period 1, then $n_b = \mu$ and $n_g = \lambda$.*

Proof. Fix $n, n_g \geq \lambda$. The demand for goods is at least λ, and so the price of goods, given the liquidation policy $y(\cdot) = \lambda x_1^\star$, is

$$P_1(n_g, n) = \frac{P_0 n_g}{y(n)} = \frac{M n_g}{\lambda x_1^\star} \geq \frac{M}{x_1^\star}.$$

Hence, a household that spends its M units of the CBDC to purchase goods in period 1 receives at most $x_1^\star$ units of consumption. On the other hand, a household that uses it CBDC to buy bonds will consume $x_2^\star > x_1^\star$. □

Intuitively, should patient households purchase goods in period 1, and the central bank does not liquidate more investment, prices in period 1 would rise. Thus, purchasing in period 1 provides these households with at most $x_1^\star$ units of consumption goods. On the other hand, buying the bonds provides patient households with $x_2^\star$, regardless of the choices made by other households.

Moreover, providing the bonds permits price stability in both periods. This result for period 1 is immediate from Lemma 1, as neither spending on goods nor the supply

[6] For ease of exposition, we only consider cases in which all impatient households spend in period 1.

of goods change in period 1. The result in period 2 comes from the fact that the amount of CBDC in period 2 declines proportionally to the amount of goods provided by the central bank in exchange for the CBDC in period 2.

Lemma 2. *If* $S = x_2^\star$ *and* $i = \frac{x_2^\star}{x_1^\star} - 1$, *then* $P_2(\cdot, \cdot) \equiv \frac{M}{x_1^\star}$.

Proof. By Lemma 1, if $S = x_2^\star$, then it must be the case that $n_g = 0$. Hence, for any n_b,

$$P_2(n_b, n) = \frac{M(1 + i(n))(1 - n)}{R(1 - y(n)) - S(n)n_b} = \frac{M\frac{x_2^\star}{x_1^\star}(1 - \lambda - n_b)}{R(1 - \lambda x_1^\star) - x_2^\star n_b} = \frac{M}{x_1^\star}\frac{x_2^\star(1 - \lambda - n_b)}{(1 - \lambda)x_2^\star - x_2^\star n_b} = \frac{M}{x_1^\star},$$

where the third equality follows from the social planner's resource constraint. □

Combining Lemmas 1 and 2 shows that the trilemma can be avoided.

Proposition 1. *Selling bonds that pay* $S(\cdot) = x_2^\star$ *allows the central bank to achieve its three goals.*

3.2 Model Extensions

SFVU consider a number of possible extensions or extra tools that the central bank could use to solve the trilemma, and then reject them. Here, we reconsider each of their potential solutions in light of the analysis above.

Cash

We begin by discussing the role of cash. SFVU consider a case of allowing cash to coincide with the CBDC. Cash in their model is implicitly backed by the same investment that backs the CBDC. It is illogical for a person running on the CBDC to be willing to hold cash, and thus they find that introducing cash has no implications for the monetary trilemma.

There are two fundamental differences between the cash they propose, which does not solve the trilemma, and the bond we propose, which does. The first is that the bond

patient households purchase cannot be used to purchase goods in period 1. This is not a restriction on the patient households, since they do not desire goods in period 1. The second is that the assets backing the bond are precommitted to not being liquidated, while the assets backing cash in SFVU are literally the same assets that back the CBDC. Thus, it is no surprise that the public does not value this cash. These differences allow the patient public to hold assets that they have faith in until period 2 without spending on goods in period 1.

Below we show that if currency (CBDC or cash) is backed by something besides the central bank investment discussed by SFVU, the results in SFVU flip automatically.

Interest Rates

SFVU argue that interest rate policy cannot help solve the trilemma. Intuitively, paying a higher interest rate in their model requires the creation of more CBDC in period 2 (to pay the interest). If people have lost faith in the CBDC, then a promise of extra CBDC does not help. Our proposed solution does not require any change to the interest rate paid on CBDC accounts. Notice that this interest rate, analyzed by SFVU, is akin to the interest rate on central bank reserves.

As discussed below, BBFW take a different view of interest rates. In a world without a CBDC, the interest rate they study is the rate the central bank receives on a loan it gives to commercial banks, not the extra it must pay out on reserves. That is, it is more like the central bank's discount window.

Open Market Operations

SFVU also consider open market operations but reject their ability to solve the trilemma. We first explain the intuition behind their finding, and then compare with the open market operations considered in this paper.

In their model, the bonds being sold by the central bank during a run are essentially equivalent to the CBDC in the sense that they are nominal and thus backed by the same investment as the CBDC (much the same as their cash, discussed above). As such, the

interest rate on such bonds does not matter and there is no reason to think that the running public should accept such bonds in lieu of spending.

In contrast, we consider a bond backed by real investment that will not be liquidated. As such, households who have lost faith in the CBDC are willing to accept this asset, while they do not accept bonds in the setting of SFVU.

State-Contingent Money Balances

There is one policy that SFVU suggest that would indeed work: state-contingent money balance adjustment, formally allowing nominal money balances to depend on the fraction of people who spend in period 1. Under this policy, during a run the central bank would reduce the nominal values of CBDC accounts such that the extra spending in a run does not increase prices. They offer more than one way of implementing such a policy, but then reject it arguing that an unconventional policy like this "might create havoc," and that it goes against traditional policy of increasing money supply during an increase of money demand.

We argue that actually what is going on during a run is not an increase in money demand, but rather an increase in the demand for safe assets (that no longer include the CBDC). Our policy recommendation allows the central bank to accommodate the public's demand. Put differently, patient runners would actually like to save until period 2 if they can (they demand safe assets), rather than withdraw money to spend (they do not demand money). Our proposed policy allows the central bank to accommodate this demand, as it would like to do during a bank run.

4 Discussion

SFVU find a trilemma, since they do not consider the policy choice we suggest above. However, even if one were to ignore our proposed policy solution, their result is surprising given the state of the literature. A trilemma under a CBDC in SFVU is in stark contrast with BBFW, who find no trilemma in a world with no CBDC.

This begs the question: what is it about the introduction of a CBDC that yields the trilemma? In this section, we argue that it is the product of a modeling choice: that the

CBDC in SFVU gets is value entirely from the investment made by the central bank, as a result of deposits, and is liable to be liquidated during a run. We argue that a model where at least some of the currency's (including CBDCs) value comes from another source, such as taxation, would not have yielded a trilemma. Indeed, we find that the introduction of a CBDC *expands* the central bank's options, rather than limits them.

Consider the framework in BBFW, who have a nominal DD setting with commercial banks that may experience a run and a central bank that can choose to print and lend to the commercial banks during a run. Explicitly, they model currency as getting its value from a government commitment to redeem the currency against a government endowment in period 2. Implicitly, this can be interpreted as a real tax that people must pay with cash, giving the cash value.[7] BBFW gives bounds on what levels of taxation are consistent with efficiency and price stability.[8]

Next, imagine a run on a commercial bank in a setting where currency has value that is not entirely a function of the commercial bank's activities. Patient runners are willing to hold cash until period 2, rather than spend in period 1, since they are still patient but have simply lost faith in the commercial bank. However, there might not be enough cash for all the runners. What happens if the central bank prints more cash during the run to lend to commercial banks? On one hand, this printing might dilute the value of the cash and yield both inflation and an unwillingness for patient runners to hold the cash until period 2. On the other hand, the central bank also receives an asset – specifically the obligation from commercial banks to repay the loan– that provides additional backing for the cash. This may well cancel any inflationary aspect of printing during a run, and incentivize runners to store cash in lieu of spending during period 1.

BBFW show that the terms of the loan, specifically the interest rate, that the central bank gives to the commercial banks determines both whether the loan is inflationary and whether the efficient allocation can be achieved. Intuitively, the interest rate on the loan balances between how much the cash is being diluted by printing more cash, versus the value of the asset that the central bank receives in the form of future payments from

[7] A comparable framework in SFVU would be that the government raises a real tax T in period 0 but gives households cash (or CBDC) against this tax, invests the goods until period 2 when it redeems the $T \cdot R$ goods against the CBDC issued in period 0.

[8] To be clear, the equivalent in SFVU would *not* preclude that much of the CBDC's value comes from deposits of real goods in period 0. It simply requires that some of the currency be backed by something besides these deposits.

the commercial banks. In other words, is the value of the asset received by the central bank enough to maintain the value of the newly created cash? They find that a loan that provides for price level stability is able to also grant people who withdraw in period 1 consumption of $x_1^\star$ and people who wait until period 2 $x_2^\star$. That is, financial stability and price level stability are achieved, and households get the optimal consumption based on the timing of their withdrawal.

What changes when a CBDC is introduced? Notice that the solution discussed above, with the bond, actually does better than in BBFW: the bond allows for patient households who run to still consume $x_2^\star$. The reason is that the central bank is able to give them a rate of return on holding their bond in this setting, while in BBFW patient households who run hold cash "under the mattress" and receive no return between periods 1 and 2.[9] If the central bank chooses to have the bond pay a real interest rate of 0 above then we would recover the result in BBFW.

We thus draw two conclusions. The first is that the modeling choice of currency being entirely backed by central bank investment, rather than part of it being valued for other purposes, is the major modeling difference between BBFW and SFVU. This is not an innocuous assumption: the ability to store something of value outside the financial system during a run is crucial both in BBFW and in our solution to the trilemma above. The second conclusion is that the move from a decentralized economy to a centralized economy, with a CBDC managed by the central bank actually allows the central bank to implement a wider range of outcomes. This is intuitive: giving the central bank more tools should expand, rather than contract, the set of feasible outcomes for policy. This is the opposite conclusion of SFVU who argue that the move to a CBDC, and thus centralizing the economy, takes away freedom from the central bank.

We also make the following observation: the central bank selling the bond we describe is actually equivalent to it selling a treasury bond. Consider the case where the central bank owns treasuries either due to normal monetary policy or as an investment it makes financed by the deposits in period 0. The central bank can thus sell these treasuries to patient investors who no longer wish to hold a CBDC (rather than issue the bond we suggest above). This policy both solves the trilemma and is normal central bank policy.

[9] Put differently, BBFW do not permit the central bank to pay interest on cash held outside the financial system, while the bond does permit the bank to do so.

Other Interventions: Fiscal Intervention

At the end of the day, to break the trilemma, we need two features. The first is to give a new asset to the patient households who no longer wish to hold their CBDC account. The second is not liquidate investment. One possibility, beyond the bond discussed above, is a fiscal intervention.

The fiscal intervention has the government purchase investment from the central bank, and funds this purchase by issuing new bonds. These bonds are purchased by the patient people who spend in period 1. In period 2 the government sells the investment goods back to the public to raise money to redeem the bonds it issued in period 1.

Notice that if the bonds are priced correctly, this intervention is in essence identical to the central bank issuing the bond, with the sole exception being that the fiscal authority caries out the intervention rather than the monetary authority.

We thus conclude that either government authority can by itself resolve the trilemma.

5 Conclusion

In this paper, we begin by solving the seeming trilemma when a CBDC is introduced proposed by SFVU. Bonds backed by investments held by the central bank can solve their trilemma in their environment. We then revisit the literature: how is it possible that a CBDC introduced a trilemma in SFVU (without our solution), when BBFW explicitly find no trilemma without a CBDC? The answer is whether money has intrinsic value.

Whether one believes money has intrinsic value determines whether one thinks that a creative solution to SFVU's CBDC trilemma is necessary. However, in either way, there is no trilemma.

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