Stablecoins, CBDC, and the Impact on Bank Lending

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October 2025

Abstract

We study how improvements in stablecoin usability and the introduction of a CBDC affect bank intermediation in a general-equilibrium model where households derive liquidity services from deposits, public money, and stablecoins, and banks set deposit rates with market power and face a profit-linked leverage constraint. We prove that the effects of improving outside money are state-dependent: when banks can expand their balance sheets, greater convenience or higher remuneration for outside money intensifies deposit competition, compresses deposit spreads, and expands deposits and lending; otherwise, if banks cannot take on more leverage, improvements shift balances toward outside money, raise loan spreads, and shrink intermediation—yielding non-monotonic outcomes. We show an equivalence between CBDC remuneration and non-pecuniary quality and provide neutrality conditions under which outside-money improvements merely reshuffle portfolios. A U.S.-calibrated exercise illustrates these results.

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1 Introduction

Stablecoins and central bank digital currencies (CBDC) are at the center of today's policy debate. In the United States, Congress has enacted the GENIUS Act, a federal framework for regulating stablecoins, while the House has passed legislation that would bar a retail CBDC[1]. In Europe, work on a digital euro continues, alongside the EU's MiCA regime which establishes a legal framework for privately issued stablecoins[2]. Proponents of both ideas emphasize the potential to modernize a payments system long reliant on commercial banks and cash. Critics warn that these instruments could reduce banking intermediation and raise financial-stability risks[3] In this paper, we study the macroeconomic effects of stablecoins and CBDCs, with an emphasis on whether they disintermediate bank lending.

Both stablecoins and CBDC are designed to serve as electronic means of payment that are alternatives to bank deposits. If these alternatives are more convenient, households are likely to shift funds out of bank deposits. A key difference is that banks use deposits to fund loans to firms and households, whereas stablecoins and CBDC are anchored in public money—directly in the case of a CBDC and indirectly in the case of fully backed stablecoins—and are not matched by new private loans. This raises concerns among policymakers that substitution into stablecoins or a CBDC could shrink bank intermediation.

This simple logic, however, rests on a delicate chain of assumptions. For stablecoins or a CBDC to shrink lending, three conditions must hold: (i) deposits must play a special role in bank funding—banks cannot readily replace them at comparable cost with alternative sources; (ii) bank credit must be special for production—firms cannot substitute it with market-based finance; and (iii) even if the first two conditions hold, banks must not compete aggressively to retain deposits by lowering their markups. Therefore, if high deposit markups concern policymakers, stronger competition for deposits from outside money may be desirable: it can lower markups and potentially increase intermediation.

In this paper, we incorporate the above logic into a general-equilibrium model with banks that have deposit-pricing power and face a profit-linked leverage constraint, and

[1] (U.S. Congress, 2025*b*,*a*).
[2] (European Central Bank, 2025*b*; European Union, 2023).
[3] (Bailey, 2025; Financial Stability Board, 2023; Bank for International Settlements, 2025).

with outside money—stablecoins and a CBDC—available to households. The central result is state dependency: the effect of improving outside-money alternatives depends on banks' capacity to absorb additional leverage. Better outside money intensifies competition for deposits. When the constraint is slack, better outside money compresses deposit markups, raises deposits, and expands lending; as profits are squeezed and the constraint binds, further improvements shift balances into outside money and shrink intermediation—yielding potentially non-monotonic responses. We also show that, in this framework, CBDC remuneration is a substitute for non-pecuniary quality (convenience/acceptance), so a policymaker focused on intermediation can replicate outcomes by adjusting either lever. Hence, the remuneration debate is second-order for intermediation.

In the model, households derive liquidity services from three imperfectly substitutable forms of money—bank deposits, stablecoins, and public money. Banks fund themselves exclusively with deposits and use them to lend to small, bank-dependent firms in the non-corporate sector. Stablecoin providers issue liabilities fully backed by government bonds, and the government supplies public money. Banks face a profit-linked leverage constraint that can limit deposit issuance. Aggregate output combines the production of non-corporate firms and large corporate firms; unlike small non-corporate firms, corporates can finance investment in the bond market. Apart from these features, the environment is a standard detrended neoclassical growth model with capital as the only input.

The first part of the paper analytically characterizes the effects of increasing the convenience/acceptance of stablecoins and of introducing a CBDC. We show that the impact on intermediation depends on which friction limits deposit supply. When banks restrict deposits supply to sustain higher markups, stronger outside competition induces them to cut spreads, raise deposits, and expand lending—improving intermediation. By contrast, when the leverage constraint limits deposit issuance, improvements in outside money compress profits and tighten the constraint; banks cannot cut deposit spreads sufficiently to retain deposits, balances reallocate toward outside money, deposits fall, and lending contracts—i.e., disintermediation.

We highlight three additional results. First, improving convenience of money can have non-monotonic effects: if banks can take on more leverage, modest improvements intensify competition, lower deposit markups, and expand lending, but beyond a threshold profits thin, the leverage constraint binds, and deposits and lending contract. Second, public money's convenience and its remuneration are substitutes: either lever operates through the same channel and has the same qualitative implications for rates and lending, so a policymaker focused on intermediation can replicate outcomes by adjusting either. Third, we show conditions for neutrality: if deposits are not special on the funding side or bank credit is not special on the production side, improvements in outside money leave lending and output unchanged, merely reshuffling household portfolios.

Finally, we calibrate the model to sensible U.S. moments and simulate improvements in stablecoin quality—safer, more widely accepted, or otherwise more useful as a means of payment. In the calibrated steady state, banks' market power—rather than the leverage constraint—is the marginal friction. The exercise shows that, for modest improvements, markups fall and intermediation expands; beyond a threshold, profits thin, the leverage constraint binds, and both deposits and lending contract, generating non-monotonic responses. Importantly, the simulations show that improvements in stablecoins need not manifest as large observed inflows, yet they can operate as a latent competitive force that disciplines deposit markups and increases intermediation without disrupting bank lending.

Related Literature A growing literature studies the implications of introducing a central bank digital currency (CBDC) for bank intermediation and monetary policy. A first set of papers—such as Andolfatto (2021) and Chiu et al. (2023)—show that introducing a CBDC need not lead to disintermediation when banks possess market power: competition for deposits can reduce spreads and expand lending. By contrast, Keister and Sanches (2023) highlight that when banks face a binding balance-sheet constraint, a CBDC can crowd out deposits and contract lending. Our model nests both mechanisms and shows how the interaction between market power and leverage constraints generates non-monotonic effects on intermediation.

Our framework shares similarities with Whited, Wu and Xiao (2023), but it differs in focus. Their analysis is primarily quantitative, estimating the effects of introducing a CBDC both in the aggregate and across heterogeneous banks. We complement their work by providing analytical results that highlight the mechanisms behind the positive or negative effects on intermediation, including the potential for non-monotonic responses.

Our neutrality result connects to the work of Brunnermeier and Niepelt (2019) and

Fernández-Villaverde et al. (2021), who show that a CBDC can be neutral if the central bank redistributes appropriately across sectors. More broadly, our framework relates to Kashyap, Rajan and Stein (2002) and subsequent work emphasizing the special role of deposits in the economy. We formalize this insight within a general-equilibrium setting and show that, absent such "specialness," changes in competition from stablecoins or a CBDC merely reshuffle portfolios without affecting real outcomes.

The emerging literature on stablecoins has focused primarily on their design and stability—examining, for instance, whether they resemble money-market funds (see Aramonte, Schrimpf and Shin, 2021; Gorton and Zhang, 2022; Ma, Zeng and Zhang, 2025) and how leverage and peg mechanisms shape risk. Liao (2022) analyzes the macro-financial implications of large-scale stablecoin adoption, showing that its effects on bank intermediation depend on whether reserves are held as deposits at the central bank or as bank liabilities. Our contribution is to analyze the introduction of stablecoins within a general-equilibrium framework, treating them as another form of public money, and to derive the conditions under which they affect bank lending and output.

2 Model

The model integrates public and private money in a general-equilibrium framework without uncertainty. Stablecoin providers supply liquidity to households, fully backing their liabilities one-to-one with government bonds. Commercial banks issue deposits and set deposit rates with market power, subject to a leverage constraint. Banks use these deposits to extend credit to non-corporate firms, which must borrow to finance capital investment. Firms in the corporate and non-corporate sector produce intermediate goods that serve as inputs for final-good producers. The final good is used both for household consumption and for investment by intermediate-good producers. Corporate firms differ from non-corporate firms in that they can bypass banks by accessing capital markets directly and borrowing from households.

Households can save in the form of public money, bank deposits, stablecoins, and corporate and government bonds. In this setting, we analyze improvements in the quality of stablecoins—understood as greater convenience and wider acceptance—as well as the introduction of a central bank digital currency (CBDC), modeled as an improvement in the quality of public money that may or may not pay interest. The model shows that the effects of stablecoins or a CBDC on bank lending are ambiguous and depend on which financial friction constrains the supply of deposits: banks' market power over deposits or their leverage constraint.

2.1 Households

There is a unit mass of identical, infinitely lived households. Each household derives utility from consumption and from the liquidity services provided by holdings of bank deposits, public money, and stablecoins. In addition, households can save in risk-free bonds issued by corporate firms or the government, which provide no liquidity services. The household's problem in recursive form is

$$V(A) = \max_{\{C,D,S,M,B_H\}} \log\left(C + \nu^{\eta}\frac{L^{1-\eta}}{1-\eta}\right) + \beta\, V(A') \tag{1}$$

subject to,

$$C + D + S + M + B_H + T = \Pi + A \tag{2}$$

$$A' = D\,(1 + r_D) + S\,(1 + r_S) + M\,(1 + r_M) + B_H\,(1 + r) \tag{3}$$

where C denotes consumption and L is an aggregator of bank deposits, stablecoins, and public money—defined below—that captures the liquidity services these assets provide to households. The household receives profits Π from financial intermediaries and firms. Each period, the household enters with savings A, consisting of the principal and interest from all fungible real assets: bank deposits D, stablecoins S, public money M, and risk-free bonds $B_H = B_{H,C} + B_{H,P}$, defined as the sum of government and corporate bonds.[4] The corresponding real interest rates are denoted r_D, r_S, r_M, and r, respectively.[5]

[4] We anticipate that, in equilibrium, both bonds pay the same interest rate.

[5] As we solely focus on steady-state comparisons and neglect the analysis of transition periods, we represent all variables in real terms. Jumps in the price level during transitions will not impact our findings, while changes in inflation would be reflected through adjustments in real interest rates, affecting the demand for real balances.

We refer to the aggregator L as the *liquidity aggregator*[6] and to its value as liquidity holdings. Similar to Drechsler, Savov and Schnabl (2017), liquid assets L are modeled as an aggregator of deposits D, stablecoins S, and public money M, with these three assets treated as imperfect substitutes. In addition, consistent with Abadi, Brunnermeier and Koby (2023), we introduce a liquidity satiation point $L^\star$, beyond which households choose not to further expand their liquidity position.[7] We assume that L follows a CES form defined by

$$L = \min\{L^\star, \left(\omega_M^\varepsilon \cdot M^{1-\varepsilon} + \omega_S^\varepsilon \cdot S^{1-\varepsilon} + D^{1-\varepsilon}\right)^{\frac{1}{1-\varepsilon}}\} \tag{4}$$

The functional forms assumed allow us to write households' optimal demands for liquidity, deposits and public money solely as a function of current spreads:

$$L = \min\{L^\star, \nu s_L^{-1/\eta}\}, \tag{5}$$

$$D = L\left(\frac{s_D}{s_L}\right)^{-1/\varepsilon}, \tag{6}$$

$$M = \omega_M L\left(\frac{s_M}{s_L}\right)^{-1/\varepsilon}, \tag{7}$$

$$S = \omega_S L\left(\frac{s_S}{s_L}\right)^{-1/\varepsilon}, \tag{8}$$

where spreads are defined as $s_D \equiv \frac{r-r_D}{1+r}$, $s_S \equiv \frac{r-r_S}{1+r}$, $s_M \equiv \frac{r-r_M}{1+r}$ and $s_L \equiv \left[s_D^{\frac{\varepsilon-1}{\varepsilon}} + \omega_M s_M^{\frac{\varepsilon-1}{\varepsilon}} + \omega_S s_S^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}$.

Finally, an Euler equation completes the household's optimal choices:

$$\left[C + \nu^\eta \frac{L^{(1-\eta)}}{1-\eta}\right]^{-1} = \beta(1+r)\left[C' + \nu^\eta \frac{L'^{(1-\eta)}}{1-\eta}\right]^{-1} \tag{9}$$

Details on the derivation can be found in Appendix A.1. For later reference, the discount

[6] Strictly speaking, all assets are liquid in the sense that they can be converted into consumption without cost or delay. However, only public money, stablecoins and bank deposits provide direct liquidity services.

[7] The satiation point is introduced solely for technical reasons, to rule out a corner solution in which households demand infinite deposits. As long as the satiation point does not bind, its level does not affect our results.

factor, Λ, of the household is given by,

$$\Lambda \equiv \beta \frac{\left[C' + \nu^{\eta} \frac{L'^{(1-\eta)}}{1-\eta}\right]^{-1}}{\left[C + \nu^{\eta} \frac{L^{(1-\eta)}}{1-\eta}\right]^{-1}} \tag{10}$$

Below we assume an ordering of household elasticities that we will use to guarantee a unique interior monopoly-pricing solution for banks:

Assumption 1 (Elasticity ordering)**.** *We assume $\varepsilon^{-1} > 1$ (deposits, stablecoins, and public money are imperfect substitutes as sources of liquidity) and $\eta^{-1} < 1$ (aggregate liquidity demand has elasticity below one).*

2.2 Firms

The economy produces a final good used for consumption and investment and intermediate goods used as inputs in final-good production. Intermediate goods are supplied by two sectors—a large-firm corporate sector (C) and a non-corporate small-firm sector (N)—that differ in productivity and financing options. While large firms can issue bonds on financial markets, small firms in the non-corporate sector rely exclusively on bank loans to fund their operations. Similar financing assumptions are made in Abadi, Brunnermeier and Koby (2023), and also such arrangements can arise as an optimal choice by banks and firms and are consistent with the data (De Fiore and Uhlig, 2011).

Final-good producers operate in a competitive market, produce output Y, and use intermediate inputs from a corporate sector, y_C, and a non-corporate sector, y_N, which are imperfect substitutes. In each period, they maximize

$$\max_{\{y_N, y_C\}} Y(y_N, y_C) - p_N y_N - p_C y_C, \tag{11}$$

where the final good is the numeraire and p_N and p_C are the relative prices of non-corporate and corporate output, respectively. The production function is

$$Y = \left[y_N^{\frac{\rho-1}{\rho}} + y_C^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}, \tag{12}$$

where ρ is the elasticity of substitution between the intermediate goods. The solution to the problem is characterized by

$$y_C = Y\, p_C^{-\rho}, \tag{13}$$

$$y_N = Y\, p_N^{-\rho}. \tag{14}$$

Intermediate good producers produce using only capital. There are small firms in the non-corporate sector N and large corporate firms C who produce output y_N and y_C with a decreasing returns to scale production technology. Non-corporate and corporate firms have constant productivity A_N and A_C, respectively. Capital depreciates over time at rate δ. Firms distribute all profits to households every period. To invest in new capital, firms need to borrow. Corporate firms issue risk-free bonds B_C at rate r that can be held by both households and banks. The ex-dividend value of the corporate firm in recursive form is:

$$V_C\left(K_C\right) = \max_{I_C, K_C'} \Lambda\left[p_C' A_C \left(K_C'\right)^{\alpha} - I_C\left(1+r\right)\right] + \Lambda'\, V_C\left(K_C'\right) \tag{15}$$

subject to

$$K_C' = I_C + \left(1-\delta\right) K_C \tag{16}$$

where Λ is the household's discount rate defined in (10). The corporate firm sells its output $y_C = A_C K_C^{\alpha}$ to final goods producers at price p_C. Equation (16) depicts a standard flow equation for capital without adjustment costs. The solution to the corporate firm's problem is characterized by:

$$\alpha p_C' A_C \left(K_C'\right)^{\alpha-1} = r + \delta \tag{17}$$

Non-corporate firms cannot issue bonds directly to households and must borrow from banks at rate r_ℓ. Their maximization problem in recursive form is:

$$V_N\left(K_N\right) = \max_{I_N, K_N'} \Lambda\left[p_N' A_N \left(K_N'\right)^{\alpha} - I_N\left(1+r_\ell\right)\right] + \Lambda'\, V_N\left(K_N'\right) \tag{18}$$

subject to

$$K_N' = I_N + (1-\delta)\, K_N. \tag{19}$$

The solution to the non-corporate firm's optimization problem is:

$$\alpha p_N' A_N (K_N')^{\alpha-1} = 1 + r_\ell - (1-\delta)\,\frac{1+r_\ell'}{1+r'} \tag{20}$$

A derivation of both the corporate and the non-corporate firms' optimization problems is available in Appendix A.2.

It is illustrative to express the previous condition in steady state to highlight the role of banks in distorting the allocation:

$$\alpha p_N A_N (K_N)^{\alpha-1} = (1+s_\ell)\,(r+\delta) \tag{21}$$

Combining this expression with the FOC of corporate firms (17) yields

$$\frac{\alpha p_N A_N (K_N)^{\alpha-1}}{\alpha p_C A_C\,(K_C)^{\alpha-1}} = (1+s_\ell) \tag{22}$$

The left-hand side represents the ratio of the marginal product of capital across the two sectors. Hence, the loan spread s_ℓ appears as a wedge that prevents their equality. A reduction in this wedge would raise output and improve welfare.

2.3 Banks

There is a unit mass of homogeneous banks, owned by households, with each bank operating on a separate island. An equal random sample of households resides on each island, and households cannot relocate across islands. Banks collect deposits, D, from households and extend loans, ℓ, to small firms. Loan supply is perfectly competitive on a common island where production and consumption take place. By contrast, deposits are raised locally: on each island, the resident bank is a monopolist in its deposit market. As a result, banks internalize the impact of their deposit pricing on local households' consumption and savings decisions, while remaining too small to influence other aggregate quantities and prices.

Banks can also hold risk-free bonds issued by corporate firms as well as public debt, $B_B = B_{B,C} + B_{B,P}$, in positive quantities. Each period, profits are distributed back to households.[8] Banks are subject to a leverage constraint that links profits, Π_B, to their debt level through an increasing function $\phi(\Pi_B)$. We assume that $\phi(\Pi_B)$ is increasing $\phi'(\Pi_B) > 0$, satisfies $\phi(0) = 0$ and is weakly concave $\phi''(\Pi_B) \leq 0$.[9] Each period, a representative bank solves

$$\max_{\ell,B_B,r_D} \Lambda \cdot \Pi_B = \max_{\ell,B_B,r_D} \Lambda \cdot [\ell\,(1+r_\ell) + B_B\,(1+r_B) - D(r_D)\,(1+r_D)] \tag{23}$$

subject to

$$\begin{aligned} \ell + B_B &= D(r_D), \\ D(r_D) &\leq \phi\left(\Pi_B\right), \\ B_{B,C}, B_{B,P} &\geq 0. \end{aligned}$$

where Λ is the household discount rate. The first constraint represents the balance sheet identity: loans and bond holdings must be financed by deposits. The second constraint is the leverage condition, which requires leverage not to exceed the function $\phi(\Pi_B)$. In addition, we assume that banks cannot borrow risk-free bonds.

The optimal deposit spread chosen by banks is derived in Appendix A.3 and characterized by

$$s_D = \varepsilon_D^{-1} + \kappa - s_\ell \tag{24}$$

where κ is zero if the leverage constraint is loose, i.e., $D(r_D) < \phi\left(\Pi_B\right)$, and positive otherwise. $\varepsilon_D(s_D)$ is the semi-elasticity of the demand for deposits with respect to its spreads which is characterized by[10]

$$\varepsilon_D(s_D) = \frac{\varepsilon^{-1}\left(1-\omega_D\right) + \eta^{-1}\omega_D}{s_D} \tag{25}$$

[8] For simplicity, we abstract from equity issuance and from financing loans through wholesale funding. These features could be incorporated by introducing an additional cost of raising external funding, as in Whited, Wu and Xiao (2023).

[9] In Appendix A.4 we discuss and motivate the shape of this constraint.

[10] A derivation of ε_D is available in Appendix A.5.

where

$$\omega_D \equiv \frac{s_D D}{s_D D + s_M M + s_S S} \tag{26}$$

Equation (24) shows that the optimal deposit spread in the banking sector, denoted as s_D, is influenced by three factors. The first one arises from market power in the deposit market, manifesting itself in the initial term of Equation (24) as the inverse of the semi-elasticity of deposits, $\varepsilon_D(s_D)^{-1}$. Similar to a classical monopoly scenario, a higher demand elasticity implies a lower markup that the monopolist optimally charges its customers. Notably, this elasticity depends on the market share of deposits within overall liquidity, $\omega_D \in [0, 1]$. The larger the share of deposits, the closer it aligns with the elasticity of liquidity, η^{-1}. The smaller the share, the closer it is to the elasticity between deposits and public money, ε^{-1}. Changes in household preferences for public money will influence the market share of deposits, thereby affecting the optimal spread charged by banks.[11]

The second factor shaping the spread is the potentially binding leverage constraint, which is captured by the second term in Equation (24): $\kappa \geq 0$. The term is only positive when the leverage constraint binds, i.e., when $D = \phi(\Pi_B)$. In a binding state, the bank would like to increase deposits to finance loans but is limited by the constraint. As a result, the deposit rate must fall—spread must increase—below the rate an unconstrained bank would charge, accommodating the need to lower deposits to adhere to the maximum allowed leverage.

The last term in Equation (24), s_ℓ, corresponds to the spread on loans, acting as a counteracting force to the deposit spread: the higher the spread on loans, the lower the one on deposits. A higher spread on loans s_ℓ incentivizes banks to issue more deposits to fund them, leading to a lowering of the deposit spread s_D.

Lastly, Proposition 1 shows that banks do not hold bonds if loans pay a higher interest rate.

Proposition 1. *If the interest rate spread between loans and bonds is positive, i.e.*

[11] Note that with $\kappa = 0$, (24) gives $\varepsilon^{-1}(1 - \omega_D) + \eta^{-1}\omega_D = \frac{1}{1+s_\ell/s_D} < 1$; an interior solution exists iff $\eta^{-1} < \frac{1}{1+s_\ell/s_D}$, i.e., η^{-1} is sufficiently below one. A similar (though looser) condition is assumed in Drechsler, Savov and Schnabl (2017).

$r_\ell - r > 0$ or $s_\ell > 0$, then banks do not hold bonds, i.e. $B_B = 0$

A proof is available in Appendix B.1. The intuition for this is straightforward: banks have no incentive other than return to invest in an asset and therefore choose to hold only the one with the highest return.

2.4 Stablecoin Providers

Stablecoin providers collect funds from households and issue stablecoins. We focus on the type of stablecoin that is fully collateralized with government bonds[12]. Specifically, for each unit of stablecoins S demanded by households, providers hold an equal amount of bonds $B_{S,P}$, so that $S = B_{S,P}$. These providers may earn profits whenever the return on bonds exceeds the interest they promise on stablecoins:

$$\Pi_S = (1+r)B_{S,P} - (1+r_S)S, \quad \text{with } S = B_{S,P}. \tag{27}$$

These profits are rebated to households every period. We take stablecoin pricing as given and assume that stablecoins pay the same return as public money in steady state, $r_S = r_M$, consistent with the prevailing practice for custodial stablecoins that pay zero nominal return. When analyzing changes in the return on public money, we keep the return on stablecoins as fixed at its steady-state level.

2.5 Government - Central Bank

The government determines the return on public money r_M and the aggregate level of government bonds B_P. Its budget constraint is

$$B_P(1+r) + M(1+r_M) = M' + B'_P + T \tag{28}$$

where public money M is determined by demand and taxes/transfers T balance the equation.

[12]Reserve composition differs across issuers. For example, Tether (USDT), the largest stablecoin, reports that the majority of its reserves are invested in short-term U.S. Treasury bills, with smaller shares in repos, cash, gold, Bitcoin, and secured loans (see Tether's quarterly attestations, e.g. BDO 2025).

2.6 Equilibrium

In each period the goods and the lending markets clear:

$$Y = C + I_C + I_N \tag{29}$$

$$I_C = B_{H,C} + B_{B,C} \tag{30}$$

$$I_N = \ell \tag{31}$$

$$B_P = B_{S,P} + B_{H,P} + B_{B,P} \tag{32}$$

Given market clearing, we can define an equilibrium.

Definition 1. *An equilibrium is an allocation for the representative household* $\{C_t, L_t, M_t, D_t, S_t, B_{H,t}\}_{t=0}^{\infty}$ *an allocation for the final good producers* $\{y_{C,t}, y_{N,t}\}_{t=0}^{\infty}$*, an allocation for corporate firms* $\{K_{C,t+1}, I_{C,t}\}_{t=0}^{\infty}$*, an allocation for non-corporate firms* $\{K_{N,t+1}, I_{N,t}\}_{t=0}^{\infty}$*, an allocation for banks* $\{\ell_t, B_{B,t}, r_{D,t}\}_{t=0}^{\infty}$*, an allocation for stablecoin suppliers* $\{S_t, B_{S,t}, r_{S,t}\}_{t=0}^{\infty}$*, a set of prices* $\{p_{C,t}, p_{N,t}, r_t, r_{\ell,t}\}_{t=0}^{\infty}$*, government policy* $\{T_t, B_{P,t}, r_{M,t}\}_{t=0}^{\infty}$ *such that:*

1. *Given* $\{r_t, r_{D,t}, r_{S,t}, r_{M,t}, T_t, \Pi_t\}_{t=0}^{\infty}$*—where* Π_t *denotes aggregate profits rebated to households—the household allocation* $\{C_t, L_t, M_t, D_t, S_t, B_{H,t}\}_{t=0}^{\infty}$ *solves the household's problem.*

2. *Given* $\{p_{C,t}, p_{N,t}\}_{t=0}^{\infty}$*, the allocation for the final good producers* $\{y_{C,t}, y_{N,t}\}_{t=0}^{\infty}$ *solves their problem.*

3. *Given* $\{p_{C,t}, r_t\}_{t=0}^{\infty}$*, the allocation for corporate firms* $\{K_{C,t+1}, I_{C,t}\}_{t=0}^{\infty}$ *solves their problem.*

4. *Given* $\{p_{N,t}, r_{\ell,t}\}_{t=0}^{\infty}$*, the allocation for non-corporate firms* $\{K_{N,t+1}, I_{N,t}\}_{t=0}^{\infty}$ *solves their problem.*

5. *Given* $\{r_{\ell,t}, r_t\}_{t=0}^{\infty}$*, the allocation for banks* $\{\ell_t, B_{B,t}, r_{D,t}\}_{t=0}^{\infty}$ *solves their problem.*

6. *Stablecoin providers are passive entities. For each* t*, they satisfy the balance-sheet identity* $S_t = B_{S,P,t}$ *and the pricing convention that* $r_{S,t}$ *is exogenous with* $r_S = r_M$ *in steady state.*

7. *Market for goods and lending clear.*

8. *The government budget constraint is satisfied.*

In Appendix C we describe the equilibrium equations and show how we solve the model.

We focus exclusively on steady-state equilibrium. An equilibrium is defined as steady-state if relative prices and quantities are constant. We restrict attention to equilibria with positive and finite quantities and prices and, in the case of liquidity, require $L < L^{\star}$. We choose the level of $L^{\star}$ such that this condition holds. Positive prices are also imposed on spreads, i.e., $s_D, s_\ell > 0$. Finally, we assume $r > -1$ and $r_D > -1$, which rules out negative gross returns: neither bonds nor banks can require repayments that exceed the principal in the following period.

3 Stablecoins, CBDC, and Bank Intermediation

In this section we study how improvements in stablecoins and the introduction of a central bank digital currency (CBDC) affect bank intermediation and aggregate output. We model stablecoin improvements in reduced form as an increase in households' preference for holding liquidity in the form of stablecoins, captured by a rise in ω_S. Such improvements reflect ongoing efforts to enhance their safety, usability, regulation, and wider acceptance—including the recent U.S. legislation establishing a regulatory framework for stablecoin issuance—as well as their integration into payment systems. By contrast, the introduction of a CBDC is modeled as an increase in households' preference for public money, ω_M, and/or as an increase in its pecuniary return, represented by a lower spread s_M. Throughout, we focus on steady-state comparisons.

Our first result is that both stablecoin improvements and the introduction of a CBDC unambiguously lower the deposit spread s_D—the implicit price households pay for holding deposits. The effect on bank lending, however, depends on whether the leverage constraint binds. When the constraint is binding ($\kappa > 0$), stronger competition from alternative liquid instruments tightens banks' profit-based constraint and reduces intermediation. By contrast, when it does not bind ($\kappa = 0$), greater household demand for stablecoins or public money reduces banks' market power in deposit markets and lending expands. Our findings also imply that the common policy debate on whether a CBDC should pay interest is of second-order importance: what matters is that households value both the non-pecuniary attributes (ω_S or ω_M) and the pecuniary return (s_M) of alternative liquid instruments. From a policy perspective, ω_M and s_M act as substitutes, and raising either dimension can trigger disintermediation.

We also show that improvements in stablecoins or the introduction of a CBDC may have non-monotonic effects. Increases in ω_S or ω_M may initially expand intermediation by compressing deposit and loan spreads, but if they rise too much, this effect can reverse once the leverage constraint becomes binding. Finally, we show that these innovations affect aggregate output only if deposits and banks play a "special" role in the economy: deposits must be imperfect substitutes for banks' bond financing and bank lending an imperfect substitute for corporate bond financing for innovations in stablecoin or CBDC to affect output.

3.1 Analytical Results

We begin by showing that the impact of improving the quality of stablecoins as a source of liquidity or introducing a CBDC on bank lending and output depends on which marginal friction binds in the banking system. First we define the two possible regions in which the equilibrium of this economy can lie.

Definition 2. *For a given ω_S, ω_M and r_M, the equilibrium steady-state prices and quantities belong to the constrained region if the bank's borrowing constraint is binding—that is, if $\kappa > 0$ and $D = \phi(\Pi_B)$. Alternatively, if the borrowing constraint does not bind ($\kappa = 0$), the equilibrium belongs to the unconstrained region.*

The key takeaway is that the marginal source of deposits spreads differs across regions. In the unconstrained region, spreads are driven by banks' market power over depositors: banks optimally set deposit rates below lending rates ($r_D < r_\ell$), and marginal changes in the borrowing constraint have no effect, as it is not binding. In the constrained region, by contrast, the borrowing constraint binds and spreads are determined at the margin by the tightness of this constraint.

Improvements in the quality of stablecoins or the introduction of a CBDC increase competition for deposits from outside options. The effect of this additional competition depends on which friction is relevant in the banking sector. The following proposition formalizes this idea.

Proposition 2. *An improvement in stablecoins—modeled as a marginal increase in households' valuation of their liquidity services (ω_S)—or the introduction of a CBDC—modeled as a marginal increase in households' valuation of central bank money (ω_M) and/or its return (a lower spread s_M)—has the following steady-state effects:*

1. *The deposit spread s_D decreases.*
2. *Unconstrained region ($\kappa = 0$):*
   (a) *The loan spread s_ℓ decreases;*
   (b) *Deposits D and bank lending ℓ increase.*
   (c) *Aggregate output Y increases.*
3. *Constrained region ($\kappa > 0$):*
   (a) *The loan spread s_ℓ increases;*
   (b) *Deposits D and bank lending ℓ decrease.*
   (c) *Aggregate output Y falls.*

Proofs are presented in Appendices B.2 and B.3.

Proposition 2 implies that when the bank's leverage constraint does not bind, a marginal increase in the quality of stablecoins (ω_S), in public money (ω_M), and/or in its return (r_M) reduces the household cost of holding deposits s_D without causing disintermediation. In fact, it leads to an expansion of bank lending.

The intuition is that improvements in the liquidity services of outside options to bank deposits—captured by higher $\omega_{S,M}$—translate into stronger competition in the deposit market, that is, a more elastic demand curve for deposits faced by banks, holding prices constant. The mechanism is that households reallocate liquidity toward stablecoins or public money, reducing the market share of deposits. A smaller market share implies a higher demand elasticity, as elasticity varies inversely with market share (see equation

(25)).[13] Banks then respond optimally to stronger competition by lowering deposit spreads.

The lower relative price of deposits outweighs the initial preference shift. Deposits increase, and this expansion passes through to loan pricing: the loan spread s_ℓ falls, which stimulates borrowing by small non-corporate firms. As a result, both deposits and bank lending rise. The fall in spreads reduces the wedge in marginal revenues between sectors in equation 22, thereby raising aggregate output.

The effect of stablecoins and CBDC depends crucially on whether market power, rather than the leverage constraint, is the marginal source of deposit spreads. Point (3) of Proposition 2 states that if the leverage constraint binds, an increase in ω_S, ω_M and/or r_M leads to bank disintermediation. The reason is that the banking sector cannot absorb additional deposits without violating the leverage constraint ($D \leq \phi(\Pi_B)$).

In this case, when ω_S, ω_M, or r_M rises, a monopolistic bank would, absent the constraint, lower the deposit spread to attract more deposits and maximize profits. However, the leverage constraint prevents this adjustment. As a result, improvements in stablecoins or the introduction of a CBDC intensify competition, reduce bank profits, and tighten the constraint, ultimately displacing deposits. This outflow contracts loan supply, raises the equilibrium lending rate and reduces aggregate output.

In summary, Proposition 2 shows that the effects of stablecoin improvements or a CBDC on intermediation depend on the binding friction: lending expands when market power is the marginal source of deposit spreads, but contracts when the leverage constraint binds.

An important implication of Proposition 2 is the possibility of non-monotonic effects: as the attractiveness of stablecoins or public money increases, the economy can transition from the unconstrained to the constrained region. The next proposition formalizes this "region-switching": For small improvements in stablecoins or public money (higher ω_S, ω_M or r_M), competition in deposits increases competition for liquid funds, banks lower spreads, and intermediation expands; beyond a threshold, however, profits compress, the leverage constraint binds, and further improvements trigger disintermediation.

[13] This requires that the elasticity of substitution between deposits, stablecoins, and public money is greater than that between liquidity and consumption—formally, $\varepsilon^{-1} > \eta^{-1}$ as we assume in Assumption 1.

Proposition 3 (Non-monotonic effects)**.** *Suppose the initial equilibrium lies in the* unconstrained *region* ($\kappa = 0$) *and the output elasticity of capital is sufficiently low (i.e.,* α *is low). Then:*

1. *For small increases in either* ω_S, ω_M *or* r_M*, the loan spread* s_ℓ *decreases and bank lending* ℓ *increases, as established in Proposition 2.*

2. *There exists a threshold for each variable* $\{\bar{\omega}_S, \bar{\omega}_M, \bar{r}_M\}$ *such that for increases beyond this point the equilibrium is pushed into the* constrained *region* ($\kappa > 0$) *and the effects reverse:* s_ℓ *increases and* ℓ *decreases.*

The proof is presented in Appendix B.2.1.

Proposition 3 follows because more useful stablecoins or a CBDC increase competition in the market for liquid funds. Banks would like to respond by cutting the deposit spread s_D, which attracts deposits and expands intermediation. This adjustment is feasible only in the *unconstrained* region. Narrower spreads, however, compress profits Π_B. With D higher and Π_B lower, the leverage condition $D \leq \phi(\Pi_B)$ tightens, moving the bank closer to the constraint. A low output elasticity of capital (small α) ensures that the additional loan supply does not raise profits enough to offset this tightening.

Once increases in $\omega_{S,M}$ or r_M are sufficiently large, the leverage constraint binds. At that point, the bank cannot cut s_D further without violating the constraint. Households reallocate out of deposits toward stablecoins or public money, deposits fall, loan supply contracts, and the loan spread s_ℓ rises—i.e., disintermediation sets in.

It is worth noting that Propositions 2 and 3 establish that increasing the quality of stablecoins (ω_S), the quality of public money (ω_M), or the return on public money (r_M) has the same qualitative effect on interest rates, bank lending and output. The next corollary formalizes this equivalence and provides a quantitative mapping from changes in the price of public money s_M to changes in the quality of public and stablacoins ω_M and ω_S.

Corollary 1. *Quantitative equivalence between changes*

i) A 1 percent increase in the quality of public money ω_M *has the same effect on steady-state equilibrium variables as a* $\frac{1}{\varepsilon^{-1}-1}$ *percent reduction in the spread on public money*

s_M. Formally, for any variable of interest y (such as equilibrium loans ℓ or aggregate output Y),

$$\frac{\partial \log y}{\partial \log \omega_M} = -\frac{1}{\varepsilon^{-1} - 1} \frac{\partial \log y}{\partial \log s_M}.$$

ii) A 1 percent increase in the quality of stablecoins ω_S has the same effect on steady-state equilibrium variables as a $\frac{\omega_S}{\omega_M}$ percent increase in the quality of public money ω_M. Formally, for any variable of interest y,

$$\frac{\partial \log y}{\partial \log \omega_S} = \frac{\omega_S}{\omega_M} \frac{\partial \log y}{\partial \log \omega_M}.$$

A proof is available in Appendix B.4.

Policymakers have generally opposed paying interest on retail CBDC[14]. Corollary 1 implies that, if disintermediation is the relevant concern, remuneration of CBDC is not the only relevant margin. Design features that enhance the non-pecuniary value of a CBDC—such as convenience, acceptance, interoperability, or privacy (captured by ω_M)—can be just as powerful as interest-bearing features in shifting household portfolios and affecting intermediation.

Corollary 1 also provides a quantitative mapping between the elasticity of equilibrium variables with respect to the public-money spread s_M and the elasticities with respect to ω_S and ω_M, the quality of stablecoins and public money. For example, suppose we have an estimate of the elasticity of loans with respect to the public-money spread, $\hat{\beta}_{s_M} \equiv \frac{\partial \ln D}{\partial \ln s_M}$ and a reasonable value for the liquidity-substitution elasticity ε^{-1}. Then the corresponding elasticity with respect to ω_M is $\frac{\partial \ln \ell}{\partial \ln \omega_M} = -\frac{1}{\varepsilon^{-1}-1} \hat{\beta}_{s_M}$. Thus, model comparative statics with respect to the relatively opaque preference parameter ω_M can be mapped into observable changes in the spread on public money s_M.[15]

The final point in this section clarifies the conditions under which stablecoins or a CBDC—by increasing competition for liquid funds—will affect intermediation: deposits must be "special" on both sides of the bank balance sheet. On the liability side, deposits

[14]See, for example, the ECB's public materials on the digital euro and the Bank of England/HM Treasury response to the digital pound consultation, which state that holdings would *not* be remunerated; e.g., European Central Bank (2025*a*); HM Treasury and Bank of England (2024).

[15]Since public money has traditionally not paid interest, estimating the elasticity with respect to s_M is equivalent to estimating the elasticity with respect to short-term interest rates r. This can be done empirically by using an exogenous instrument for r, as is done in many papers in the in the literature.

must be a special source of funding for banks (in our baseline they are the only funding source—no wholesale or bond issuance). On the asset side, bank credit must be special for aggregate production (in our baseline, non-corporate firms are bank-dependent, and the final-good technology requires their input because non-corporate and corporate outputs are imperfect substitutes). Absent either form of "specialness," tighter competition for liquid balances will not alter equilibrium intermediation—only the composition of household portfolios.

If either banks can borrow freely on wholesale markets or non-corporate firms can bypass banks and borrow like corporates, the introduction of a CBDC is neutral for intermediation. The next proposition formalizes this neutrality result.

Proposition 4 (Neutrality without deposit or bank-credit "specialness")**.** *Suppose one of the following holds:*

1. Deposits not special: *Banks can replace deposits with wholesale funding supplied by households at a given constant rate and wholesale funding does not enter the borrowing constraint; or*
2. Bank credit not special: *Small firms can borrow directly from households at a given constant rate.*

Then improvements in stablecoins (modeled as an increase in ω_S) or the introduction of a CBDC (modeled as an increase in ω_M and/or r_M) have no effect on bank intermediation: equilibrium bank lending ℓ, the loan spread s_ℓ and aggregate output Y are unchanged. The only impact is on the composition of household balance sheets, as households reshuffle between deposits, public money, and stablecoins.

A proof is available in Appendix B.5.

Proposition 4 formalizes that changes in banking competition affect real outcomes only when the instruments on both sides of banks' balance sheets are special—deposits as a special source of funding and loans as a special financial input. Absent either feature, a stablecoin- or CBDC-induced increase in competition for liquid funds is neutral for intermediation and output.

Without both forms of specialness, competition from stablecoins or CBDC merely reshuffles household portfolios without affecting real activity. Quantitatively, the magnitude of these effects depends on two key elasticities: (i) banks' liability-side substitution between deposits and wholesale funding, and (ii) firms' substitution between bank loans and market (bond) borrowing.[16]

The next section presents a quantitative exercise that illustrates our results.

3.2 Numerical Illustration

In this section, we simulate the introduction of outside money and how frictions in the financial sector determine its impact on bank lending. We calibrate the parameters of the model to match key moments in the US economy and simulate an increase in the households' preference for outside money—either through a higher stablecoin demand (ω_S) or an introduction of CBDC (ω_M).

3.2.1 Calibration

The model is calibrated to match key moments of the U.S. economy over the period 1987–2019, where each period in the model corresponds to one year. A subset of parameters is taken directly from the existing literature, while the remaining ones are chosen to match salient moments in the data. Table 1 summarizes the parameters calibrated externally from previous studies.

Table 1: Externally calibrated parameters

Parameter	Description	Value	Source
ρ	Elasticity between intermediate goods	3.9	Abadi, Brunnermeier and Koby (2023)
δ	Depreciation rate	0.1	Abadi, Brunnermeier and Koby (2023)
ε	Elasticity between M, D, and S	0.4	see text

We follow Abadi, Brunnermeier and Koby (2023) in setting the elasticity of substitution between intermediate goods to $\rho = 3.9$ and the depreciation rate to $\delta = 0.1$. The elasticity between liquidity sources, denoted as ε^{-1}, is relevant for understanding outside money's impact on the outflow from private to other forms of money. However, the

[16] Estimating these elasticities is beyond the scope of this paper. For a related quantitative assessment, see Whited, Wu and Xiao (2023).

literature lacks consensus on a specific value for this parameter. We opt for $\varepsilon = 0.4$, considering it as a midpoint among estimates found in the literature.[17]

Crucial for our conclusions is how we interpret—and thus calibrate—the borrowing constraint faced by banks. The literature offers several interpretations and microfoundations. In the macro-finance tradition, the constraint is typically microfounded as an agency or moral-hazard limit on leverage (e.g., Gertler and Kiyotaki (2015)) and is generally the sole source of banking spreads. In the banking and corporate-finance literature, constraints reflect regulatory capital requirements or risk-based leverage rules (e.g., Whited, Wu and Xiao (2023), Adrian and Boyarchenko (2012)). This choice is crucial for our framework because, in our model, both the source of bank spreads—whether they arise from market power in deposit markets or from a binding leverage constraint—and the tightness of banks' constraint determine the effects of improving the quality of outside liquidity.

For our baseline calibration, we assume a linear borrowing constraint, $\phi(\Pi_B) = \phi \cdot \Pi_B$. As shown in Appendix A.4, a linear constraint on profits ($D \leq \phi\Pi_B$) can be mapped into the more common formulation in the literature that links the size of the balance sheet to equity (e), $\ell + B \leq \varphi \cdot e$. This mapping requires setting $\phi = \varphi/\gamma$, where φ denotes the maximum leverage ratio and γ is the ratio of profits to equity, $\gamma = \Pi_B/e$. Our choice of φ depends on the interpretation of the constraint; we set $\varphi = 10$ in our main calibration, corresponding to a midpoint in the range of values used in the literature.[18] We map γ to the data using FDIC data on banks' net interest income and equity, which yields $\phi = 25$ in our main calibration. Further details are provided in Appendix E.

The remaining parameters are chosen to align with moments observed in US data that are presented in Table 2. We target the time series average of the deposit spread s_D, the spread on cash s_M, the loan rate spread s_ℓ, deposit supply over GDP, D/Y, the share of money holdings over deposit holdings, M/D, and the real rate r. Furthermore, we set the stablecoin-to-deposit ratio $S/D = 0$, reflecting that privately issued, fully backed stablecoins were negligible in the U.S. over our calibration period and we set the stablecoin interest rate spread equal to the one on cash, since stablecoins mostly do not

[17]For instance, Wang (2020) uses $\varepsilon \approx 0.125$, Abad, Nuño and Thomas (2023) $\varepsilon \approx 0.15$, Burlon, Muñoz and Smets (2023) $\varepsilon \approx 0.3$, George, Xie and Alba (2022) $\varepsilon \approx 0.4$, and Perazzi and Bacchetta (2022) $\varepsilon \approx 0.7$.

[18]For example, Gertler and Kiyotaki (2015) use $\varphi = 8$, while Whited, Wu and Xiao (2023) adopt $\varphi = 0.06^{-1}$.

pay interest. Lastly, following Abadi, Brunnermeier and Koby (2023), we interpret the bank-dependent non-corporate sector as small and medium-sized enterprises (SMEs) and use estimates from the U.S. Small Business Administration's Office of Advocacy, which reports that SMEs account for roughly 43 percent of U.S. output. Further details on the data are provided in Appendix D. We choose parameters assuming that the leverage constraint is slack in steady state, and confirm afterward that this is indeed the case, implying that in our calibration the marginal friction arises from banks' market power on deposits.

Table 2: Targeted Moments

Moment	**Description**	**Value**	**Source**
r	Real rate on bonds	1.0%	FRED
s_D	Deposit spread	2.0%	FDIC
s_M	Cash spread	3.5%	FRED
s_S	Stablecoin spread	3.5%	s_M
s_ℓ	Loan spread	3.5%	FDIC
D/Y	Deposit demand	0.44	FRED
M/D	Cash over deposit holdings	0.05	FRED
S/D	Stablecoins over deposit holdings	0	No stablecoin supply
$p_N y_N/Y$	Share of non corporate production	43%	SBA Advocacy (2024)

Note: The table presents the targeted moments used to derive the parameters shown in Table 3. Data values represent the time series average of the US economy from 1987 to 2019. Cash holdings are adjusted for currency holdings abroad, following Judson (2017). For additional information on the data, refer to Appendix D.

The calibrated parameters are presented in Table 3. The discount factor β is set to match the real interest rate $\beta = (1+r)^{-1}$. The preference parameter for public money ($\omega_M = 0.2$) and stablecoins ($\omega_S = 0$) are chosen to meet the respective shares of money/stablecoins with respect to deposits. The liquidity elasticity (η) and preference (ν) parameters are chosen to meet money demand and the deposit rate spread. The parameters on the firm problem (α, A_S, A_C) are chosen to target the corporate vs. non-corporate production shares and loan spread. Lastly, we set the liquidity satiation point L^* large enough such that it never binds but ensures an interior solution to the bank's problem.

Table 3: Calibrated Parameters

Par.	**Description**	**Value**
β	Discount factor	0.99
ω_M	Preference for M	0.20
ω_S	Preference for S	0
η^{-1}	Liquidity elasticity	0.18
ν	Liquidity Preference	0.76
α	Output elasticity of capital	0.89
A_N	Productivity non-corporate firm	0.14
A_C	Productivity corporate firm	0.12
ϕ	Leverage ratio	24.9

Note: The table shows the calibrated parameters to match the moments in Table 2. The choice of ϕ combines previous literature and moments from the data (see text).

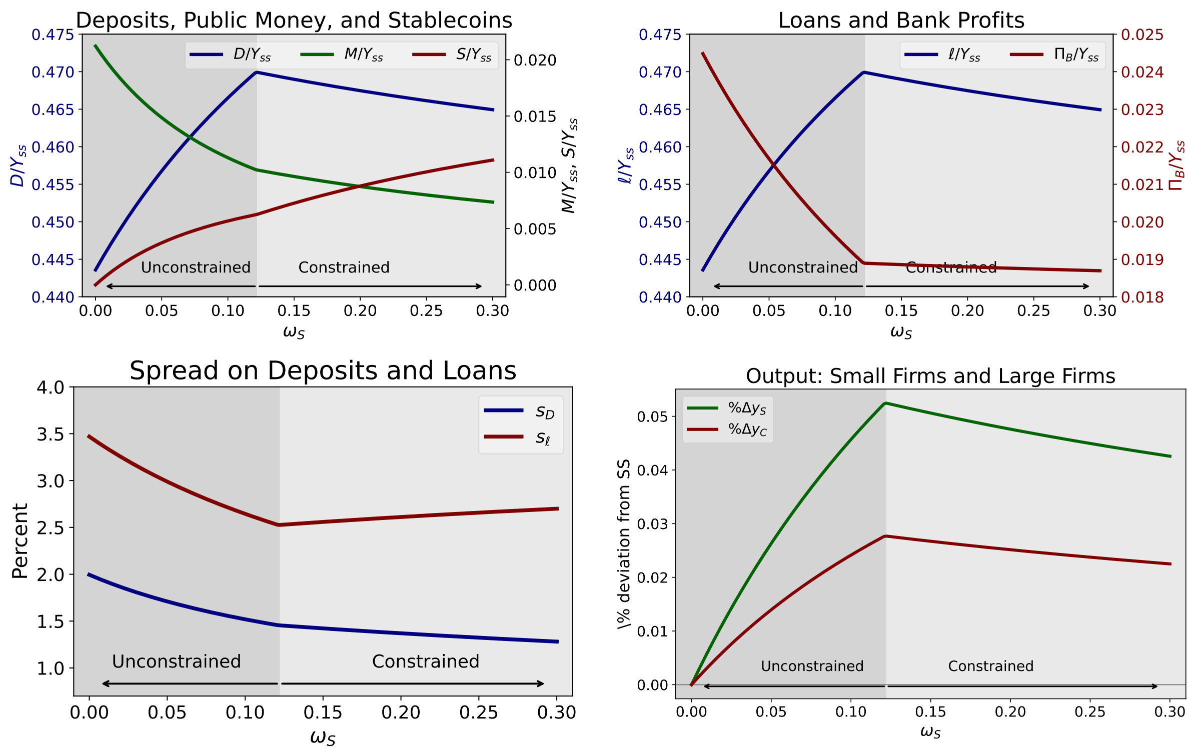
3.2.2 Numerical Exercise

Our first and main quantitative exercise simulates improvements in the quality of stablecoins. This corresponds to a higher value of the parameter ω_S, which captures the convenience or liquidity services provided by stablecoins. Intuitively, higher ω_S reflects that stablecoins become safer, more widely accepted, or otherwise more useful as a means of payment. We trace how such improvements affect the equilibrium steady state.

Figure 1 illustrates the steady-state impact of increasing the quality of stablecoins, ω_S, from its baseline value of zero to higher levels. The upper-left panel shows the response of deposits, public money, and stablecoins, each normalized by steady-state output. The figure illustrates point (b) of Proposition 2: in the unconstrained region, even though the quality of stablecoins improves and their holdings expand, deposit holdings also rise. This occurs because banks respond to higher competition from better outside money by optimally reducing deposit spreads. Hence, there is no crowding out of deposits from banks following improvements in stablecoins when banks are unconstrained. As deposits increase, so does intermediation: loan spreads fall, lending rises, and output increases in both the corporate and non-corporate sectors.

Yet, as shown in Proposition 3, this effect eventually reverses. As competition from stablecoins intensifies, bank profits decline. When the improvement in ω_S is large enough, the leverage constraint becomes binding. As illustrated in the figure, once the constraint

Figure 1: Effects of improving stablecoins (ω_S).



Note: The figure shows the steady-state equilibrium outcomes for different values of the quality of stablecoins (ω_S) in our calibrated economy. The unconstrained region refers to steady states such that $D < \phi \cdot \Pi_B$; the constrained regions to those with $D = \phi \cdot \Pi_B$.

binds, banks can no longer absorb the inflow of deposits, and intermediation begins to contract. Loan spreads rise, lending falls, and output declines.

Our illustrative calibration shows that there is room to enhance the convenience of stablecoins before witnessing any crowding out of deposits from the banking sector. It is also important to note that improvements in stablecoins may not necessarily translate into large observed inflows toward these instruments, yet they can operate as a latent competitive force on banks' market power, increasing intermediation without disrupting bank lending.

4 Conclusion

We develop a general-equilibrium framework to study how improvements in stablecoin usability and the introduction of a CBDC affect bank intermediation when banks possess deposit market power and face a profit-linked leverage constraint. The central insight is state dependence. When banks can expand their balance sheets, making outside money more attractive—through higher convenience or remuneration—intensifies deposit competition, compresses deposit markups, and expands deposits and lending. Once profits thin and the constraint binds, however, the same improvements shift balances toward outside money, raise loan spreads, and shrink intermediation, yielding non-monotonic effects. We further show an equivalence between CBDC remuneration and non-pecuniary quality, and provide neutrality conditions under which outside-money improvements merely reshuffle portfolios without affecting lending or output.

Our quantitative illustration, calibrated to U.S. moments, suggests there is scope to raise the quality of stablecoins without triggering deposit flight: modest improvements reduce deposit markups and expand lending even in the absence of large observed inflows into stablecoins.

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Appendix

for Online Publication

Appendix A Derivations

A.1 Derivation of the household equations

We solve the household's optimization problem defined in Equation (1) using the constraints in Equations (2) and (3), and the liquidity aggregator in Equation (4) assuming the solution is internal $L < L^{\star}$. The first order conditions, where the superscript $'$ defines the subsequent period, are:

$$[C]: \quad \lambda \;=\; \left[C + \nu^{\eta}\frac{L^{1-\eta}}{1-\eta}\right]^{-1}$$

$$[B]: \quad \lambda \;=\; \beta(1+r)\,\lambda'$$

$$[M]: \quad \lambda \;=\; \beta(1+r_M)\,\lambda' + \left[C + \nu^{\eta}\frac{L^{1-\eta}}{1-\eta}\right]^{-1} \nu^{\eta}L^{-\eta}\left(\omega_M^{\varepsilon}M^{1-\varepsilon} + \omega_S^{\varepsilon}S^{1-\varepsilon} + D^{1-\varepsilon}\right)^{\frac{\varepsilon}{1-\varepsilon}}\omega_M^{\varepsilon}M^{-\varepsilon}$$

$$[D]: \quad \lambda \;=\; \beta(1+r_D)\,\lambda' + \left[C + \nu^{\eta}\frac{L^{1-\eta}}{1-\eta}\right]^{-1} \nu^{\eta}L^{-\eta}\left(\omega_M^{\varepsilon}M^{1-\varepsilon} + \omega_S^{\varepsilon}S^{1-\varepsilon} + D^{1-\varepsilon}\right)^{\frac{\varepsilon}{1-\varepsilon}} D^{-\varepsilon}$$

$$[S]: \quad \lambda \;=\; \beta(1+r_S)\,\lambda' + \left[C + \nu^{\eta}\frac{L^{1-\eta}}{1-\eta}\right]^{-1} \nu^{\eta}L^{-\eta}\left(\omega_M^{\varepsilon}M^{1-\varepsilon} + \omega_S^{\varepsilon}S^{1-\varepsilon} + D^{1-\varepsilon}\right)^{\frac{\varepsilon}{1-\varepsilon}}\omega_S^{\varepsilon}S^{-\varepsilon}.$$

Define,

$$\chi \;\equiv\; \left[C + \nu^{\eta}\frac{L^{1-\eta}}{1-\eta}\right]^{-1} \nu^{\eta}L^{-\eta}\left(\omega_M^{\varepsilon}M^{1-\varepsilon} + \omega_S^{\varepsilon}S^{1-\varepsilon} + D^{1-\varepsilon}\right)^{\frac{\varepsilon}{1-\varepsilon}}$$

In $[M]$, $[S]$, and $[D]$, replace λ as defined in $[B]$ and divide by $\beta\lambda'$ to get

$$
\begin{aligned}
r - r_M &= \frac{\mathcal{X}\,\omega_M^{\varepsilon} M^{-\varepsilon}}{\beta\lambda'}, \\
r - r_S &= \frac{\mathcal{X}\,\omega_S^{\varepsilon} S^{-\varepsilon}}{\beta\lambda'}, \\
r - r_D &= \frac{\mathcal{X}\,D^{-\varepsilon}}{\beta\lambda'}.
\end{aligned}
$$

Next, divide the equations pairwise to obtain relative spreads,

$$
\begin{aligned}
\frac{r - r_M}{r - r_D} &= \frac{\omega_M^{\varepsilon} M^{-\varepsilon}}{D^{-\varepsilon}}, \\
\frac{r - r_S}{r - r_D} &= \frac{\omega_S^{\varepsilon} S^{-\varepsilon}}{D^{-\varepsilon}},
\end{aligned}
$$

Express relative to public money

$$
\begin{aligned}
\frac{r - r_M}{r - r_D} &= \frac{\omega_M^{\varepsilon} M^{-\varepsilon}}{D^{-\varepsilon}} \quad \Rightarrow \quad \frac{D}{M} = \frac{1}{\omega_M}\left(\frac{r - r_D}{r - r_M}\right)^{-1/\varepsilon}, \\
\frac{r - r_M}{r - r_S} &= \frac{\omega_M^{\varepsilon} M^{-\varepsilon}}{\omega_S^{\varepsilon} S^{-\varepsilon}} \quad \Rightarrow \quad \frac{S}{M} = \frac{\omega_S}{\omega_M}\left(\frac{r - r_M}{r - r_S}\right)^{1/\varepsilon}.
\end{aligned}
$$

Replace in the liquidity aggregator

$$
\begin{aligned}
L &= \left(\omega_M^{\varepsilon} M^{1-\varepsilon} + \omega_S^{\varepsilon} S^{1-\varepsilon} + D^{1-\varepsilon}\right)^{\frac{1}{1-\varepsilon}} \\
&= M\left[\omega_M^{\varepsilon} + \omega_S^{\varepsilon}\left(\frac{S}{M}\right)^{1-\varepsilon} + \left(\frac{D}{M}\right)^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}} \\
&= M\left[\omega_M^{\varepsilon} + \omega_S^{\varepsilon}\left(\frac{\omega_S}{\omega_M}\right)^{1-\varepsilon}\left(\frac{r - r_M}{r - r_S}\right)^{\frac{1-\varepsilon}{\varepsilon}} + \left(\frac{1}{\omega_M}\right)^{1-\varepsilon}\left(\frac{r - r_D}{r - r_M}\right)^{\frac{1-\varepsilon}{\varepsilon}}\right]^{\frac{1}{1-\varepsilon}}.
\end{aligned}
$$

Define spreads as

$$s_D \equiv \frac{r - r_D}{1 + r}, \qquad s_M \equiv \frac{r - r_M}{1 + r}, \qquad s_S \equiv \frac{r - r_S}{1 + r},$$

$$s_L \equiv \left[s_D^{\frac{\varepsilon-1}{\varepsilon}} + \omega_M \, s_M^{\frac{\varepsilon-1}{\varepsilon}} + \omega_S \, s_S^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}}.$$

therefore we have

$$\begin{aligned} M &= \omega_M \, L \left(\frac{s_M}{s_L} \right)^{-1/\varepsilon}, \\ S &= \omega_S \, L \left(\frac{s_S}{s_L} \right)^{-1/\varepsilon}, \\ D &= L \left(\frac{s_D}{s_L} \right)^{-1/\varepsilon}. \end{aligned}$$

Next, we want to find an expression for L. To do so we first rearrange [M]. By using Equation (4) for the liquidity aggregator with M, S, D, we can rewrite the last part in [M], i.e.,

$$\begin{aligned} \left[\omega_M^\varepsilon M^{1-\varepsilon} + \omega_S^\varepsilon S^{1-\varepsilon} + D^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}-1} \omega_M^\varepsilon M^{-\varepsilon} &= L^\varepsilon \, \omega_M^\varepsilon M^{-\varepsilon} \\ &= L^\varepsilon \, \omega_M^\varepsilon \, (\omega_M L)^{-\varepsilon} \left(\frac{s_M}{s_L} \right) \\ &= \left(\frac{s_M}{s_L} \right). \end{aligned}$$

which then yields

$$\lambda = (1 + r_M) \, \beta \lambda' + \left[C + \nu^\eta \frac{L^{1-\eta}}{1 - \eta} \right]^{-1} \nu^\eta L^{-\eta} \left(\frac{s_M}{s_L} \right),$$

$$\frac{\lambda}{\beta \lambda'} - (1 + r_M) = \frac{\left[C + \nu^\eta \frac{L^{1-\eta}}{1-\eta} \right]^{-1} \nu^\eta L^{-\eta} \left(\frac{s_M}{s_L} \right)}{\beta \lambda'}.$$

Use $[B]$ to replace $\beta\lambda'$:

$$
\begin{aligned}
(r - r_M) &= \frac{\left[C + \nu^{\eta}\frac{L^{1-\eta}}{1-\eta}\right]^{-1} \nu^{\eta} L^{-\eta} \left(\frac{s_M}{s_L}\right)}{\lambda/(1+r)}, \\
\lambda\, s_L &= \left[C + \nu^{\eta}\frac{L^{1-\eta}}{1-\eta}\right]^{-1} \nu^{\eta} L^{-\eta}.
\end{aligned}
$$

Take $[C]$, i.e.,

$$
\lambda = \left[C + \nu^{\eta}\frac{L^{1-\eta}}{1-\eta}\right]^{-1},
$$

and insert:

$$
s_L \left[C + \nu^{\eta}\frac{L^{1-\eta}}{1-\eta}\right]^{-1} = \left[C + \nu^{\eta}\frac{L^{1-\eta}}{1-\eta}\right]^{-1} \nu^{\eta} L^{-\eta}.
$$

It follows

$$
\begin{aligned}
s_L &= \nu^{\eta} L^{-\eta}, \quad \text{or} \\
L &= \nu\, s_L^{-1/\eta}.
\end{aligned}
$$

A.2 Derivation of the intermediate goods producers equations

The problem of the corporate firms in sequential form cum-dividend is to solve the following problem:

$$
\max_{\{K_{C,t+1}, I_{C,t}\}} \sum_{t=0}^{\infty} \beta^t \lambda_t \left[p_{C,t} A_C \left(K_{C,t}\right)^{\alpha} - I_{C,t-1}\left(1 + r_{t-1}\right)\right]
$$

subject to:

$$
K_{C,t+1} = (1-\delta)\, K_{C,t} + I_{C,t}
$$

where $\lambda_t = \left[C_t + \nu^{\eta}\frac{L_t^{1-\eta}}{1-\eta}\right]^{-1}$ is the Lagrange multiplier for the household's problem. The problem can be formulated in a Lagrangean:

$$\mathcal{L}(K_{C,t+1}, I_C) = \sum_{t=0}^{\infty} \beta^t \lambda_t \left[p_{C,t} A_C \left(K_{C,t}\right)^{\alpha} - I_{C,t-1}\left(1 + r_{t-1}\right)\right] + \sum_{t=0}^{\infty} \beta^t \lambda_t \mu_t \left[\left(1-\delta\right) K_{C,t} + I_{C,t} - K_{C,t+1}\right]$$

The first order conditions are:

$$[K_{C,t+1}] : \beta^{t+1} \lambda_{t+1} \left[p_{C,t+1} A_C \alpha K_{C,t+1}^{\alpha-1} + \mu_{t+1}\left(1-\delta\right)\right] - \beta^t \lambda_t \mu_t = 0$$
$$[I_{C,t}] : \; - \beta^{t+1} \lambda_{t+1}\left(1 + r_t\right) + \beta^t \lambda_t \mu_t = 0$$

Combining both yields:

$$\mu_t = \beta \frac{\lambda_{t+1}}{\lambda_t}\left(1 + r_t\right) = 1$$
$$p_{C,t+1} A_C \alpha K_{C,t+1}^{\alpha-1} + \mu_{t+1}\left(1-\delta\right) = 1 + r_t$$

The first equality follows from the households optimization for bonds B. It follows:

$$p_{C,t+1} A_C \alpha K_{C,t+1}^{\alpha-1} = r_t + \delta$$

Non-corporate small firms solve:

$$\max_{\{K_{N,t+1}, I_{N,t}\}} \sum_{t=0}^{\infty} \beta^t \lambda_t \left[p_{N,t} A_N \left(K_{N,t}\right)^{\alpha} - I_{N,t-1}\left(1 + r_{\ell,t-1}\right)\right]$$

subject to:

$$K_{N,t+1} = (1-\delta) K_{N,t} + I_{N,t}.$$

Rearranged as a Lagrangian:

$$\mathcal{L}(K_{N,t+1}, I_{N,t}) = \sum_{t=0}^{\infty} \beta^t \lambda_t \left[p_{N,t} A_N \left(K_{N,t}\right)^{\alpha} - I_{N,t-1}\left(1 + r_{\ell,t-1}\right)\right]$$
$$+ \sum_{t=0}^{\infty} \beta^t \lambda_t \mu_t \left[(1-\delta) K_{N,t} + I_{N,t} - K_{N,t+1}\right].$$

The first-order conditions are:

$$[K_{N,t+1}]: \quad \beta^{t+1} \lambda_{t+1} \left[p_{N,t+1} \alpha A_N K_{N,t+1}^{\alpha-1} + \mu_{t+1}(1-\delta)\right] - \beta^t \lambda_t \mu_t = 0,$$
$$[I_{N,t}]: \quad -\beta^{t+1} \lambda_{t+1}(1 + r_{\ell,t}) + \beta^t \lambda_t \mu_t = 0.$$

Combining both yields:

$$\mu_t = \beta \frac{\lambda_{t+1}}{\lambda_t}(1 + r_{\ell,t}) = \frac{1 + r_{\ell,t}}{1 + r_t},$$
$$\alpha p_{N,t+1} A_N K_{N,t+1}^{\alpha-1} = (1 + r_{\ell,t}) - (1-\delta)\frac{1 + r_{\ell,t+1}}{1 + r_{t+1}}.$$

The first equality again uses the household's first-order condition for bonds B.

A.3 Derivation of the bank equations

Banks are small and homogeneous. They monopolize a random sample of households in which they enjoy market power on deposits and lend the collected money issuing loans to small firms and to corporate in the forms of bonds, in case they find it profitable. As dividends are fully paid back to households every period, the problem of the bank is static and can be writen as:

$$\max_{\ell, B, r_D} \Pi_B = \max_{\ell, B, r_D} \ell\left(1 + r_\ell\right) + B_B\left(1 + r_B\right) - D(r_D)\left(1 + r_D\right)$$

subject to

$$(\lambda) : \ell + B_B = D(r_D),$$
$$(\mu) : D(r_D) \leq \phi\left(\Pi_B\right),$$
$$(\zeta) : 0 \leq B_B.$$

The Lagrangian for this problem is:

$$\mathcal{L} = \left[\ell\left(1+r_\ell\right) + B_B\left(1+r_B\right) - D\left(1+r_D\right)\right] - \lambda\left[\ell + B_B - D(r_D)\right] + \mu\left[\phi\left(\Pi_B\right) - D(r_D)\right] + \zeta B_B$$

The first order conditions are:

$$[\ell] : \left[1 + \mu\phi'\left(\Pi_B\right)\right]\left(1+r_\ell\right) - \lambda = 0$$
$$[r_D] : -\left[D'\left(1+r_D\right) + D\right]\left(1 + \mu\phi'\left(\Pi_B\right)\right) - \mu D' + \lambda D' = 0$$
$$[B_B] : \left(1+r_B\right)\left[1 + \mu\phi'\left(\Pi_B\right)\right] - \lambda + \zeta = 0$$

plus a complementary slackness condition on deposits,

$$\mu \cdot [\phi(\Pi_B) - D(r_D)] = 0 \text{ with } \mu \geq 0$$

and bonds,

$$\zeta \cdot B_B = 0 \text{ with } \zeta \geq 0$$

First let's see that the bank will never hold safe bond if the spread between loans and bonds is positive. Combine the FOC of bonds $[B_B]$ and loans $[\ell]$ to get,

$$\frac{\zeta}{1 + \mu\phi'\left(\Pi_B\right)} = r_\ell - r$$

which means that if $r_\ell - r > 0 \rightarrow \zeta > 0$ as $\mu \geq 0$ and $\phi' > 0$ which implies that if $r_\ell - r > 0$ then $B = 0$.

Next combine the FOC of loans $[\ell]$ and deposits $[r_D]$ to get,

$$s_\ell + s_D = \varepsilon_D^{-1} + \frac{\mu}{1 + \mu\phi'\left(\Pi_B\right)}$$

where $\varepsilon_D = -\dfrac{1}{D}\dfrac{\partial D}{\partial s_D}$ is semi-elasticity of deposit demand with respect to the spread. In the main paper we define $\kappa \equiv \frac{\mu}{1+\mu\phi'(\Pi_B)}$.

A.4 Bank's Leverage Constraint

We assume a bank's admissible deposits satisfy $D \leq \phi(\Pi_B)$, where ϕ is increasing, weakly concave, and $\phi(0) = 0$. These monotonicity and zero restrictions imply that more profitable banks can raise more funding, while a bank that generates no profits cannot expand its balance sheet through this channel—features consistent with a leverage-type cap. Weakly concavity means that each additional dollar of profit relaxes the cap equally or less than proportionally.

Our constraint $D \leq \phi(\Pi_B)$ nests the equity constraints typically used in macro-finance intermediation (e.g., Gertler and Kiyotaki 2015; Abadi, Brunnermeier and Koby 2023) as a particular case. Suppose a fraction $\gamma \in (0, 1)$ of equity is paid out each period. Equity then evolves as

$$e_{t+1} \;=\; (1-\gamma)\, e_t \;+\; \Pi_{B,t}, \qquad \Pi_{B,t} \;=\; (1+r_t^{\ell})\, \ell_t \;-\; (1+r_t^{D})\, D_t, \qquad \ell_t \;=\; e_t + D_t,$$

and the standard equity cap is $D_t \leq \psi\, e_t$. In a stationary environment with constant prices/quantities, steady state satisfies

$$e \;=\; (1-\gamma)e + \Pi_B \quad \Rightarrow \quad e \;=\; \frac{\Pi_B}{\gamma}.$$

Hence the equity cap becomes

$$D \;\leq\; \psi\, e \;=\; \frac{\psi}{\gamma}\, \Pi_B,$$

which is exactly our profit-based constraint with a linear mapping $\phi(\Pi) = \big(\psi/\gamma\big)\Pi$. Equity-type constraints are therefore a special (linear) case of our formulation; allowing $\phi(\cdot)$ to be concave provides additional flexibility and delivers a bounded, well-behaved leverage cap.

The economic meaning and mapping into the data of the leverage constraint are not straightforward. The literature takes different routes: some papers treat it as a regulationbased limit and calibrate parameters to capital or liquidity requirements (e.g., Whited, Wu and Xiao 2023); others interpret it as an incentive-compatibility constraint and discipline it using observed spreads (e.g., Gertler and Kiyotaki 2015). Our profit-based formulation nests the regulatory view when $\phi(\cdot)$ is linear. We remain agnostic about the precise microfoundation and present numerical simulations under alternative calibrations to assess the quantitative implications.

A.5 Derivation of deposit semi-elasticity

The semi-elasticity of deposit demand, ε_D, is defined as

$$\varepsilon_D \;=\; -\frac{\partial D/\partial s_D}{D} \;=\; -\frac{\partial \log D}{\partial s_D}.$$

Using the demand system $D = \nu\, s_L^{\frac{1}{\varepsilon}-\frac{1}{\eta}}\, s_D^{-1/\varepsilon}$, we have

$$D \;=\; \nu\, s_L^{\frac{1}{\varepsilon}-\frac{1}{\eta}}\, s_D^{-\frac{1}{\varepsilon}}.$$

Taking logs:

$$\log D \;=\; \log \nu \;+\; \left(\frac{1}{\varepsilon}-\frac{1}{\eta}\right)\log s_L \;-\; \frac{1}{\varepsilon}\log s_D.$$

With three liquid assets, the liquidity spread is

$$s_L \;=\; \left[\, s_D^{\frac{\varepsilon-1}{\varepsilon}} \;+\; \omega_M\, s_M^{\frac{\varepsilon-1}{\varepsilon}} \;+\; \omega_S\, s_S^{\frac{\varepsilon-1}{\varepsilon}} \,\right]^{\frac{\varepsilon}{\varepsilon-1}}.$$

Differentiate s_L w.r.t. s_D:

$$\frac{\partial s_L}{\partial s_D} = s_L^{\frac{1}{\varepsilon}}\, s_D^{-\frac{1}{\varepsilon}}.$$

Hence,

$$\begin{aligned}
\frac{\partial \log D}{\partial s_D}\, s_D &= \left(\frac{1}{\varepsilon} - \frac{1}{\eta}\right) \frac{s_L^{\frac{1}{\varepsilon}}\, s_D^{-\frac{1}{\varepsilon}}}{s_L}\, s_D \;-\; \frac{1}{\varepsilon} \\
&= \left(\frac{1}{\varepsilon} - \frac{1}{\eta}\right) \frac{s_D^{\frac{\varepsilon-1}{\varepsilon}}}{s_L^{\frac{\varepsilon-1}{\varepsilon}}} \;-\; \frac{1}{\varepsilon} \\
&= \left(\frac{1}{\varepsilon} - \frac{1}{\eta}\right) \frac{s_D^{\frac{\varepsilon-1}{\varepsilon}}}{s_D^{\frac{\varepsilon-1}{\varepsilon}} + \omega_M s_M^{\frac{\varepsilon-1}{\varepsilon}} + \omega_S s_S^{\frac{\varepsilon-1}{\varepsilon}}} \;-\; \frac{1}{\varepsilon}.
\end{aligned}$$

Using the demand ratios

$$\frac{M}{D} \;=\; \omega_M \left(\frac{s_M}{s_D}\right)^{-\frac{1}{\varepsilon}}, \qquad \frac{S}{D} \;=\; \omega_S \left(\frac{s_S}{s_D}\right)^{-\frac{1}{\varepsilon}},$$

we get

$$\omega_M\, \frac{s_M^{\frac{\varepsilon-1}{\varepsilon}}}{s_D^{\frac{\varepsilon-1}{\varepsilon}}} = \frac{s_M M}{s_D D}, \qquad \omega_S\, \frac{s_S^{\frac{\varepsilon-1}{\varepsilon}}}{s_D^{\frac{\varepsilon-1}{\varepsilon}}} = \frac{s_S S}{s_D D}.$$

Therefore,

$$\begin{aligned}
\frac{\partial \log D}{\partial s_D}\, s_D &= \left(\frac{1}{\varepsilon} - \frac{1}{\eta}\right) \frac{1}{1 + \frac{s_M M}{s_D D} + \frac{s_S S}{s_D D}} \;-\; \frac{1}{\varepsilon} \\
&= \left(\frac{1}{\varepsilon} - \frac{1}{\eta}\right) \frac{s_D D}{s_D D + s_M M + s_S S} \;-\; \frac{1}{\varepsilon}.
\end{aligned}$$

Define the deposit share

$$\omega_D \;\equiv\; \frac{s_D D}{s_D D + s_M M + s_S S},$$

so that the semi-elasticity is

$$\varepsilon_D \;=\; -\frac{\partial \log D}{\partial s_D} \;=\; \frac{1}{s_D}\left[\frac{1}{\varepsilon}(1 - \omega_D) \;+\; \frac{1}{\eta}\,\omega_D\right].$$

A.6 Bank Second Order Condition

For the problem to have an internal unique solution, as we assume, we need the bank's second-order condition to be strictly negative.

Use the results that is $s_\ell > 0$ then bank hold no bonds, impose that the discount factor $\Lambda = (1+r)^{-1}$ and replace the balance sheet identity into the objective. In this case the objective of the bank can be written in terms of the spread as,

$$\mathcal{L} = \max_{s_D} D\left(s_D\right)\left(s_D + s_\ell\right) + \mu\left[\phi(\Pi_B) - D(s_D)\right]$$

where the FOC, as before, is

$$[\text{FOC}] : D'\left(s_D + s_\ell\right) + D + \mu\left[\phi'(.)\left(D'\left(s_D + s_\ell\right) + D\right) - D'\right] = 0$$

and the SOC is

$$[\text{SOC}] : D''\left(s_D + s_\ell\right) + 2D' + \mu\left[\phi''\left(D'\left(s_D + s_\ell\right) + D\right)^2 + \phi'\left(D''\left(s_D + s_\ell\right) + 2D'\right) - D''\right] < 0 \tag{1}$$

and so

$$\left[D''\left(s_D + s_\ell\right) + 2D'\right]\left[1 + \mu\phi'\right] + \mu\left[\phi''\left(D'\left(s_D + s_\ell\right) + D\right)^2 - D''\right] < 0 \tag{2}$$

$$\left[\frac{D''}{D'}\left(s_D + s_\ell\right) + 2\right]\left[1 + \mu\phi'\right] + \mu\left[\phi''\left(\left(s_D + s_\ell\right) + \frac{D}{D'}\right)^2 D' - \frac{D''}{D'}\right] > 0 \tag{3}$$

$$\frac{D''}{D'}\left(s_D + s_\ell\right) + 2 > -\frac{\mu}{\left[1 + \mu\phi'\right]}\left[\phi''\left(\left(s_D + s_\ell\right) + \frac{D}{D'}\right)^2 D' - \frac{D''}{D'}\right] \tag{4}$$

where the change of sign is due to $D' < 0$. The right hand side is weakly positive as ϕ is weakly concave and D convex. It is equal to zero only if the constraint binds. Remember that the semi-elasticity of D with respect to s_D is

$$\varepsilon_D = -\frac{\partial D}{\partial s_D} = \frac{1}{s_D}\left[\varepsilon^{-1} + \left(\eta^{-1} - \varepsilon^{-1}\right)\omega_D\right] \tag{5}$$

take logs

$$\ln \varepsilon_D = -\ln D + \ln \left(-\frac{\partial D}{\partial s_D}\right) = -\ln (s_D) + \ln \left(\varepsilon^{-1} + \left(\eta^{-1} - \varepsilon^{-1}\right) \omega_D\right)$$

differentiate it with respect to s_D

$$\underbrace{-\frac{1}{D}\frac{\partial D}{\partial s_D}}_{\varepsilon_D} + \frac{\frac{\partial^2 D}{\partial s_D^2}}{\frac{\partial D}{\partial s_D}} = -\frac{1}{s_D} + \frac{\left(\eta^{-1} - \varepsilon^{-1}\right)}{\varepsilon^{-1} + \left(\eta^{-1} - \varepsilon^{-1}\right) \omega_D} \frac{\partial \omega_D}{\partial s_D} \tag{6}$$

We will need $\frac{\partial \omega_D}{\partial s_D}$:

$$\frac{\partial \omega_D}{\partial s_D} = \left(1 - \omega_D\right) \frac{\omega_D}{s_D} \left(1 - \varepsilon^{-1}\right) \tag{7}$$

where the steps to this last equation are the same as to get (B.32). Now combine to get,

$$\varepsilon_D + \frac{D''}{D'} = -\frac{1}{s_D} + \frac{\left(\eta^{-1} - \varepsilon^{-1}\right)}{\varepsilon^{-1} + \left(\eta^{-1} - \varepsilon^{-1}\right) \omega_D} \left[\left(1 - \omega_D\right) \frac{\omega_D}{s_D} \left(1 - \varepsilon^{-1}\right)\right] \tag{8}$$

Since in the unconstrained regime $\varepsilon_D^{-1} = s_\ell + s_D$ we have,

$$\frac{D''}{D'} = -\frac{1}{s_\ell + s_D} - \frac{1}{s_D} + \frac{\left(\eta^{-1} - \varepsilon^{-1}\right)}{\varepsilon^{-1} + \left(\eta^{-1} - \varepsilon^{-1}\right) \omega_D} \left[\left(1 - \omega_D\right) \frac{\omega_D}{s_D} \left(1 - \varepsilon^{-1}\right)\right] \tag{9}$$

Use (9) in (4) in the unconstrained space ($\mu = 0$) to get the inequality of the SOC,

$$\left[-\frac{1}{s_\ell + s_D} - \frac{1}{s_D} + \frac{\left(\eta^{-1} - \varepsilon^{-1}\right)}{\varepsilon^{-1} + \left(\eta^{-1} - \varepsilon^{-1}\right) \omega_D} \left[\left(1 - \omega_D\right) \frac{\omega_D}{s_D} \left(1 - \varepsilon^{-1}\right)\right]\right] \left(s_D + s_\ell\right) + 2 > 0 \tag{10}$$

Re-arrange to get a useful condition for later

$$\frac{\left(\eta^{-1} - \varepsilon^{-1}\right)\left(1 - \omega_D\right)\left(1 - \varepsilon^{-1}\right) \omega_D}{\varepsilon^{-1} + \left(\eta^{-1} - \varepsilon^{-1}\right) \omega_D} - \frac{s_\ell}{s_\ell + s_D} > 0 \tag{11}$$

Use the definition in (B.33) of Γ to rewrite the equation as

$$\Gamma \left(1 - \varepsilon^{-1}\right) - \frac{s_\ell}{s_\ell + s_D} > 0 \tag{12}$$

a condition which will then be used.

Appendix B Proofs

B.1 Proof of Proposition 1

From Appendix A.3, combine the first order condition of the bank's problem for loans [ℓ] and bonds [B_B]:

$$\frac{\zeta}{\lambda} = r_\ell - r$$

Since $\zeta \geq 0$, a positive interest rate spread implies that ζ has to be positive, i.e. $r_\ell - r > 0 \implies \zeta > 0$. A positive ζ, by the complementary slackness condition, implies that the inequality constraint for bonds is binding, i.e. $B_B = 0$.

B.2 Proof of Proposition 2 & 3 - Unconstrained Scenario

In this section we show the effect on spreads and quantities of both improving the quality of stablecoins and introducing a CBDC. First, we begin by defining an aggregator between public money M and stablecoins S called public money P. The reason for the name is that, since every dollar in stablecoin is backed with public debt, then effectively stablecoins are a form of public money.

Definition of the public-money composite.

$$\omega_P \equiv \omega_M + \omega_S, \qquad s_P^{\frac{\varepsilon-1}{\varepsilon}} \equiv \frac{\omega_M \, s_M^{\frac{\varepsilon-1}{\varepsilon}} + \omega_S \, s_S^{\frac{\varepsilon-1}{\varepsilon}}}{\omega_P}$$

With this definition, the liquidity spread aggregator can be written as

$$s_L = \left[s_D^{\frac{\varepsilon-1}{\varepsilon}} + \omega_M s_M^{\frac{\varepsilon-1}{\varepsilon}} + \omega_S s_S^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}} = \left[s_D^{\frac{\varepsilon-1}{\varepsilon}} + \omega_P s_P^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}}.$$

Where the demand for the composite P is given by:

$$P \equiv \omega_P \, L \left(\frac{s_P}{s_L} \right)^{-\frac{1}{\varepsilon}}.$$

and we can write the demand for public money M and stablecoins S in terms of public money aggregator P and its spread:

$$\frac{M}{P} = \frac{\omega_M}{\omega_P}\left(\frac{s_M}{s_P}\right)^{-\frac{1}{\varepsilon}}, \qquad \frac{S}{P} = \frac{\omega_S}{\omega_P}\left(\frac{s_S}{s_P}\right)^{-\frac{1}{\varepsilon}}.$$

Since all our experiments will be changes in ω_M, s_M and/or ω_S then all our proofs will be studying changes in ω_P and s_P.

The relevant share is

$$\omega_D \equiv \frac{s_D D}{s_D D + s_M M + s_S S} = \frac{s_D D}{s_D D + s_P P}$$

Now differentiate the steady-state system to characterize deviations. We would like to map changes in $\omega_{S,M}$ and r_M to the new equilibrium. Variables with hat, i.e. $\widehat{x}$, represent log-changes, including for interest rates and spreads.

Household deviations Perturbation of households equations give:

$$\widehat{L} = -\frac{1}{\eta}\widehat{s}_L, \tag{B.1}$$

$$\widehat{D} = \widehat{L} - \frac{1}{\varepsilon}\big(\widehat{s}_D - \widehat{s}_L\big), \tag{B.2}$$

$$\widehat{P} = \widehat{\omega}_P + \widehat{L} - \frac{1}{\varepsilon}\big(\widehat{s}_P - \widehat{s}_L\big), \tag{B.3}$$

$$\widehat{r} = 0, \tag{B.4}$$

$$\widehat{s}_L = \omega_D\,\widehat{s}_D + (1-\omega_D)\,\widehat{s}_P - \frac{\varepsilon}{1-\varepsilon}(1-\omega_D)\,\widehat{\omega}_P, \tag{B.5}$$

$$C\cdot\widehat{C} = \Pi\cdot\widehat{\Pi} + D\cdot r_D\big(\widehat{D}+\widehat{r}_D\big) + P\cdot r_P\big(\widehat{P}+\widehat{r}_P\big) + B_H\cdot r\big(\widehat{B}_H+\widehat{r}\big). \tag{B.6}$$

Spread equations:

$$\widehat{s}_x = \frac{r\widehat{r} - r_x\widehat{r}_x}{r - r_x} - \frac{r\widehat{r}}{1+r} \quad \forall x \in \{D, P\} \tag{B.7}$$

Bank equations:

$$-\widehat{\varepsilon}_D = \widehat{s}_D - \frac{\left(\eta^{-1} - \varepsilon^{-1}\right)\omega_D\widehat{\omega}_D}{\varepsilon^{-1}\left(1-\omega_D\right) + \eta^{-1}\omega_D} \tag{B.8}$$

$$\widehat{\omega}_D = \left(1-\omega_D\right)\left[\ \left(\widehat{s}_D + \widehat{D}\right)\ -\ \left(\widehat{s}_P + \widehat{P}\right)\ \right] \tag{B.9}$$

$$\widehat{\ell} = \widehat{D} \tag{B.10}$$

In the unconstrained scenario ($\mu = 0$):

$$-\,\widehat{\varepsilon}_D = \frac{s_\ell \widehat{s}_\ell + s_D \widehat{s}_D}{s_\ell + s_D} \tag{B.11}$$

In the constrained scenario ($\mu > 0$):

$$\frac{s_\ell \widehat{s}_\ell + s_D \widehat{s}_D}{s_\ell + s_D} = \frac{-\widehat{\varepsilon}_D \varepsilon_D^{-1} + \left[1 + \mu\phi'\left(\Pi_B\right)\right]\left[-\mu^{-1}\widehat{\mu} + \phi''\left(\Pi_B\right)\Pi_B\widehat{\Pi}_B\right]}{\varepsilon_D^{-1} + \frac{\mu}{1+\mu\phi'\left(\Pi_B\right)}} \tag{B.12}$$

$$\widehat{D} = \frac{\phi'\left(\Pi_B\right)\Pi_B}{\phi\left(\Pi_B\right)}\widehat{\Pi}_B \tag{B.13}$$

where bank profits evolve as,

$$\widehat{\Pi}_B = \frac{s_\ell \widehat{s}_\ell + s_D \widehat{s}_D}{s_\ell + s_D} + \frac{r_B \widehat{r}_B}{1 + r_B} + \widehat{D} \tag{B.14}$$

Final goods producer equations:

$$\widehat{y}_C = \widehat{Y} - \rho \cdot \widehat{p}_C \tag{B.15}$$

$$\widehat{y}_N = \widehat{Y} - \rho \cdot \widehat{p}_N \tag{B.16}$$

$$\widehat{Y} = \frac{p_N y_N}{Y}\widehat{y}_N + \frac{p_C y_C}{Y}\widehat{y}_C \tag{B.17}$$

Intermediate goods producer equations:

$$\widehat{p}_C + (\alpha - 1)\widehat{K}_C = \frac{r\widehat{r}}{r+\delta} \tag{B.18}$$

$$\widehat{p}_N + (\alpha - 1)\widehat{K}_N = \frac{s_\ell \widehat{s}_\ell}{1+s_\ell} + \frac{r\widehat{r}}{r+\delta} \tag{B.19}$$

$$\widehat{y}_C = \alpha \widehat{K}_C \tag{B.20}$$

$$\widehat{y}_N = \alpha \widehat{K}_N \tag{B.21}$$

$$\widehat{K}_C = \widehat{I}_C \tag{B.22}$$

$$\widehat{K}_N = \widehat{I}_N \tag{B.23}$$

Market clearing equations:

$$\widehat{Y} = \frac{C}{Y}\widehat{C} + \frac{I_N}{Y}\widehat{I}_N + \frac{I_C}{Y}\widehat{I}_C \tag{B.24}$$

$$\widehat{I}_C = \widehat{B}_H \tag{B.25}$$

$$\widehat{I}_N = \widehat{\ell} \tag{B.26}$$

The first step is to write $\widehat{Y}$ in terms of $\widehat{s}_\ell$. Start by combining the final good producer and the corporate firm equations (B.15), (B.18) and (B.20).

$$\rho^{-1}\left[\widehat{Y} - \widehat{y}_C\right] + \alpha^{-1}(\alpha - 1)\widehat{y}_C = \frac{r\widehat{r}}{r+\delta}$$

Use Equation (B.4), i.e. $\widehat{r} = 0$.

$$\widehat{y}_C = \left[1 + \frac{\rho}{\alpha}(1-\alpha)\right]^{-1}\widehat{Y} \tag{B.27}$$

Combine the final good producers and non-corporate firm equations (B.16), (B.19) and (B.21).

$$\widehat{y}_N = \left[1 + \frac{\rho}{\alpha}(1-\alpha)\right]^{-1}\left[\widehat{Y} - \rho\frac{s_\ell \widehat{s}_\ell}{1+s_\ell}\right] \tag{B.28}$$

Replace the expressions for $\widehat{y}_C$ (B.27) and $\widehat{y}_N$ (B.28) in the final good producer equation

(B.17).

$$\widehat{Y} = \frac{p_N y_N}{Y}\left[1+\frac{\rho}{\alpha}(1-\alpha)\right]^{-1}\left[\widehat{Y}-\rho\frac{s_\ell \widehat{s}_\ell}{1+s_\ell}\right]+\frac{p_C y_C}{Y}\left[1+\frac{\rho}{\alpha}(1-\alpha)\right]^{-1}\widehat{Y}$$

$$\widehat{Y} = -\frac{p_N y_N}{Y}\left[\frac{\rho}{\alpha}(1-\alpha)\right]^{-1}\rho\frac{s_\ell \widehat{s}_\ell}{1+s_\ell}$$

$$\widehat{Y} = -\frac{p_N y_N}{Y}\,\alpha\,(1-\alpha)^{-1}\,\frac{s_\ell}{1+s_\ell}\widehat{s}_\ell \tag{B.29}$$

Since we restrict our analysis to cases with a positive loan spread, i.e. $s_\ell > 0$, Equation (B.29) implies that an increase in the loan interest rate r_ℓ reduces final good output Y.

Now the objective is to write $\widehat{s}_\ell$ as a function of $\widehat{\omega}_P$, which determines the effect of a shift to public money on loan interest rates. But this will take several steps. Thus, we begin by writing $\widehat{D}$ as a function of $\widehat{\omega}_P$, $\widehat{s}_M$ and $\widehat{s}_D$. Take the household's deposit demand equation (B.2) and combine with (B.1) and (B.5).

$$\begin{aligned}
\widehat{D} &= -\frac{1}{\eta}\widehat{s}_L - \frac{1}{\varepsilon}(\widehat{s}_D-\widehat{s}_L)\\
&= \left(\frac{1}{\varepsilon}-\frac{1}{\eta}\right)\widehat{s}_L - \frac{1}{\varepsilon}\widehat{s}_D\\
&= \left(\frac{1}{\varepsilon}-\frac{1}{\eta}\right)\left[\omega_D\,\widehat{s}_D+(1-\omega_D)\,\widehat{s}_P-\tfrac{\varepsilon}{1-\varepsilon}(1-\omega_D)\,\widehat{\omega}_P\right]-\frac{1}{\varepsilon}\widehat{s}_D\\
&= -\left(\tfrac{1}{\varepsilon}-\tfrac{1}{\eta}\right)\tfrac{\varepsilon}{1-\varepsilon}(1-\omega_D)\,\widehat{\omega}_P+\left(\tfrac{1}{\varepsilon}-\tfrac{1}{\eta}\right)(1-\omega_D)\,\widehat{s}_P-\left[\tfrac{1}{\varepsilon}(1-\omega_D)+\tfrac{1}{\eta}\omega_D\right]\widehat{s}_D.
\end{aligned} \tag{B.30}$$

Next, we write $\widehat{P}$ as a function of $\widehat{\omega}_P$, $\widehat{s}_P$ and $\widehat{s}_D$. Take the household's money demand equation (B.3) and combine with (B.1) and (B.5).

$$\begin{aligned}
\widehat{P} &= \widehat{\omega}_P - \frac{1}{\eta}\widehat{s}_L - \frac{1}{\varepsilon}\left(\widehat{s}_P - \widehat{s}_L\right) \\
&= \widehat{\omega}_P + \left(\frac{1}{\varepsilon} - \frac{1}{\eta}\right)\widehat{s}_L - \frac{1}{\varepsilon}\widehat{s}_P \\
&= \widehat{\omega}_P + \left(\frac{1}{\varepsilon} - \frac{1}{\eta}\right)\Big[\omega_D\widehat{s}_D + (1-\omega_D)\widehat{s}_P - \tfrac{\varepsilon}{1-\varepsilon}(1-\omega_D)\widehat{\omega}_P\Big] - \frac{1}{\varepsilon}\widehat{s}_P \\
&= \left[1 - \left(\frac{1}{\varepsilon} - \frac{1}{\eta}\right)\frac{\varepsilon}{1-\varepsilon}(1-\omega_D)\right]\widehat{\omega}_P \;+\; \left(\frac{1}{\varepsilon} - \frac{1}{\eta}\right)\omega_D\,\widehat{s}_D \;-\; \left[\frac{\omega_D}{\varepsilon} + \frac{1-\omega_D}{\eta}\right]\widehat{s}_P.
\end{aligned} \tag{B.31}$$

Next we look at the banking equations. First, we write changes in the deposit share as a function of $\widehat{\omega}_P$, $\widehat{s}_P$ and $\widehat{s}_D$. Take Equation (B.9) and insert (B.30) and (B.31) in it:

$$\begin{aligned}
\widehat{\omega}_D &= (1-\omega_D)\Big[(\widehat{s}_D + \widehat{D}) - (\widehat{s}_P + \widehat{P})\Big] \\
&= (1-\omega_D)\left[\left(1 - \frac{1}{\varepsilon}\right)\left(\widehat{s}_D - \widehat{s}_P\right) \;-\; \widehat{\omega}_P\right].
\end{aligned} \tag{B.32}$$

We now replace the expression for $\widehat{\omega}_D$ into the expression of the deposit elasticity in Equation (B.8).

$$\begin{aligned}
-\widehat{\varepsilon}_D &= \widehat{s}_D - \frac{\left(\eta^{-1} - \varepsilon^{-1}\right)\,\omega_D}{\varepsilon^{-1}\left(1-\omega_D\right) + \eta^{-1}\omega_D}\,\widehat{\omega}_D \\
&= \widehat{s}_D - \frac{\left(\eta^{-1} - \varepsilon^{-1}\right)\,\omega_D\left(1-\omega_D\right)}{\varepsilon^{-1}\left(1-\omega_D\right) + \eta^{-1}\omega_D}\left[\left(1 - \frac{1}{\varepsilon}\right)\left(\widehat{s}_D - \widehat{s}_P\right) - \widehat{\omega}_P\right].
\end{aligned}$$

Define

$$\Gamma \equiv \frac{\left(\eta^{-1} - \varepsilon^{-1}\right)\omega_D\left(1-\omega_D\right)}{\varepsilon^{-1}\left(1-\omega_D\right) + \eta^{-1}\omega_D} < 0 \tag{B.33}$$

since $\eta^{-1} < 1 < \varepsilon^{-1} \implies \Gamma < 0$. Rewrite previous equation:

$$-\widehat{\varepsilon}_D = \left[1 - \Gamma\left(1 - \frac{1}{\varepsilon}\right)\right]\widehat{s}_D + \Gamma\left(1 - \frac{1}{\varepsilon}\right)\widehat{s}_P + \Gamma\widehat{\omega}_P \tag{B.34}$$

Next, we write $\widehat{s}_\ell$ as a function of $\widehat{\omega}_P$, $\widehat{s}_P$ and $\widehat{s}_D$. Combine (B.11) with (B.34).

$$\frac{s_\ell}{s_\ell + s_D}\widehat{s}_\ell = \widehat{s}_D\left[1 - \Gamma\left(1 - \frac{1}{\varepsilon}\right) - \frac{s_D}{s_\ell + s_D}\right] + \Gamma\left(1 - \frac{1}{\varepsilon}\right)\widehat{s}_P + \Gamma\widehat{\omega}_P \tag{B.35}$$

Next we need to move to the supply side, or how $\widehat{s}_\ell$ relates to $\widehat{s}_D$ through the supply of loans. The demand for loans comes from non-corporate small firms. We know from the market clearing condition (B.26) and the non-corporate firm Equations (B.23) and (B.21) that

$$\widehat{y}_N/\alpha = \widehat{K}_N = \widehat{I}_N = \widehat{\ell}.$$

Combine Equations (B.28) and (B.29)

$$\widehat{y}_N = -\left[1 + \frac{\rho}{\alpha}(1-\alpha)\right]^{-1} \frac{s_\ell}{1+s_\ell}\left[\frac{p_N y_N}{Y}\alpha(1-\alpha)^{-1} + \rho\right]\widehat{s}_\ell \tag{B.36}$$

From Equation (B.36) we see that non-corporate firm output decreases if the loan interest rate increases. Now plug in Equation (B.36) into $\widehat{\ell} = \widehat{y}_N/\alpha$:

$$\widehat{\ell} = -\frac{1}{\alpha}\left[1 + \frac{\rho}{\alpha}(1-\alpha)\right]^{-1} \frac{s_\ell}{1+s_\ell}\left[\frac{p_N y_N}{Y}\alpha(1-\alpha)^{-1} + \rho\right]\widehat{s}_\ell \tag{B.37}$$

It is straightforward that outstanding loans decrease if the loan interest rate increases.

Next, use the resource constraint from the bank (B.10) to get,

$$\widehat{D} = -\frac{1}{\alpha}\left[1 + \frac{\rho}{\alpha}(1-\alpha)\right]^{-1} \frac{s_\ell}{1+s_\ell}\left[\frac{p_N y_N}{Y}\alpha(1-\alpha)^{-1} + \rho\right]\widehat{s}_\ell \tag{B.38}$$

and use (B.30) in this last equation to get,

$$\begin{aligned} -\left(\frac{1}{\varepsilon} - \frac{1}{\eta}\right)\frac{\varepsilon}{1-\varepsilon}(1-\omega_D)\widehat{\omega}_P + \left(\frac{1}{\varepsilon} - \frac{1}{\eta}\right)(1-\omega_D)\widehat{s}_P - \left[(1-\omega_D)\frac{1}{\varepsilon} + \omega_D\frac{1}{\eta}\right]\widehat{s}_D \\ = -\frac{1}{\alpha}\left[1 + \frac{\rho}{\alpha}(1-\alpha)\right]^{-1} \frac{s_\ell}{1+s_\ell}\left[\frac{p_N y_N}{Y}\alpha(1-\alpha)^{-1} + \rho\right]\widehat{s}_\ell. \end{aligned} \tag{B.39}$$

call,

$$\clubsuit \equiv -\frac{1}{\alpha}\left[1 + \frac{\rho}{\alpha}(1-\alpha)\right]^{-1} \frac{s_\ell}{1+s_\ell}\left[\frac{p_N y_N}{Y}\alpha(1-\alpha)^{-1} + \rho\right] < 0 \tag{B.40}$$

and rearrange (B.39) to get,

$$\widehat{s}_\ell = \frac{-\left(\frac{1}{\varepsilon}-\frac{1}{\eta}\right)\frac{\varepsilon}{1-\varepsilon}\left(1-\omega_D\right)\widehat{\omega}_P + \left(\frac{1}{\varepsilon}-\frac{1}{\eta}\right)\left(1-\omega_D\right)\widehat{s}_P - \left[\left(1-\omega_D\right)\frac{1}{\varepsilon}+\omega_D\frac{1}{\eta}\right]\widehat{s}_D}{\clubsuit} \tag{B.41}$$

We end up with a 2 by 2 system on $\widehat{s}_\ell$ and $\widehat{s}_D$ given by (B.35) and (B.41) which we rewrite below

$$\frac{s_\ell}{s_\ell+s_D}\widehat{s}_\ell = \widehat{s}_D\left[1-\Gamma\left(1-\frac{1}{\varepsilon}\right)-\frac{s_D}{s_\ell+s_D}\right]+\Gamma\left(1-\frac{1}{\varepsilon}\right)\widehat{s}_P+\Gamma\widehat{\omega}_P$$

$$\widehat{s}_\ell = \frac{-\left(\frac{1}{\varepsilon}-\frac{1}{\eta}\right)\frac{\varepsilon}{1-\varepsilon}\left(1-\omega_D\right)\widehat{\omega}_P + \left(\frac{1}{\varepsilon}-\frac{1}{\eta}\right)\left(1-\omega_D\right)\widehat{s}_P - \left[\left(1-\omega_D\right)\frac{1}{\varepsilon}+\omega_D\frac{1}{\eta}\right]\widehat{s}_D}{\clubsuit}$$

Combine these two equations to get,

$$\widehat{s}_D = \frac{\left[\frac{1}{\clubsuit}\left(\frac{1}{\varepsilon}-\frac{1}{\eta}\right)\left(1-\omega_D\right)-\frac{s_\ell+s_D}{s_\ell}\Gamma\left(1-\frac{1}{\varepsilon}\right)\right]}{\left[\left(1-\Gamma\left(1-\frac{1}{\varepsilon}\right)-\frac{s_D}{s_\ell+s_D}\right)\frac{s_\ell+s_D}{s_\ell}+\frac{\left[\left(1-\omega_D\right)\frac{1}{\varepsilon}+\omega_D\frac{1}{\eta}\right]}{\clubsuit}\right]}\left[\widehat{s}_P-\frac{1}{\varepsilon^{-1}-1}\widehat{\omega}_P\right]. \tag{B.42}$$

To know the effect of $\widehat{s}_P$ or $\widehat{\omega}_P$ on $\widehat{s}_D$, label

$$\widehat{s}_D = \frac{\mathcal{B}}{\mathcal{A}}\left[\widehat{s}_P-\frac{1}{\varepsilon^{-1}-1}\widehat{\omega}_P\right], \tag{B.43}$$

with

$$\mathcal{A} \equiv \left[1-\Gamma\left(1-\frac{1}{\varepsilon}\right)-\frac{s_D}{s_\ell+s_D}\right]\frac{s_\ell+s_D}{s_\ell} + \frac{\left[\left(1-\omega_D\right)\frac{1}{\varepsilon}+\omega_D\frac{1}{\eta}\right]}{\clubsuit}, \tag{B.44}$$

$$\mathcal{B} \equiv \frac{1}{\clubsuit}\left(\frac{1}{\varepsilon}-\frac{1}{\eta}\right)\left(1-\omega_D\right) - \frac{s_\ell+s_D}{s_\ell}\Gamma\left(1-\frac{1}{\varepsilon}\right), \tag{B.45}$$

where $\Gamma < 0$ is defined in (B.33) and $\clubsuit < 0$ in (B.40).

Fist we show that $\mathcal{A} < 0$. To see this note that $\clubsuit < 0$ and from bank's SOC (B.33) in the unconstrained regime we get that $\left[1-\Gamma\left(1-\frac{1}{\varepsilon}\right)-\frac{s_D}{s_\ell+s_D}\right]\frac{s_\ell+s_D}{s_\ell} = \left[\frac{s_\ell}{s_D+s_\ell}-\Gamma\left(1-\frac{1}{\varepsilon}\right)\right]\frac{s_\ell+s_D}{s_\ell} < 0$ which together with $\omega_D \in [0,1]$ proves it.

Lastly, the sign of $\mathcal{B}$ is more straightforward since $\eta^{-1} < 1 < \varepsilon^{-1}$, $\clubsuit < 0$ and $\Gamma < 0$ we have that $\mathcal{B} < 0$.

We are interested in the effect of ω_M, ω_S and s_M, so it remains to prove the effect of these variables in ω_P and s_P. Go back to our definition of them, which we rewrite below

$$\omega_P \equiv \omega_M + \omega_S, \qquad s_P^{\frac{\varepsilon-1}{\varepsilon}} \equiv \frac{\omega_M\, s_M^{\frac{\varepsilon-1}{\varepsilon}} + \omega_S\, s_S^{\frac{\varepsilon-1}{\varepsilon}}}{\omega_P}$$

Then we have that,

$$\widehat{\omega}_P = \widehat{\omega}_M \frac{\omega_M}{\omega_P} + \widehat{\omega}_S \frac{\omega_S}{\omega_P}$$

Now, using previous formula for the evolution of ω_P, that in steady-state the spread between public money M and stablecoins are the same $s_M = s_S$, and that we are studying only changes in s_M we get

$$\widehat{s}_P = \frac{\omega_M}{\omega_P}\,\widehat{s}_M \tag{B.46}$$

Now let's go back to equation (B.43) and replace previous results,

$$\widehat{s}_D = \frac{\mathcal{B}}{\mathcal{A}}\left[\frac{\omega_M}{\omega_P}\,\widehat{s}_M - \frac{1}{\varepsilon^{-1}-1}\left(\widehat{\omega}_M\frac{\omega_M}{\omega_P} + \widehat{\omega}_S\frac{\omega_S}{\omega_P}\right)\right] \tag{B.47}$$

Then we have that,

$$\frac{\partial s_D}{\partial s_M} = \frac{\mathcal{B}}{\mathcal{A}}\frac{\omega_M}{\omega_P}\frac{s_D}{s_M} > 0 \tag{B.48}$$

$$\frac{\partial s_D}{\partial \omega_M} = \frac{\partial s_D}{\partial \omega_S} = -\frac{\mathcal{B}}{\mathcal{A}}\left(\varepsilon^{-1}-1\right)^{-1}\frac{s_D}{\omega_P} < 0 \tag{B.49}$$

which proves point (1) of Proposition (2) in the unconstrained region.

To pin down the effect on s_ℓ, which ultimately will give the effect on loans, deposits and aggregate output from equations (B.29), (B.37), (B.38) and (B.40), go back to Equation (B.35), i.e.:

$$\widehat{s}_\ell = \widehat{s}_D \underbrace{\left[1 - \Gamma\left(1-\frac{1}{\varepsilon}\right) - \frac{s_D}{s_\ell + s_D}\right]\frac{s_\ell + s_D}{s_\ell}}_{\mathcal{C}<0} + \frac{s_\ell + s_D}{s_\ell}\Gamma\left(1-\frac{1}{\varepsilon}\right)\widehat{s}_P + \frac{s_\ell + s_D}{s_\ell}\Gamma\widehat{\omega_P}$$

Remember that we showed above using the SOC of the bank's problem that $\mathcal{C}$ is negative.

Replace the expression for $\widehat{s}_D$ and collect terms:

$$\widehat{s}_\ell = \frac{\mathcal{BC}}{\mathcal{A}}\left[\widehat{s}_P - \frac{1}{\varepsilon^{-1}-1}\widehat{\omega}_P\right] + \frac{s_\ell + s_D}{s_\ell}\Gamma\left(1-\frac{1}{\varepsilon}\right)\widehat{s}_P + \frac{s_\ell + s_D}{s_\ell}\Gamma\widehat{\omega}_P \tag{B.50}$$

$$= \left[\frac{\mathcal{BC}}{\mathcal{A}} + \frac{s_\ell + s_D}{s_\ell}\Gamma\left(1-\frac{1}{\varepsilon}\right)\right]\widehat{s}_P + \left[\frac{s_\ell + s_D}{s_\ell}\Gamma - \frac{\mathcal{BC}}{\mathcal{A}(\varepsilon^{-1}-1)}\right]\widehat{\omega}_P \tag{B.51}$$

$$= \left[\frac{\mathcal{BC}}{\mathcal{A}} + \frac{s_\ell + s_D}{s_\ell}\Gamma\left(1-\varepsilon^{-1}\right)\right]\cdot\left[\widehat{s}_P - \frac{1}{\varepsilon^{-1}-1}\widehat{\omega}_P\right] \tag{B.52}$$

Remember that,

$$\widehat{s}_P - \frac{1}{\varepsilon^{-1}-1}\widehat{\omega}_P = \frac{\omega_M}{\omega_P}\widehat{s}_M - \frac{1}{\varepsilon^{-1}-1}\left(\widehat{\omega}_M\frac{\omega_M}{\omega_P} + \widehat{\omega}_S\frac{\omega_S}{\omega_P}\right) \tag{B.53}$$

and so the sign of sign of the effect of changes s_P is the same as s_M and the same for ω_P and $\omega_{M,S}$. Therefore, we want to sign the first bracket term of equation (B.52). We will show that,

$$\left[\frac{\mathcal{BC}}{\mathcal{A}} + \frac{s_\ell + s_D}{s_\ell}\Gamma\left(1-\varepsilon^{-1}\right)\right] > 0 \tag{B.54}$$

Let's begin by using the definition of $\mathcal{A}, \mathcal{B}, \mathcal{C}$ and Γ to simplify,

$$\mathcal{C} \equiv \left[1 - \Gamma\left(1-\frac{1}{\varepsilon}\right) - \frac{s_D}{s_\ell + s_D}\right]\frac{s_\ell + s_D}{s_\ell} < 0 \text{ (due to bank SOC)} \tag{B.55}$$

$$\mathcal{A} \equiv \left[1 - \Gamma\left(1-\frac{1}{\varepsilon}\right) - \frac{s_D}{s_\ell + s_D}\right]\frac{s_\ell + s_D}{s_\ell} + \frac{\left[(1-\omega_D)\frac{1}{\varepsilon} + \omega_D\frac{1}{\eta}\right]}{\clubsuit} = \mathcal{C} + \frac{\left[(1-\omega_D)\frac{1}{\varepsilon} + \omega_D\frac{1}{\eta}\right]}{\clubsuit} \tag{B.56}$$

$$\mathcal{B} \equiv \frac{1}{\clubsuit}\left(\frac{1}{\varepsilon} - \frac{1}{\eta}\right)(1-\omega_D) - \frac{s_\ell + s_D}{s_\ell}\Gamma\left(1-\frac{1}{\varepsilon}\right) = \frac{1}{\clubsuit}\left(\frac{1}{\varepsilon} - \frac{1}{\eta}\right)(1-\omega_D) + (\mathcal{C}-1) \tag{B.57}$$

$$\Gamma = \left[\frac{\left(\eta^{-1} - \varepsilon^{-1}\right)\omega_D\left(1-\omega_D\right)}{\varepsilon^{-1}\left(1-\omega_D\right) + \eta^{-1}\omega_D}\right] < 0 \tag{B.58}$$

We want to establish the sign of

$$E \;\equiv\; \frac{\mathcal{B}\,\mathcal{C}}{\mathcal{A}} + \frac{s_\ell + s_D}{s_\ell}\,\Gamma\big(1-\varepsilon^{-1}\big)\,. \tag{B.59}$$

From (B.55) we have

$$\mathcal{C} = \left[1 - \Gamma\big(1-\varepsilon^{-1}\big) - \frac{s_D}{s_\ell + s_D}\right]\frac{s_\ell + s_D}{s_\ell} = 1 - \frac{s_\ell + s_D}{s_\ell}\Gamma\big(1-\varepsilon^{-1}\big)\,,$$

so that

$$\frac{s_\ell + s_D}{s_\ell}\Gamma\big(1-\varepsilon^{-1}\big) = 1 - \mathcal{C}.$$

Substituting into (B.59) yields

$$E \;=\; \frac{\mathcal{B}\mathcal{C}}{\mathcal{A}} + 1 - \mathcal{C}. \tag{B.60}$$

Using (B.56) and (B.57)

$$(\mathcal{A} - \mathcal{C}) - \big(\mathcal{B} - (\mathcal{C} - 1)\big) = \frac{\eta^{-1}}{\clubsuit},$$

hence

$$\mathcal{B} = \mathcal{A} - 1 - \frac{\eta^{-1}}{\clubsuit}. \tag{B.61}$$

Substituting (B.61) into (B.60) we obtain

$$E = \frac{\mathcal{C}}{\mathcal{A}}\Big(\mathcal{A} - 1 - \tfrac{\eta^{-1}}{\clubsuit}\Big) + 1 - \mathcal{C} = 1 - \frac{\mathcal{C}}{\mathcal{A}}\left(1 + \frac{\eta^{-1}}{\clubsuit}\right).$$

Thus,

$$E \;=\; 1 - \frac{\mathcal{C}}{\mathcal{A}}\Big(1 + \tfrac{\eta^{-1}}{\clubsuit}\Big). \tag{B.62}$$

Since $\mathcal{C} < 0$ (bank SOC, see (B.55)) and $\clubsuit < 0$. From (B.56), $\mathcal{A} = \mathcal{C} + \frac{(1-\omega_D)\varepsilon^{-1} + \omega_D\eta^{-1}}{\clubsuit}$, where the fraction is negative. Thus $\mathcal{A} < \mathcal{C} < 0$, implying

$$0 < \frac{\mathcal{C}}{\mathcal{A}} < 1.$$

Moreover, since $\eta^{-1} > 0$ and $\clubsuit < 0$, we have

$$1 + \frac{\eta^{-1}}{\clubsuit} < 1.$$

Therefore the product $\frac{\mathcal{C}}{\mathcal{A}}(1+\eta^{-1}/\clubsuit)$ is strictly less than 1, and from (B.62) it follows that

$$E > 0.$$

We have then shown that,

$$\left[\frac{\mathcal{BC}}{\mathcal{A}} + \frac{s_\ell + s_D}{s_\ell}\Gamma\left(1-\varepsilon^{-1}\right)\right] > 0 \tag{B.63}$$

and so,

$$\frac{\partial s_\ell}{\partial s_P} > 0 \quad \text{and} \quad \frac{\partial s_\ell}{\partial \omega_P} < 0 \tag{B.64}$$

since signs are preserved we have,

$$\frac{\partial s_\ell}{\partial s_M} > 0 \quad \text{and} \quad \frac{\partial s_\ell}{\partial \omega_{M,S}} < 0$$

which proves point (2) and (3) of Proposition (2).

B.2.1 Dynamics of the Constraint in the Unconstrained Regime

We finish this section by studying movements in profits to determine whether the constraint is becoming tighter as Stablecoins is improved or CBDC introduced. Bank profits evolve as (B.14)—recall $\widehat{r}_B = 0$:

$$\widehat{\Pi}_B = \frac{s_\ell \widehat{s}_\ell + s_D \widehat{s}_D}{s_\ell + s_D} + \widehat{D}$$

We know that $\widehat{D} = \clubsuit \widehat{s}_\ell$. Note that the evolutions of profits is not immediate as spreads might contract but quantities grow:

$$\begin{aligned}\widehat{\Pi}_B &= \frac{s_\ell \widehat{s}_\ell + s_D \widehat{s}_D}{s_\ell + s_D} + \widehat{D} \\ &= \frac{s_D \widehat{s}_D}{s_\ell + s_D} + \widehat{s}_\ell \left[\clubsuit + \frac{s_\ell}{s_\ell + s_D}\right]\end{aligned}$$

the sign of $\left[\clubsuit + \frac{s_\ell}{s_\ell + s_D}\right]$ is not immediate as $\clubsuit$ determines the elasticity of bank loans to its price and in the case whether they are very elastic, quantities might respond strongly to the fall in loan prices, and banks profits will not fall.

A sufficient condition that guarantees profits falling after Stablecoins are improved or CBDC introduced is to bound the elasticity of loans to prices in order to get $\left[\clubsuit + \frac{s_\ell}{s_\ell+s_D}\right] > 0$. Note that,

$$\begin{aligned}
&\left[\clubsuit + \frac{s_\ell}{s_\ell+s_D}\right] \\
&\quad = -\frac{1}{\alpha}\left[1+\frac{\rho}{\alpha}(1-\alpha)\right]^{-1}\frac{s_\ell}{1+s_\ell}\left[\frac{p_N y_N}{Y}\alpha(1-\alpha)^{-1}+\rho\right]+\frac{s_\ell}{s_\ell+s_D} \\
&\quad = -\frac{s_\ell}{1+s_\ell}\frac{1}{1-\alpha}\frac{\frac{p_N y_N}{Y}\alpha(1-\alpha)^{-1}+\rho}{\alpha(1-\alpha)^{-1}+\rho}+\frac{s_\ell}{s_\ell+s_D}
\end{aligned}$$

a sufficient condition to guarantee that the term is positive is to have a sufficient inelastic demand for aggregate capital $\alpha \to 0$. To see this note that

$$\begin{aligned}
\frac{s_\ell}{1+s_\ell} &\in (0,1) \\
\frac{\frac{p_N y_N}{Y}\alpha(1-\alpha)^{-1}+\rho}{\alpha(1-\alpha)^{-1}+\rho} &\in (0,1)
\end{aligned}$$

then in the limit when $\alpha \to 0$ we have that in order for the term to be negative we need,

$$\frac{s_\ell}{1+s_\ell} < \frac{s_\ell}{s_\ell+s_D} \tag{B.65}$$

which is satisfied so long as $0 < s_D < 1$ a condition we impose for the equilibrium prices. Note that $s_D > 1$ will imply that deposits return is less than the principal, that is, $r_D < -1$, a condition we find economically irrelevant.

Then, we know that for a sufficiently low α profits move like spreads, s_D and s_ℓ, which fall as CBDC is introduced or stablecoins improced via a fall in s_M or an increase in $\omega_{S,M}$.

We would like to study the movements in $D - \phi(\Pi_B)$ in order to show that μ will eventually become greater than zero when s_M falls or $\omega_{S,M}$ increases enough.

To see this notice that in the unconstrained region $D - \phi(\Pi_B) < 0$ and therefore the complementary slackness condition $\mu \cdot [D - \phi(\Pi_B)] = 0$ needs $\mu = 0$. Yet if, for example, $D - \phi(\Pi_B)$ increases with $\omega_{S,M}$ monotonically and we show that exists an $\omega_{S,M}$ such that it is positive then given that they are continuous functions it will have to be that eventually $D - \phi(\Pi_B) > 0$ and we move to the constraint region if $\omega_{S,M}$ grows enough.

The evolution of $D(r_D) - \phi(\Pi_B)$ is driven by

$$\left[D\,\widehat{D} - \phi'\left(\Pi_B\right)\Pi_B\widehat{\Pi}_B\right]$$

We know that $\widehat{D} = \clubsuit \widehat{s}_\ell$ and so D moves contrarily to s_ℓ as $\clubsuit < 0$. If again we impose that α is sufficiently low, then profits move like s_ℓ, which gives that

$$\frac{\partial\left[D(r_D) - \phi(\Pi_B)\right]}{\partial s_M} < 0 \text{ and } \frac{\partial\left[D(r_D) - \phi(\Pi_B)\right]}{\partial \omega_{S,M}} > 0$$

which makes the constraint "tighter" as Stablecoins improve or CBDC is introduced.

What remains is to show that it exists a s_M or $\omega_{S,M}$ such that the constraint bind. But since $\phi(0) = 0$ and deposits are monotonically increasing in $\omega_{S,M}$ and decreasing in s_M (conditional on $L^\star$ being sufficiently high). Then the constraint will eventually bind.

B.3 Proof of Proposition 2 - Constrained Scenario

In this case, the bank deposit spread equation is driven by the constraint, whose evolution is driven by (B.13):

$$\widehat{D} = \frac{\phi'\left(\Pi_B\right)\Pi_B}{\phi\left(\Pi_B\right)}\widehat{\Pi}_B \tag{B.66}$$

where bank profits evolve as (B.14):

$$\widehat{\Pi}_B = \frac{s_\ell \widehat{s}_\ell + s_D \widehat{s}_D}{s_\ell + s_D} + \frac{r_B \widehat{r}_B}{1 + r_B} + \widehat{D} \tag{B.67}$$

and the multiplier as (B.12)

$$\frac{s_\ell \widehat{s}_\ell + s_D \widehat{s}_D}{s_\ell + s_D} = \frac{-\widehat{\varepsilon}_D \varepsilon_D^{-1} + \left[1 + \mu\phi'\left(\Pi_B\right)\right]\left[-\mu^{-1}\widehat{\mu} + \phi''\left(\Pi_B\right)\Pi_B\widehat{\Pi}_B\right]}{\varepsilon_D^{-1} + \frac{\mu}{1+\mu\phi'\left(\Pi_B\right)}}$$

Combine (B.13) and (B.14), the fact that in steady state $\widehat{r}_B = 0$ and assume a strictly concave constraint[19] to get

$$\widehat{D} = \frac{\phi'(\Pi_B)\,\Pi_B}{\phi(\Pi_B) - \phi'(\Pi_B)\,\Pi_B}\left(\frac{s_\ell \widehat{s}_\ell + s_D \widehat{s}_D}{s_\ell + s_D}\right). \tag{B.68}$$

then use (B.30) to get

$$\frac{\phi'(\Pi_B)\,\Pi_B}{\phi(\Pi_B) - \phi'(\Pi_B)\,\Pi_B}\left(\frac{s_\ell \widehat{s}_\ell + s_D \widehat{s}_D}{s_\ell + s_D}\right) = -\left(\frac{1}{\varepsilon} - \frac{1}{\eta}\right)\frac{\varepsilon}{1-\varepsilon}\,(1-\omega_D)\,\widehat{\omega}_P + \left(\frac{1}{\varepsilon} - \frac{1}{\eta}\right)(1-\omega_D)\,\widehat{s}_P - \left[(1-\omega_D)\,\frac{1}{\varepsilon} + \omega_D \frac{1}{\eta}\right]\widehat{s}_D. \tag{B.69}$$

collect the terms,

$$\left(\tfrac{1}{\varepsilon} - \tfrac{1}{\eta}\right)(1-\omega_D)\left[\widehat{s}_P - \tfrac{1}{\varepsilon^{-1}-1}\,\widehat{\omega}_P\right] - \left[(1-\omega_D)\varepsilon^{-1} + \omega_D \eta^{-1} + \frac{\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}{1 - \frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}\,\frac{s_D}{s_D + s_\ell}\right]\widehat{s}_D = \frac{\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}{1 - \frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}\,\frac{s_\ell}{s_\ell + s_D}\,\widehat{s}_\ell. \tag{B.70}$$

We also know from (B.41) that

$$\widehat{s}_\ell = \frac{-\left(\frac{1}{\varepsilon} - \frac{1}{\eta}\right)\frac{\varepsilon}{1-\varepsilon}\,(1-\omega_D)\,\widehat{\omega}_P + \left(\frac{1}{\varepsilon} - \frac{1}{\eta}\right)(1-\omega_D)\,\widehat{s}_P - \left[(1-\omega_D)\,\frac{1}{\varepsilon} + \omega_D \frac{1}{\eta}\right]\widehat{s}_D}{\clubsuit}$$

[19] The case of linear constraint is addressed below as a special case.

Now combine the previous equation (B.41) with (B.70) to get

$$\left(\frac{1}{\varepsilon}-\frac{1}{\eta}\right)(1-\omega_D)\left[\widehat{s}_P-\frac{1}{\varepsilon^{-1}-1}\,\widehat{\omega}_P\right]-\Bigg[(1-\omega_D)\varepsilon^{-1}+\omega_D\eta^{-1}$$
$$+\frac{\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}{1-\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}\,\frac{s_D}{s_D+s_\ell}\Bigg]\widehat{s}_D$$
$$=\frac{\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}{1-\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}\,\frac{s_\ell}{s_\ell+s_D}\,\frac{1}{\clubsuit}\Bigg[\left(\varepsilon^{-1}-\eta^{-1}\right)(1-\omega_D)\left(\widehat{s}_P-\frac{1}{\varepsilon^{-1}-1}\,\widehat{\omega}_P\right)$$
$$-\left((1-\omega_D)\varepsilon^{-1}+\omega_D\eta^{-1}\right)\widehat{s}_D\Bigg]. \tag{B.71}$$

Collect terms,

$$\left[\widehat{s}_P-\frac{1}{\varepsilon^{-1}-1}\,\widehat{\omega}_P\right]\left(\frac{1}{\varepsilon}-\frac{1}{\eta}\right)(1-\omega_D)\left[1-\frac{\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}{1-\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}\,\frac{s_\ell}{s_\ell+s_D}\,\frac{1}{\clubsuit}\right]$$
$$=\Bigg[\left((1-\omega_D)\varepsilon^{-1}+\omega_D\eta^{-1}\right)\left(1-\frac{\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}{1-\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}\,\frac{s_\ell}{s_\ell+s_D}\,\frac{1}{\clubsuit}\right)$$
$$+\frac{\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}{1-\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}\,\frac{s_D}{s_D+s_\ell}\Bigg]\widehat{s}_D. \tag{B.72}$$

now we proceed on signing this. The term on the left hand side is,

$$\mathcal{F}\equiv\left(\frac{1}{\varepsilon}-\frac{1}{\eta}\right)(1-\omega_D)\left[1-\frac{\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}{1-\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}\,\frac{s_\ell}{s_\ell+s_D}\,\frac{1}{\clubsuit}\right]$$

where we know that $\left(\frac{1}{\varepsilon}-\frac{1}{\eta}\right)>0$ and $(1-\omega_D)>0$. For the last term note that since $\phi(\Pi_B)$ is strictly concave, then

$$\phi'(\Pi_B)<\frac{\phi(\Pi_B)}{\Pi_B}\rightarrow 1-\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}>0$$

then, since $\clubsuit<0$ we have that

$$\mathcal{F}>0 \tag{B.73}$$

similarly the right hand side is

$$\mathcal{G} \equiv \left[\left((1-\omega_D)\varepsilon^{-1} + \omega_D \eta^{-1} \right) \left(1 - \frac{\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}{1 - \frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}} \frac{s_\ell}{s_\ell + s_D} \frac{1}{\clubsuit} \right) + \frac{\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}{1 - \frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}} \frac{s_D}{s_D + s_\ell} \right]$$

using the concavity of $\phi(\Pi_B)$ and that $\clubsuit < 0$ we have that,

$$\mathcal{G} > 0 \tag{B.74}$$

therefore, the effect of s_M and ω on s_D is given by

$$\widehat{s}_D = \frac{\mathcal{F}}{\mathcal{G}} \left[\widehat{s}_P - \tfrac{1}{\varepsilon^{-1}-1} \widehat{\omega}_P \right] \tag{B.75}$$

and therefore we know that,

$$\frac{\partial s_D}{\partial s_P} > 0 \text{ and } \frac{\partial s_D}{\partial \omega_P} < 0 \tag{B.76}$$

and therefore by the same argument as (B.53) we know,

$$\frac{\partial s_D}{\partial s_M} > 0 \text{ and } \frac{\partial s_D}{\partial \omega_{S,M}} < 0 \tag{B.77}$$

which proves point (1) of Proposition 2 for the constrain region with strictly concave constraints.

If we assume a linear constraint, we will have instead of equation (B.68):

$$0 = \frac{s_\ell}{s_\ell + s_D} \widehat{s}_\ell + \frac{s_D}{s_\ell + s_D} \widehat{s}_D \tag{B.78}$$

or

$$\widehat{s}_\ell = -\frac{s_D}{s_\ell} \widehat{s}_D$$

Combine again with (B.41) to get,

$$-\frac{s_D}{s_\ell} \widehat{s}_D = \frac{-\left(\frac{1}{\varepsilon} - \frac{1}{\eta}\right) \frac{\varepsilon}{1-\varepsilon} (1-\omega_D) \widehat{\omega}_P + \left(\frac{1}{\varepsilon} - \frac{1}{\eta}\right) (1-\omega_D) \widehat{s}_P - \left[(1-\omega_D) \frac{1}{\varepsilon} + \omega_D \frac{1}{\eta} \right] \widehat{s}_D}{\clubsuit}$$

Collect the terms

$$\widehat{s}_D = \frac{\left(\frac{1}{\varepsilon} - \frac{1}{\eta}\right)(1-\omega_D)}{(1-\omega_D)\frac{1}{\varepsilon} + \omega_D \frac{1}{\eta} - \frac{s_D}{s_\ell}\clubsuit}\left[\widehat{s}_P - \frac{1}{\varepsilon^{-1}-1}\widehat{\omega}_P\right].$$

which, since $\clubsuit < 0$, implies that the term multiplying the bracket is positive, and therefore the sign results in (B.77) carry through.

Back to the strictly concave constraint. Replace (B.75) in (B.41) to get the effect on s_ℓ

$$\widehat{s}_\ell = \frac{-\left(\frac{1}{\varepsilon} - \frac{1}{\eta}\right)\frac{\varepsilon}{1-\varepsilon}(1-\omega_D)\widehat{\omega}_P + \left(\frac{1}{\varepsilon} - \frac{1}{\eta}\right)(1-\omega_D)\widehat{s}_P - \left[(1-\omega_D)\frac{1}{\varepsilon} + \omega_D\frac{1}{\eta}\right]\widehat{s}_D}{\clubsuit}$$

replace the solution for $\widehat{s}_D$, collect terms and simplify

$$\widehat{s}_\ell = \frac{1}{\clubsuit}\left\{\left(\tfrac{1}{\varepsilon} - \tfrac{1}{\eta}\right)(1-\omega_D)\left[\widehat{s}_P - \tfrac{1}{\varepsilon^{-1}-1}\widehat{\omega}_P\right] - \left[(1-\omega_D)\varepsilon^{-1} + \omega_D\eta^{-1}\right]\frac{\mathcal{F}}{\mathcal{G}}\left[\widehat{s}_P - \tfrac{1}{\varepsilon^{-1}-1}\widehat{\omega}_P\right]\right\} \tag{B.79}$$

$$= \frac{1}{\clubsuit}\left[\left(\tfrac{1}{\varepsilon} - \tfrac{1}{\eta}\right)(1-\omega_D) - \left((1-\omega_D)\varepsilon^{-1} + \omega_D\eta^{-1}\right)\frac{\mathcal{F}}{\mathcal{G}}\right]\left[\widehat{s}_P - \tfrac{1}{\varepsilon^{-1}-1}\widehat{\omega}_P\right]. \tag{B.80}$$

We want to sign the first term, so let's begin with the bracket and show it is positive

$$\left[\left(\tfrac{1}{\varepsilon} - \tfrac{1}{\eta}\right)(1-\omega_D) - \left((1-\omega_D)\varepsilon^{-1} + \omega_D\eta^{-1}\right)\frac{\mathcal{F}}{\mathcal{G}}\right] > 0$$

Let's operate on the bracket and use the definitions of $\mathcal{F}$ and $\mathcal{G}$

$$\left[\left(\tfrac{1}{\varepsilon}-\tfrac{1}{\eta}\right)(1-\omega_D)-\left((1-\omega_D)\varepsilon^{-1}+\omega_D\eta^{-1}\right)\frac{\mathcal{F}}{\mathcal{G}}\right]$$

$$=\frac{\left(\tfrac{1}{\varepsilon}-\tfrac{1}{\eta}\right)(1-\omega_D)\,\mathcal{G}-\left((1-\omega_D)\varepsilon^{-1}+\omega_D\eta^{-1}\right)\mathcal{F}}{\mathcal{G}}$$

$$=\frac{\left(\tfrac{1}{\varepsilon}-\tfrac{1}{\eta}\right)(1-\omega_D)\left\{\left((1-\omega_D)\varepsilon^{-1}+\omega_D\eta^{-1}\right)\left[1-\frac{\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}{1-\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}\,\frac{s_\ell}{s_\ell+s_D}\,\frac{1}{\clubsuit}\right]+\frac{\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}{1-\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}\,\frac{s_D}{s_D+s_\ell}\right\}}{\mathcal{G}}$$

$$-\frac{\left((1-\omega_D)\varepsilon^{-1}+\omega_D\eta^{-1}\right)\left(\tfrac{1}{\varepsilon}-\tfrac{1}{\eta}\right)(1-\omega_D)\left[1-\frac{\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}{1-\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}\,\frac{s_\ell}{s_\ell+s_D}\,\frac{1}{\clubsuit}\right]}{\mathcal{G}}$$

$$=\frac{\left(\tfrac{1}{\varepsilon}-\tfrac{1}{\eta}\right)(1-\omega_D)\,\frac{\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}{1-\frac{\phi'(\Pi_B)\Pi_B}{\phi(\Pi_B)}}\,\frac{s_D}{s_D+s_\ell}}{\mathcal{G}}>0$$

where the sign is positive because $\mathcal{G}>0$, $\phi(\Pi_B)$ increasing and concave and $\varepsilon^{-1}>\eta^{-1}$.

Coming back now to our equation of interest (B.80) we know that

$$\widehat{s}_\ell=\frac{1}{\clubsuit}\left[\left(\tfrac{1}{\varepsilon}-\tfrac{1}{\eta}\right)(1-\omega_D)-\left((1-\omega_D)\varepsilon^{-1}+\omega_D\eta^{-1}\right)\frac{\mathcal{F}}{\mathcal{G}}\right]\left[\widehat{s}_P-\tfrac{1}{\varepsilon^{-1}-1}\,\widehat{\omega}_P\right]$$

and since we show that the terms in brackets is positive and $\clubsuit<0$ we have that

$$\frac{\partial s_\ell}{\partial s_M}<0\quad\text{and}\quad\frac{\partial s_\ell}{\partial\omega_{S,M}}>0 \tag{B.81}$$

which proves point (2) and (3) of Proposition 2 for strictly concave constraint (the effect on quantities come from (B.29), (B.37), (B.38) and (B.40) which are valid under both scenarios as they come from the production side).

For linear constraints equation (B.80) now becomes

$$\widehat{s}_\ell = -\frac{s_D}{s_\ell}\,\frac{\left(\frac{1}{\varepsilon}-\frac{1}{\eta}\right)(1-\omega_D)}{(1-\omega_D)\,\frac{1}{\varepsilon}+\omega_D\frac{1}{\eta}-\frac{s_D}{s_\ell}\clubsuit}\left[\widehat{s}_P-\frac{1}{\varepsilon^{-1}-1}\,\widehat{\omega}_P\right].$$

where in this case again since $\clubsuit < 0$ then the term multiplying the braket,

$$-\frac{s_D}{s_\ell}\,\frac{\left(\frac{1}{\varepsilon}-\frac{1}{\eta}\right)(1-\omega_D)}{(1-\omega_D)\,\frac{1}{\varepsilon}+\omega_D\frac{1}{\eta}-\frac{s_D}{s_\ell}\clubsuit} < 0$$

and the results in (B.81) carry though for the linear case as well.

For deposits quantities take (B.80), (B.38) and (B.41)

$$\widehat{D} = \left[\left(\tfrac{1}{\varepsilon}-\tfrac{1}{\eta}\right)(1-\omega_D) - \left((1-\omega_D)\varepsilon^{-1}+\omega_D\eta^{-1}\right)\frac{\mathcal{F}}{\mathcal{G}}\right]\left[\widehat{s}_P-\tfrac{1}{\varepsilon^{-1}-1}\,\widehat{\omega}_P\right] \tag{B.82}$$

for which we prove before that the term in brackets is positive. Therefore, $\frac{\partial D}{\partial s_M} > 0$ and $\frac{\partial D}{\partial \omega} < 0$ and so do loans.

B.4 Proof of Corollary 1

The proof of Corollary 1 comes naturally from previous proofs. Note that all our results, for example equations (B.75), (B.43) or (B.52), depends on the effect of movements in $\left[\widehat{s}_P-\frac{1}{\varepsilon^{-1}-1}\,\widehat{\omega}_P\right]$, therefore changes in $\omega_{S,M}$ or s_M that make the term move by the same magnitude will have the same effect on equilibrium variables.

Let's first decompose the term using the definitions of s_P and ω_P. Let's call the term $\widehat{\varphi}$:

$$\widehat{\varphi} = \widehat{s}_P-\tfrac{1}{\varepsilon^{-1}-1}\,\widehat{\omega}_P = \frac{\omega_M}{\omega_P}\,\widehat{s}_M - \frac{1}{\varepsilon^{-1}-1}\,\left(\widehat{\omega}_M\frac{\omega_M}{\omega_P}+\widehat{\omega}_S\frac{\omega_S}{\omega_P}\right)$$

Then if we care about the partial effect of perturbing only one variable at a time we get,

$$\frac{\widehat{\varphi}}{\widehat{s}_M} = \frac{\partial \log \varphi}{\partial \log s_M} = \frac{\omega_M}{\omega_P}$$
$$\frac{\widehat{\varphi}}{\widehat{\omega}_M} = \frac{\partial \log \varphi}{\partial \log \omega_M} = -\frac{1}{\varepsilon^{-1} - 1}\frac{\omega_M}{\omega_P}$$
$$\frac{\widehat{\varphi}}{\widehat{\omega}_S} = \frac{\partial \log \varphi}{\partial \log \omega_S} = -\frac{1}{\varepsilon^{-1} - 1}\frac{\omega_S}{\omega_P}$$

Corollary 1 follows from previous equations by replacing φ for any variable of interest.

B.5 Proof of Proposition 4

Case (i): Deposits not special. Remove banks constraint on wholesale funding, that is now $B \lesseqgtr 0$, and assume also that wholesale liabilities do not enter the borrowing constraint. Then the bank's problem is

$$\max_{\ell,D,B} \; (1 + r_\ell)\,\ell + (1 + r)\,B - (1 + r_D)\,D, \quad \text{s.t. } \ell + B = D, \;\; D \leq \phi(\Pi_B).$$

The FOC that characterize the solution are,

$$[\ell] : (1 + r_\ell)\,[1 + \mu\phi'] = \lambda$$
$$[B] : (1 + r)\,[1 + \mu\phi'] = \lambda$$
$$[r_D] : [(1 + r_D) + D/D']\,[1 + \mu\phi'] = -\lambda + \mu$$

Combine $[\ell]$, $[B]$ to get,

$$r = r_\ell \rightarrow r_\ell = \frac{1}{\beta} - 1$$

where the last equation comes from households Euler equation at steady state.

Case (ii): Bank credit not special. If non-corporate firms can borrow directly from households at an exogenous rate then by non-arbitrage of households portfolio we have that the rate should equal the bond interest rate. Since also firms small firms now can arbitrage between banks and firms borrowing, we have again in this case that $r_\ell = r$.

Appendix C Equilibrium

As described in Definition 1, we have the following endogenous variables: Consumption C, deposits D, government money M, stablecoins S, bonds held by households B_H, final goods output Y, output, capital, investment and relative prices by corporate and small non-corporate firms $y_X, K_X, I_X, p_X\ \forall X \in \{C, N\}$, loans ℓ, bonds held by banks B_B, bonds held by stablecoin suppliers B_S, deposit r_D and loan interest rate r_ℓ, taxes T and the Lagrange multipliers for the leverage constraint μ and the bond holdings κ. As mentioned in Section 2.6, we focus on steady state equilibria with a positive loan rate spread, $s_\ell > 0$, such that banks do not hold bonds $B_B = 0$ and $\kappa > 0$.

Furthermore, there are three exogenous interest rates r_M, r and r_S, where r is determined by the agent's discount factor $\beta = (1+r)^{-1}$. In the base case, the interest rate on stablecoins is equal to the public money rate, $r_S = r_M$. The equilibrium equations are shown below. From the household problem we have the deposit and money demand equations, and the budget constraint:

$$D = L\left(\frac{s_D}{s_L}\right)^{-1/\varepsilon}, \tag{C.1}$$

$$M = \omega_M L\left(\frac{s_M}{s_L}\right)^{-1/\varepsilon}, \tag{C.2}$$

$$S = \omega_S L\left(\frac{s_S}{s_L}\right)^{-1/\varepsilon} \tag{C.3}$$

$$C = \Pi + r_D D + r B_H, \tag{C.4}$$

where the last equation imposes the government budget constraint and the fact that the stablecoin suppliers profit also drops out since only government bonds are held and the profit is distributed to households. Total liquidity L, the spread s_L and overall profit Π, composed of bank and firm profits, are given by:

$$L = \min\{L^*, \nu s_L^{-1/\eta}\} \tag{C.5}$$

$$s_L = \left(\omega_M s_M^{\frac{\varepsilon-1}{\varepsilon}} + s_D^{\frac{\varepsilon-1}{\varepsilon}} + \omega_S s_S^{\frac{\varepsilon-1}{\varepsilon}}\right)^{\frac{\varepsilon}{\varepsilon-1}} \tag{C.6}$$

$$\Pi = \underbrace{\Pi_B}_{\text{Bank}} + \underbrace{p_N y_N - I_N(1+r_\ell)}_{\text{Non-corporate Firm}} + \underbrace{p_C y_C - I_C(1+r)}_{\text{Corporate Firm}} \tag{C.7}$$

From the bank problem, we get the deposit supply equation, the profit equation, the balance sheet identity and the complementary slackness condition:

$$\begin{aligned} s_D =& \varepsilon_D^{-1} + \kappa - s_\ell, & \text{(C.8)} \\ \Pi_B =& \ell\left(1+r_\ell\right) - D\left(1+r_D\right) & \text{(C.9)} \\ \ell =& D, & \text{(C.10)} \\ 0 =& \mu(\phi(\Pi_B) - D), & \text{(C.11)} \end{aligned}$$

where the elasticity of deposit demand ε_D and the deposit market share ω_D is defined by:

$$\begin{aligned} \varepsilon_D^{-1} =& \frac{s_D}{\varepsilon^{-1}\left(1-\omega_D\right) + \eta^{-1}\omega_D}, & \text{(C.12)} \\ \omega_D =& \frac{Ds_D}{Ds_D + Ms_M + Ss_S}. & \text{(C.13)} \end{aligned}$$

From the final goods producer we have the production function and the two first order conditions with respect to the two inputs:

$$\begin{aligned} Y &= \left[y_N^{\frac{\rho-1}{\rho}} + y_C^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}, & \text{(C.14)} \\ y_C &= Y p_C^{-\rho}, & \text{(C.15)} \\ y_N &= Y p_N^{-\rho}. & \text{(C.16)} \end{aligned}$$

From the intermediate goods producers we have two production functions, two capital evolution equations and the two first order conditions:

$$\begin{aligned} y_C &= A_C K_C^{\alpha}, & \text{(C.17)} \\ y_N &= A_N K_N^{\alpha}, & \text{(C.18)} \\ \delta K_N &= I_N, & \text{(C.19)} \\ \delta K_C &= I_C, & \text{(C.20)} \\ \alpha p_C A_C K_C^{\alpha-1} &= r + \delta, & \text{(C.21)} \\ \alpha p_N A_N K_N^{\alpha-1} &= \left(1+s_\ell\right)\left(r+\delta\right). & \text{(C.22)} \end{aligned}$$

Lastly, we have market clearing in the goods and lending market

$$Y = C + I_C + I_N, \tag{C.23}$$

$$I_C = B_H, \tag{C.24}$$

$$I_N = \ell, \tag{C.25}$$

$$B_P = B_{S,P} + B_{H,P}, \tag{C.26}$$

and the definitions for the spreads:

$$s_D = \frac{r - r_D}{1 + r},, \tag{C.27}$$

$$s_M = \frac{r - r_M}{1 + r},, \tag{C.28}$$

$$s_S = \frac{r - r_S}{1 + r},, \tag{C.29}$$

$$s_\ell = \frac{r_\ell - r}{1 + r},. \tag{C.30}$$

To solve the model numerically, we apply the following algorithm depicted below. If the algorithm converges, the values determined in the last iteration represent the model solution.

Algorithm 1 Solve model numerically

Input: Initial guess s_0^D and $\{\beta, \nu, \eta, \omega_M, \omega_S, s_M, s_S, \varepsilon, \rho, \phi, \alpha, A_S, A_C, \delta, L^*\}$
Output: s_D

1: $s_D \leftarrow s_0^D$
2: Calculate $s_L, L, D, M, S, \omega_D, \varepsilon_D$ using (C.6), (C.5), (C.1), (C.2), (C.3), (C.13) and (C.12).
3: Set $\mu = \kappa = 0$. ▷ Assuming unconstrained region.
4: Calculate s_ℓ using (C.8).
5: Calculate ℓ and Π_B using (C.10) and (C.9).
6: **if** $D > \phi(\Pi_B)$ **then** ▷ Constrained region.
7: $\Pi_B = \phi^{-1}(D)$ ▷ Leverage constraint binding.
8: Calculate s_ℓ using (C.10) and (C.9).
9: Calculate κ using (C.8).
10: **end if**
11: Calculate I_N, K_N, y_N, p_N using (C.25), (C.19), (C.18) and (C.22).
12: $p_C = (1 - p_N^{1-\rho})^{1/(1-\rho)}$ ▷ Price level for CES-function.
13: Calculate K_C, y_C, Y using (C.21), (C.17) and (C.14).
14: **if** $y_C \neq Y p_C^{-\rho}$ **then** ▷ Use Equation (C.15).
15: Choose different s_D in line 1
16: **end if**
17: **return** s_D

Appendix D Data

The model is calibrated to the US economy spanning from 1987 to 2019. We obtain data on the federal funds rate from FRED. To calculate real interest rates, we utilize inflation expectations measured by the Federal Reserve Bank of Cleveland, also obtained from FRED. Our measure for M is derived from the currency component of M1. Additionally, we incorporate estimates from Judson (2017) to account for US-dollar holdings abroad. However, these estimates are available only until 2016, so we extrapolate the time series up to 2019. Lastly, we measure aggregate deposit supply to calculate money demand using FRED data as well.

Table D.1: FRED and FDIC call report data.

Variable	**Source**	**Mnemonic**
Federal Funds Rate	FRED	DFF
Expected Inflation	FRED	EXPINF1YR
Currency component of M1	FRED	WCURRNS
Deposits, All Commercial Banks	FRED	DPSACBW027SBOG
Transaction Deposit Expense	FDIC	ETRANDEP; RIAD4508
Transaction Deposit Amount	FDIC	TRN; RCON2215
Savings Deposit Expense	FDIC	ESAVDP; RIAD0093
Savings Deposit Amount	FDIC	AVSAVDP; RCONB563
Loan Income	FDIC	ILN; RIAD4010
Loan Amount	FDIC	AVLN; RCON3360
Total Equity	FDIC	EQ; RCFD3210

The first set of FDIC mnemonics (e.g. ETRANDEP) are the ones used in the bulk download data. The second set of FDIC mnemonics are the ones that are used in the call reports (e.g. RIAD4508). A mapping can be found here: `https://www7.fdic.gov/DICT/app/templates/Index.html#!/Main`

All other data required for the calibration is derived from FDIC call reports, obtained via bulk download from `https://www.fdic.gov/foia/ris/`. For each quarter spanning from 1987 to 2019, our initial step involves computing a banking-sector interest rate by aggregating the expenses of all banks on transaction and saving deposits, which is then divided by the aggregated amounts of transaction and saving deposits. Subsequently, we compute the spread between the banking-sector interest rate and the federal funds rate to get s_D. We proceed analogously for the loan rate spread. To obtain estimates for the steady state, we calculate the time series' average. To compute the banking sector's leverage, we utilize total equity. The data points used are presented in Table D.1.

Appendix E Calibration

First, we set the parameter calibrated to literature values, $\beta, \delta, \rho, \varepsilon$.

To compute ω and ω_S, we divide Equation (C.2) and (C.3) by Equation (C.1) and rearrange the expressions as follows:

$$\omega_M = \frac{M}{D}\left(\frac{s_D}{s_M}\right)^{-1/\varepsilon}$$

$$\omega_S = \frac{S}{D}\left(\frac{s_D}{s_S}\right)^{-1/\varepsilon}$$

We determine ω_M and ω_S using the steady-state values of M/D, S/D, s_D, s_M and s_S.

As discussed in Section 3.2.1, we first assume, and then check, that banks' leverage constraints are not binding in steady state and the deposit spread arises exclusively due to the market power of banks on deposits. Thus, η is chosen such that the spreads in Equation (24) match the data moments, utilizing $\mu = 0$ in the unconstrained case. By combining Equations (24) and (25), i.e.,

$$\frac{s_D}{s_D + s_\ell} = \left[\varepsilon^{-1}\left(1 - \frac{s_D}{s_M M/D + s_D + s_S S/D}\right) + \eta^{-1}\left(\frac{s_D D}{s_M M/D + s_D + s_S S/D}\right)\right]$$

we can pin down η, using ε and the steady state values of s_D, s_M, s_ℓ, M/D and S/D.

Next, calculate relative prices. Combine equations (C.16) and (C.15) and use the definition of relative prices given that the aggregate price level is set to $P = 1$, i.e., $p_C = (1 - p_N^{1-\rho})^{\frac{1}{1-\rho}}$. This yields:

$$\frac{y_C}{y_N} = \left(\frac{(1 - p_N^{1-\rho})^{\frac{1}{1-\rho}}}{p_N}\right)^{-\rho}$$

Using this we can caculate p_N given ρ and the data moment of y_C/y_N. Now calculate $p_C = (1 - p_N^{1-\rho})^{\frac{1}{1-\rho}}$.

Calculate Y, i.e.,

$$Y = \left[y_N^{\frac{\rho-1}{\rho}} + y_C^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}$$

by normalizing $y_C = 1$ and using the data moment for y_C/y_N.

Calculate D using the data moment for D/Y. Then calculate ν by combining (C.1) and (C.5), i.e.,

$$\nu = s_D^{1/\varepsilon} D s_L^{1/\eta - 1/\varepsilon}$$

where s_L is defined by (C.6) and the data moments for s_D, s_M and s_S.

Next, calculate $I_N = \ell = D$ and $K_N = I_N/\delta$. Given the equations (C.18) and (C.22) from the small firm's problem you can pin down α and A_N solving the system of equations.

Pin down A_C using the first order condition of the corporate sector:

$$A_C = \left(\frac{r+\delta}{\alpha p_C y_C^{\frac{\alpha-1}{\alpha}}} \right)^{\alpha}$$

Lastly, we pin down the parameter ϕ for the leverage constraint. As discussed in Appendix A.4, we can rearrange the standard leverage constraint including equity, i.e. $D \leq \psi e$, to $D \leq \Pi_B \psi/\gamma$. As discussed in Section 3.2.1, for the standard leverage constraint we choose $\psi = 10$. For γ we aim to match $\gamma = \Pi_B/e$ in the data. Since in our model, the only profit the banks make is due to the interest rate spread between loans and deposits, we use the FDIC data to calculate the income from the net interest margin and relate it to equity. This yields a steady state value of $\gamma = 0.4$. Thus it follows, $\phi = \psi/\gamma = 10/0.402 = 24.9$.