Deposit Insurance, Bank Regulation, and Narrow Banking

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Abstract

Narrow banking has surfaced frequently as a proposed framework for dealing with financial instability and inefficiency. Recent proposals include reforms intended to improve the implementation of monetary policy, and to deal with perceived problems related to stablecoins. A model is constructed in which banks must deal with three frictions: limited commitment, moral hazard with respect to risky assets, and potential misrepresentation of safe assets. Surprisingly, deposit insurance does not engender inefficiency, and government-imposed capital requirements and leverage requirements serve to reduce welfare. The viability of narrow banking depends on inefficient regulation in conventional banking, and narrow banking is never welfare-improving.

1 Introduction

Narrow banking ideas originated in the 1930s (Pennacchi 2012) when the "Chicago School" promoted the notion that banking could work efficiently if banks were constrained to backing transactions deposits with safe assets. Since then, narrow banking proposals have resurfaced frequently as potential solutions to perceived problems of financial instability and inefficiency. Recently, for example, there has been concern with growth in "stablecoins," and what this entails for optimal financial industry regulation. And, not surprisingly (e.g. Gorton and

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Zhang 2021), the imposition of a narrow banking structure on stablecoins has been suggested as an approach to mitigating or eliminating misrepresentation and potential systemic risk associated with stablecoin activity.

The purpose of this paper is to examine banking regulation and narrow banking in a general equilibrium model of payments and banking. In the model, banks are subject to financial frictions – limited commitment and private information – typically thought important for banking regulation. Specifically, banks can abscond on their debts, and there is moral hazard with respect to the risky assets held by banks. We also include a financial friction that appears important in the context of stablecoin issue – potential misrepresentation of a bank's safe asset portfolio. For example, Tether, the largest stablecoin, with assets that would place it in the top 40 banks in the United States, has been plagued with questions about the quality of its asset portfolio since inception – an asset portfolio that is alleged by its managers to consist of safe and liquid securities.

Why have economists, past and present, argued that narrow banking is a good idea? Early advocates, e.g. Fisher (1936) thought there would be benefits from separating money from credit (see also Sargent 2011). According to the argument, narrow banking would guarantee the safety of bank deposits, and eliminate fluctuations in confidence in the banking system. Friedman (1960) proposed a specific narrow banking restriction – a 100% reserve requirement. Friedman thought of the 100% reserve requirement as assuring monetary control. That is, for Friedman, separating money from credit was seen as a sound quantity theory principle, which would engender macroeconomic stability.

More recent advocates of narrow banking include Cochrane (2014) and Gorton and Zhang (2021) who propose narrow banking as a solution to instability in, respectively, the regulated banking system, and the stablecoin industry. Narrow banking is sometimes viewed as a vehicle for doing away with costly banking regulation. For example, deposit insurance is conventionally viewed as a solution to banking instability, but is also seen as producing a moral hazard problem. That is, deposit-insured banks will take on too much risk, a problem that could be corrected with other regulations, for example bank capital requirements (Kareken and Wallace 1978, Boyd and Rolnick 1989, Dewatripont and Tirole 1993, Cooper and Ross 2002). But a narrow bank would be safe by virtue of the safety of its asset portfolio, and would not require deposit insurance, or the costly regulatory structure that goes with it, according to the argument.

Another recent narrow banking proposal involves the use of "segregated balance accounts" (Garratt et al. 2015) which could be offered by commercial banks. That is, according to the proposal, a narrow banking operation could be segregated within a standard commercial banking entity subject to the usual array of regulations. While typical narrow banking proposals are aimed at reforming the entire banking system, the arguments for segregated balance accounts relate to improving efficiency and monetary policy implementation.

Not everyone thinks that narrow banking is a simple solution to eliminating financial instability and costly banking regulations. For example, Diamond and Dybvig (1986) and Wallace (1996) have argued against narrow banking.

Their view is that banking has an important social function in transforming illiquid assets into liquid assets, so preventing banks from carrying out this transformation, by requiring them to be narrow, does more harm than good (see also Boyd and Rolnick 1989). Also, Diamond and Dybvig (1986) and Gorton and Zhang (2021) argue that deposit insurance has done a good job in the United States in promoting financial stability.

In our model, banks hold risky assets and safe assets, where the safe assets are government bonds. But there are three ways in which banks, in the model, cannot be trusted. First, banks have limited commitment, and so can default on their deposit liabilities. Second, banks are subject to moral hazard, in that unobservable bank actions affect the payoffs on a bank's risky assets. Third, banks can misrepresent the quality of safe assets. Given limited commitment, a bank can secure its deposit liabilities by posting its assets as collateral, but the other frictions in the model may call the quality of the bank's collateral into question. Potentially, the bank is able to signal the quality of its risky and safe assets through self-imposed capital constraints. That is, a bank may choose to borrow against only a fraction of the risky assets it holds, which can give it the incentive to choose high effort, and therefore increase the expected return on its risky assets. Similarly, with a self-imposed capital constraint on safe assets, a bank can signal to depositors that it has not faked the quality of its safe assets. The incentive problems associated with the quality of risky and safe assets in the model are related to problems in Li et al. (2012) and Williamson (2018).

Banks in the model provide means of payment for consumers, who carry out transactions in a decentralized context, using claims on banks. The model builds on a Lagos-Wright (2005) type framework. Since it is recognized that the scarcity of safe assets could be important to the efficacy of narrow banking arrangements (Diamond and Dybvig 1986, Wallace 1996), we build this scarcity into the model by assuming the stock of government debt is limited by fiscal policy.

In order to understand the effects of narrow banking, we need to first learn something about how a conventional regulated banking system operates under deposit insurance. In the model, deposit insurance is government-provided, supported by actuarially fair insurance premia and lump sum taxes. Depending on the cost to a bank of supplying high effort, there may be a low-effort or high-effort equilibrium. Interestingly, if the bank chooses high effort it will signal this by acquiring "skin-in-the-game," in funding part of its risky asset portfolio with internally-generated bank capital. We find that equilibria are efficient, in the sense that there would be no welfare benefit were a social planner able to force banks to choose a particular level of effort. So, deposit insurance does not engender inefficiency in this environment. This contrasts with conventional wisdom (Kareken and Wallace 1978, Diamond and Dybvig 1986, Boyd and Rolnick 1989, Dewatripont and Tirole 1993, Cooper and Ross 2002), which holds that government-provided deposit insurance creates inefficiency by aggravating moral hazard.

Further, conventional wisdom also appears to view government-imposed bank capital requirements favorably, as a vehicle for correcting the perceived moral hazard problem associated with deposit insurance. But, in this environment, government-imposed capital requirements at best have no effect, and at worst reduce welfare. Capital requirements indeed encourage banks to choose high effort, but either these capital requirements do not bind – banks choose to acquire even more capital than required – or welfare is reduced because high effort is chosen by banks when low effort is socially appropriate, and/or the capital requirement causes collateral to be used inefficiently.

Narrow banks are introduced in the model in two forms. First, suppose that banks can choose to be regulated or narrow. If a bank chooses to be narrow it foregoes regulation but is not permitted to hold risky assets. In this case, if regulated banks and narrow banks face the same costs of faking safe assets, then permitting narrow banks is irrelevant. And for this result, it does not matter whether or not there is a government capital requirement for the regulated banking sector. So, given symmetry between the regulated and narrow banking sectors, in the frictions relating to safe assets, the fraction of narrow banks in the system is indeterminate. Some safe assets could migrate to the narrow banking sector and the regulated banking sector could shrink, but this would not matter.

But, suppose that regulated banks cannot fake safe assets, but narrow banks can, which seems realistic. And also, assume that regulated banks face a leverage requirement – skin in the game is required for both risky and safe assets in the regulated bank's portfolio. In this case, a sufficiently high leverage requirement can lead to an equilibrium in which all safe assets migrate to narrow banks, while regulated banks hold all the risky assets and no safe assets. Alternatively, if the leverage requirement is low enough, narrow banks are not viable. That is, it may be that narrow banking is permitted but does not exist in equilibrium.

Second, rather than allowing banks to choose to be narrow or regulated, suppose in line with Friedman (1960) that all banks must be narrow. We show that this will in general reduce welfare. If safe assets are sufficiently plentiful, then in equilibrium all banks are narrow, but banks would choose this if they were not required to.

So, the conclusion is that narrow banking, even if permitted, will not be viable unless there are sufficiently restrictive inefficient regulations in place in the conventional banking sector. Key to this result is that, given our assumptions, banks have the means to signal risky asset quality without the imposition of capital requirements.

The paper is organized as follows. The second section contains the model setup, while Section 3 is an analysis of regulated banking with deposit insurance. Then, in Sections 4 and 5, narrow banking is analyzed in regimes where, respectively, regulated banking and narrow banking coexist, and where all banks are required to be narrow. The final section is a conclusion.

2 Model

Periods are indexed by $t = 0, 1, 2, ...$, and each period has two subperiods, the centralized market (CM), followed by the decentralized market (DM). There are three types of economic agents in the model: buyers, sellers, and banks. There is a continuum of buyers with unit mass, and each buyer maximizes

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[-H_t + u(x_t)\right], \tag{1}$$

where $0 < \beta < 1$, H_t denotes labor supply in the CM, x_t denotes consumption in the DM,and $u(\cdot)$ is strictly increasing, strictly concave, and twice continuously differentiable. Assume that $u(0) = 0$, $u(\hat{x}) = \hat{x}$ for some $\hat{x} > 0$, and

$$-\frac{xu''(x)}{u'(x)} < 1. \tag{2}$$

This latter assumption guarantees that asset demands are increasing in rates of return (substitution effects dominate income effects). Define x^* by $u'(x^*) = 1$, where x^* denotes the surplus-maximizing quantity of consumption in a DM exchange. There is a continuum of sellers with unit mass, with each seller maximizing

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[X_t - h_t\right], \tag{3}$$

where X_t denotes consumption in the CM, and h_t is labor supply in the DM. Finally, there exists a continuum of banks with unit mass, each of which has preferences

$$E_0 \sum_{t=0}^{\infty} \beta^t (X_t^b - H_t^b - e_t^b), \tag{4}$$

where X_t^b and H_t^b are consumption and labor supply, respectively, for the bank in the CM, and e_t^b is the cost of effort in the CM. We will not construct a deep theory of financial intermediation here. Banks are individual agents that can consume and produce in the CM and, as we will outline in what follows, these banks will be endowed with some powers that other economic agents do not have. This simplifies things, and will not detract from any issues addressed in this paper.

There exists a technology, accessible to all economic agents, which can produce k units of risky assets in the CM at a cost σk, in CM goods, where $\sigma > 0$. In equilibrium, since risky assets are produced subject to constant marginal costs, any agent will earn zero profits from such production, so it will be irrelevant who produces risky assets. A risky asset can produce consumption goods, but only if held by a bank. Risky assets produced in the CM of period t become productive in the CM of period $t+1$, if held by a bank, and then depreciate by 100%. A bank acquiring risky assets k_t^B in the CM of period t must make a choice concerning effort applied to these assets. In particular, the cost to the bank of applying high effort per unit of risky assets is $\omega > 0$, while the cost of applying low effort is zero. Effort is private information to the bank, though other agents can discern whether the same level of effort has been applied to a given quantity of risky assets, though it cannot be observed whether this effort is low or high.[1]

Risky assets held by banks, with an effort choice by the bank, is a modeling choice that can be interpreted as standing in for a more complicated lending problem for banks. For example, we could have borrowers who have a choice of effort that determines the riskiness of the borrowers' investment projects. And then, banks could be assumed to have choices concerning whether they do due diligence with respect to borrowers by screening loans. Then, features of the environment – regulations, deposit insurance, etc. – would affect the bank's choices about loan screening. Instead, to make the analysis more transparent, we follow the more direct approach of simply making some of the bank's assets risky, with riskiness determined by an effort choice of banks. For our purposes, the problem is essentially the same as following a more detailed approach.

In general, the return on the bank's risky assets depends on an aggregate shock $\xi_t \epsilon \{0, 1\}$,and on the bank's individual effort, denoted $e_t \epsilon \{0, \omega k_t^B\}$. Assume that ξ_t is i.i.d. and realized at the beginning of period t. If $\xi_{t+1} = 0$ and $e_t = 0$, then the payoff on the bank's risky assets k_t^B in period $t+1$ is rk_t^b with probability $1 - \alpha_0$, and the payoff is zero with probability α_0. However, if $\xi_{t+1} = 0$ and $e_t = \omega k_t^B$, then the payoff on the bank's risky assets is $r^k k_t^B$ with probability $1 - \alpha_1$, and the payoff is zero with probability α_1. If $\xi_{t+1} = 1$, then the payoff on the bank's risky assets is $r^k k_t^B$, independent of the bank's effort choice in period t. Assume $\Pr[\xi_t = 0] = \delta$ and $\Pr[\xi_t = 1] = 1 - \delta$, where $0 < \delta < 1$, and $0 < \alpha_1 < \alpha_0 < 1$. As well, assume that

$$\omega < \beta\delta \left(\alpha_0 - \alpha_1\right) r^k, \tag{5}$$

so it is efficient for the bank to invest in high effort. As well, assume that

$$\sigma > \beta(1 - \delta\alpha_1)r^k - \omega. \tag{6}$$

Then, defining ϕ_i, for $i = 0, 1$ to be the discounted expected payoff on risky assets when the bank chooses low effort and high effort, respectively, that is

$$\phi_i \equiv \beta(1 - \delta\alpha_i)r^k,$$

for $i = 0, 1$, then (5) and (6) imply

$$\frac{\phi_0}{\sigma} < \frac{\phi_1}{\sigma + \omega} < 1.$$

That is, the gross rate of return to investing in risky assets and incurring low effort is lower than the gross rate of return to investing in risky assets and incurring high effort, but a bank will not invest in risky assets unless those assets bear a liquidity premium (risky assets are negative present value projects). In the model, as we will show, this liquidity premium can arise if safe assets are

[1] This assumption will imply that the bank cannot cheat by applying a low level of effort to risky assets backing bank deposits, and a high level of effort to risky assets held by the bank only for their payoffs.

sufficiently scarce. But, in the absence of a sufficient scarcity of safe assets, risky assets will not be produced in equilibrium. As well,

$$\omega < \phi_1 - \phi_0,$$

so the cost of high effort for a bank is less than the discounted difference between the payoffs on one unit of a high-effort risky asset and one unit of a low-effort risky asset.

2.1 Government

In the CM, the government issues one-period real government bonds, each paying off r_t^b units of consumption goods in the next CM,. The government can also issue lump-sum transfers to buyers, in equal amounts, in the CM.

The government's budget constraints are then

$$\bar{b}_0 = \tau_0, \tag{7}$$

and

$$\bar{b}_t = \tau_t + r_{t-1}\bar{b}_{t-1} \tag{8}$$

In equations (7) and (8), all quantities are in units of current period CM goods, with $\bar{b}_t$ denoting one-period government bonds issued by the government in period t, and τ_t denoting the lump sum transfer to each buyer in the CM in period t.

2.2 Exchange in the CM and DM

In the CM, buyers, sellers, and banks are together in one location. Debts of banks and the government are first settled, production and consumption take place, assets trade on Walrasian markets, and buyers write deposit contracts with banks. Each buyer can contact only one bank during the CM. In the DM, each buyer is randomly matched with a seller. Assume that there is limited commitment, and that a seller does not know the history of the buyer with whom they are matched. As well, government debt and risky assets cannot be directly traded in the DM in exchange for goods. Further, in contrast to banks, for a buyer there is no technology that permits the posting of collateral in a loan contract with a seller. Banks have limited commitment, but there also exists a collateral technology which the bank can use to secure its deposit contracts. Banks' histories are not observable. When a buyer and seller meet, the buyer makes a take-it-or-leave-it offer to the seller, and then the buyer exchanges claims on banks for goods produced by the seller. In the DM of period t, ξ_{t+1} is observed, and so are the idiosyncratic shocks to the returns on banks' risky assets for period $t+1$. Therefore, in any DM meeting, the buyer and seller know the period $t+1$ payoffs on individual bank liabilities.

Banks secure their deposit liabilities by posting assets – risky assets and safe government bonds – as collateral. In addition to the effort choice a bank makes, which affects the quality of the risky assets in its portfolio, the bank can also misrepresent its holdings of government debt. That is, when the bank acquires assets in the CM, it can fake the existence of holdings of b units of government bonds (where b is in units of the current CM good) by incurring a cost ψb, where $0 < \psi < 1$. Fake government bonds will bear no return, but these fake assets are indistinguishable from actual government bonds to other economic agents. Just as with effort decisions for risky assets, faking safe assets is private information to the bank, but other agents can discern whether a given quantity of assets is a mix of fake and genuine, or consists of a single type (either fake or genuine), though the agent cannot determine which type. We can interpret a bank's holdings of government bonds as including central bank liabilities (reserves or reverse repos, for example) remunerated at the interest rate on government bonds, ignoring any transactions role that might be played by reserves in practice.

It may not be obvious why we should want to think of safe assets – government bonds and central bank liabilities – as being subject to misrepresentation by banks. Indeed, proponents of narrow banking typically appear to assume that a portfolio of safe bank asset holdings is essentially costless to monitor. However, stablecoin arrangements — which are typically banking arrangements, essentially — can be fraught with issues of misrepresentation. For example, Tether is currently the largest stablecoin, with asset holdings which would place it among the top 40 banks in the United States, ordered by asset size. As of September 30, 2023, Tether claimed to hold 85% of its assets as "cash and cash equivalents plus short-term deposits."[2] Of this quantity, Tether claimed that 76% consisted of U.S. Treasury bills, 11% overnight reverse repos (effectively equivalent to reserves held with the Fed), and 11% "money market funds." Tether also claims that Tether "tokens" are pegged one-to-one to the U.S. dollar. Thus, if we believe Tether's claims, then it is close to being a narrow bank, with one-to-one convertibility to U.S. dollars. But Tether has been plagued since inception by doubts about the quality of its asset portfolio. One cannot independently verify exactly what Tether's assets are.

It is certainly the case that the assets of regulated banks can be observed – there is no doubt, for example, about the quantity of safe assets held by the Bank of America. But when the case for narrow banks is made, proponents typically argue that narrow banking allows us to do away with most regulation. Stablecoins are then a useful example that illustrates an issue with narrow banking – the absence of regulation can cause a narrow bank to misrepresent the quality of assets in its portfolio. It thus seems important to model this. We can then allow ψ to be large for a regulated bank (in fact, $\psi = 1$, as is sometimes the case in the analysis that follows) and small for an unregulated bank, if we desire this modeling choice.

[2]See https://tether.to/en/

3 Regulated Banks Only

Before introducing narrow banking, we want to understand how a regulated banking system with deposit insurance performs. As the costs of regulation are typically an important element in arguments for narrow banking, we want to know what these regulatory costs might entail. We start with an environment in which banks have no specific restrictions on their asset portfolios, and have access to government-provided deposit insurance. Then we will consider the wisdom of subjecting banks to capital requirements – typically put forward as a regulatory correction to perceived moral hazard problems created by deposit insurance.

We restrict attention to fiscal policy that fixes the supply of bonds for all t, that is $\bar{b}_t = \bar{b}$ for all t, and to stationary equilibria in which quantities and interest rates are constant forever.

Dropping t subscripts, in equilibrium the bank chooses a deposit contract (a, d_0, d_1). Here, a denotes the deposit quantity for a depositor in the CM, in units of CM goods. The deposit is made in goods, or as an equivalent quantity of assets. As well, d_0 denotes the quantity of deposit claims the depositor can trade in the DM in the state where the payoff on the bank's risky assets is zero, and d_1 denotes the quantity of deposit claims tradeable in the DM in the state where risky assets pay off. A bank acquires a portfolio of b bonds and k^B units of risky assets, per depositor, with risky assets selling at the price p in the CM, in units of the CM good.

The government offers insurance to bank depositors. That is, if the bank provides access to d_1 deposit claims for each depositor in the state of the world in which its risky assets pay off, and provides d_0 claims in the state in which its risky assets do not pay off, the government makes up the difference $d_1 - d_0$ in the bad state. Government deposit insurance is actuarially fair, given the bank's effort i' reported to the deposit insurer, where $i' = 0$ denotes low effort, and $i' = 1$ denotes high effort. So, given i', the reported probability the bad state occurs is $\delta\alpha_{i'}$ and the reported probability the good state occurs is $1 - \delta\alpha_{i'}$. Then, the actuarially fair deposit insurance premium, paid by the bank in the good state, is

$$P = \frac{\delta\alpha_{i'}\,(d_1 - d_0)}{1 - \delta\alpha_{i'}}. \tag{9}$$

Deposit insurance payouts are financed through lump sum transfers paid by buyers, while deposit insurance premia are rebated lump sum to buyers. Thus, the financing of deposit insurance nets out with payouts and premia in the government's budget constraints (7) and (8).

Note that, given our assumptions, this government-provided deposit insurance system cannot be replicated by the private sector. First, note that the deposit insurance system does not balance its budget each period. In the bad state of the world in which some of the stock of risky assets does not pay off, deposit insurance premia fall short of funding insurance payouts to bank depositors. And in the good state of the world, where all risky assets pay off, all banks pay an insurance premium and there are no insurance payouts. So, to replicate this arrangement, a private insurance company would have to borrow in the bad aggregate state and accumulate assets in the good aggregate state. But private borrowing in this environment is subject to limited commitment, whereas the government faces no limited commitment problem. We have assumed that the government has access to lump sum taxes and transfers, and that the government is always able to costlessly collect the taxes it levies. So, the asymmetry between the government and the private sector in this respect is critical to the role of the government in providing deposit insurance, in this environment.

In equilibrium, deposit insurance premia paid by banks are appropriately risk-adjusted, so there are no issues here of mis-priced deposit insurance (e.g. Boyd and Rolnick 1989), at least in equilibrium. However, off-equilibrium, banks can misreport effort, and consequently pay a deposit insurance premium that is not actuarially fair.

Though a bank has private information about the quality of its assets, so that depositors cannot observe whether the bank's government bonds are fake, and cannot observe the bank's effort, the bank may find it optimal to signal asset quality through what are essentially self-imposed capital requirements, in line with Li, Rocheteau, and Weill (2012). That is, in order to demonstrate to its depositors that the government bonds it is holding are not fake, the bank limits the fraction of government bonds that it posts as collateral. Similarly, the bank can signal high effort by limiting the fraction of risky assets posted as collateral. In particular, let θ^b and θ^k denote, respectively, the fractions of the bank's bond and risky asset holdings that are not posted as collateral. Then, when the payoff on the bank's risky assets is zero in the subsequent CM, the following collateral constraint must be satisfied:

$$(1-\theta^b)r^b b - d_0 \geq 0. \tag{10}$$

That is, in equilibrium it must be the case that the bank prefers to settle its deposit liabilities rather than defaulting and giving up its posted collateral. Similarly, when the payoff on the bank's risky assets is positive, the following inequality must hold:

$$(1-\theta^b)r^b b + (1-\theta^k)r^k k^B - d_1 - \frac{\delta\alpha_{i'}\,(d_1-d_0)}{1-\delta\alpha_{i'}} \geq 0. \tag{11}$$

In (11), the first two terms are the payoffs on posted collateral (government bonds and risky assets, respectively), and the third and fourth terms are the negative of the deposit and deposit insurance premium liabilities (from (9)), respectively. We will assume for now that (10) and (11) bind in equilibrium, and later derive conditions that guarantee that this is the case.

In addition to (10) and (11), the bank must have the incentive not to fake its portfolio of government bonds. That is, it chooses θ^b so that

$$(1-\psi)b-\beta r^b b+\beta\delta\alpha_i d_0+\beta\left(1-\delta\alpha_i\right)\left[-(1-\theta^k)r^k k^B + d_1 + \frac{\delta\alpha_{i'}\,(d_1-d_0)}{1-\delta\alpha_{i'}}\right] \leq 0. \tag{12}$$

So, the net gain to faking bonds cannot be strictly positive. In (12) the net gain from faking b bonds rather than acquiring actual bonds is the net benefit at the acquisition stage, $(1-\psi)b$, minus the discounted payoff on genuine bonds, plus two terms that capture the discounted expected benefit from defaulting on deposit liabilities in the next CM. That is, since (10) and (12) bind, if the bank were to acquire fake bonds (off equilibrium), it would choose to default in all states of the world in the next CM, thus giving up any posted collateral, but gaining the value of the deposit liabilities. But, since (10) and (11) bind, we can rewrite (12) as

$$1-\psi-\beta r^b\theta^b \leq 0 \tag{13}$$

To assure that there exists a value of $\theta^b \epsilon (0,1)$ satisfying (13), assume that

$$r^b > \frac{1-\psi}{\beta} \tag{14}$$

in equilibrium. That is, there is a lower bound on the real interest rate on government debt, which we will later check. In the bank's decision problem, θ^b will appear only in (10), (11), and (13), so since reducing θ^b tightens (13) and relaxes binding constraints (10) and (11), therefore the optimal choice of θ^b is determined by (13) with equality, or

$$\theta^b = \frac{(1-\psi)}{\beta r^b}. \tag{15}$$

So, in (15), for the bank to signal that it is not cheating on its portfolio of safe assets, the bank's "skin in the game" (that is, θ^b) increases as the cost of faking safe assets falls, and as the real interest rate on bonds falls. That is, both a low cost of fakery and a low return on actual safe assets encourage fakery, making it more costly for the bank to signal that it is not misrepresenting its safe assets.

Though the moral hazard problem associated with the bank's risky assets seems different from the incentive problem of faking a portfolio of safe government bonds, the bank deals with the two problems similarly, signaling high effort by having skin in the game. If the bank were to choose low effort, then clearly there is no value in signaling high effort by choosing $\theta^k > 0$, so the bank chooses between: (i) low effort and $\theta^k = 0$; and (ii) high effort and $\theta^k > 0$, and we need to be concerned with only one incentive constraint, which involves evaluating the net payoff from cheating, given θ^k. The present value payoff for the bank, per depositor, is given by

$$\pi = a-b-pk^B-i\omega k^B+\beta r^b b-\beta\delta\alpha_i d_0+\beta(1-\delta\alpha_i)\left[r^k k^B - d_1 - \frac{\delta\alpha_{i'}(d_1-d_0)}{1-\delta\alpha_{i'}}\right], \tag{16}$$

where i denotes the actual choice of effort, with $i=1$ representing high effort and $i=0$ low effort. So, suppose the bank reports high effort to the regulator, $i'=1$, but chooses low effort rather than high effort. This does not affect the incentive constraints (10) and (11), so off-equilibrium the bank's incentive to default is not affected. Thus, the net payoff from cheating comes only from how it affects the net present value payoff (16). We require the net payoff from cheating to be less than or equal to zero, that is

$$\omega k^B - \beta\delta\left(\alpha_1 - \alpha_0\right) d_0 + \beta\delta\left(\alpha_1 - \alpha_0\right)\left[r^k k^B - d_1 - \frac{\delta\alpha_{i'}\left(d_1 - d_0\right)}{1 - \delta\alpha_{i'}}\right] \leq 0. \quad (17)$$

So, the net payoff from cheating is the cost of high effort plus the change in the present value of payoffs resulting from the fact that the good state will occur with lower probability, and the bad state with higher probability. Then, since (10) and (11) bind, we can rewrite (17) as

$$\omega k^B + \beta\delta\left(\alpha_1 - \alpha_0\right)\theta^k r^k k^B \leq 0,$$

that is,

$$\omega - \left(\phi_1 - \phi_0\right)\theta^k \leq 0 \quad (18)$$

If the bank claims that effort is high, that is $i' = 1$,then the net gain from choosing low effort is the cost of high effort, ω, minus the loss in the expected present value of future payoffs for the risky assets that are skin in the game. And, inequality (18) states that the net gain from cheating, per unit of risky asset, must be less than or equal to zero. Similar to the incentive problem for government bonds, there is no incentive for the bank to choose θ^k larger than what is required to satisfy (18) with equality, so if high effort is chosen, then

$$\theta^k = \frac{\omega}{\phi_1 - \phi_0} \quad (19)$$

Then, from (15) and (19), we can rewrite the two constraints (10), (11) as

$$r^b b - \frac{(1-\psi)b}{\beta} - d_0 \geq 0, \quad (20)$$

and

$$r^b b - \frac{(1-\psi)b}{\beta} + \left(1 - \frac{i\omega}{\phi_1 - \phi_0}\right) r^k k^B - d_1 - \frac{\delta\alpha_i\left(d_1 - d_0\right)}{1 - \delta\alpha_i} \geq 0, \quad (21)$$

respectively. Note that, in (20) and (21), we have implicitly incorporated $i = i'$, since (15) and (19) guarantee incentive compatibility.

In equilibrium, the contract offered by banks will maximize the expected utility of the representative depositor, subject to the constraint that $\pi \geq 0$ (nonnegative present value expected profits, from (16)), and the two collateral constraints (20) and (21), along with $i = i'$. Otherwise, a bank could offer a deposit contract that also earns nonnegative present-value expected profits, and is strictly preferred by all depositors. So the equilibrium banking contract (a, d_0, d_1) and bank portfolio (b, k^B) solve

$$\max_{a, d_0, d_1, b, k^B} \left[-a + u(\beta d_1)\right] \quad (22)$$

subject to

$$a - b - pk^B - i\omega k^B + \beta r^b b - \beta d_1 + \beta(1-\delta\alpha_i) r^k k^B \geq 0, \tag{23}$$

(20), and (21).

Next, we want to characterize a solution to the bank's problem (22) subject to (23), (20), and (21). Assume throughout that the collateral constraints (20) and (21) bind.

Optimal choices for d_0 and d_1, respectively, give

$$\beta\delta\alpha_i \left[u'(x) - 1\right] - \lambda_1 = 0, \tag{24}$$

and

$$\beta(1-\delta\alpha_i) \left[u'(x) - 1\right] - \lambda_2 = 0. \tag{25}$$

In (24) and (25), x is the consumption of bank depositors in the DM in all states of the world, and λ_1 and λ_2 denote the multipliers associated with the constraints (20) and (21), respectively.

Further, optimal choice of b and k^B, respectively, in the problem (22) subject to (23), (20), and (21), implies

$$-1 + \beta r^b + (\lambda_1 + \lambda_2)\left[r^b - \frac{(1-\psi)}{\beta}\right] = 0, \tag{26}$$

and

$$-p - \omega i + \beta(1-\delta\alpha_i) r^k + r^k\left(1 - \frac{i\omega}{\phi_1 - \phi_0}\right)\lambda_2 = 0. \tag{27}$$

Then, from (24)-(27), we get

$$r^b = \frac{\psi + (1-\psi)u'(x)}{\beta u'(x)}, \tag{28}$$

and

$$p + i\omega = \frac{\phi_i}{\phi_1 - \phi_0}\left[i\omega + (\phi_1 - \phi_0 - i\omega)\, u'(x)\right]. \tag{29}$$

Equation (28) is an asset-pricing equation for the government bond, where we can think of inefficiencies in exchange (the extent to which $u'(x)$ exceeds 1) and the cost of misrepresenting safe assets, ψ, determining the gross real rate of return on government debt, r^b. In general, an increase in inefficiency in exchange reduces the real return on government debt, that is the liquidity premium on government debt increases. As well, a decrease in ψ will increase the real return on government debt, since lower ψ means that government debt is less efficient as collateral for the bank, in backing bank deposits. That is, the smaller is ψ,the more tempting is misrepresentation of the bank's safe asset portfolio, and so the fraction of government bonds held by the bank, and not backing bank deposits, falls. Note that, if there were no misrepresentation of government bonds ($\psi = 1$), and no inefficiency in DM exchange ($u'(x) = 1$), then from (28) we have $r^b = \frac{1}{\beta}$. So, the baseline case is a real interest rate equal to the rate of time preference, and then the shortage of safe assets acts to reduce the real rate of return on government debt below the baseline value.

As well, equation (29) prices risky assets. When low effort is chosen ($i = 0$), then (29) gives

$$p = \phi_0 u'(x), \tag{30}$$

in which case only the inefficiency in DM exchange ($u'(x)$) and the expected discounted payoff on the risky asset is relevant for determining its price. However, if high effort is chosen by banks ($i = 1$), then

$$p = -\omega + \phi_1 u'(x) - \frac{\omega \phi_1 \left(u'(x) - 1\right)}{\phi_1 - \phi_0}. \tag{31}$$

In (31), the first two terms on the right-hand side follow the logic of equation (30), that is the price of the risky asset reflects the cost of producing it, the expected discounted payoff, and the inefficiency in DM exchange. But the third term on the right-hand side of (31) captures the negative incentive effect on the price of the risky asset when effort is high. Note that this effect increases with the cost of high effort and the inefficiency in the DM, since higher ω and higher $u'(x)$ act to increase the fraction of the risky asset the bank holds which does not back deposits. Note that, if there is no inefficiency in the DM ($u'(x) = 1$), then from (31) we get $p = -\omega + \phi_1$, in which case the risky asset's price is determined only by its cost of production and discounted expected payoff.

Recall that any agent can produce risky assets in the CM at marginal cost σ. So, in equilibrium, risky asset producers must earn zero profits, implying

$$p = \sigma, \tag{32}$$

so, since (32) pegs the price of the risky asset to its marginal cost of production, the pricing equation (29) determines the degree of inefficiency in DM exchange in equilibrium, by determining x.

3.1 Low Effort in Equilibrium

If the bank chooses low effort, that is $i = 0$, then from (29) and (32) we get

$$u'(x) = \frac{\sigma}{\phi_0}. \tag{33}$$

Then, (33) and (28) give

$$r^b = \frac{1}{\beta} - \frac{\psi\left(\sigma - \phi_0\right)}{\beta\sigma}. \tag{34}$$

Finally, given equilibrium in the market for government bonds, and using binding constraints (20) and (21), as well as (34), we can solve for k^B, obtaining

$$k^B = \frac{x}{\phi_0} - \frac{\psi\bar{b}}{\sigma}. \tag{35}$$

As we are constructing an equilibrium in which banks hold positive quantities of safe and risky assets, the solution for k^B in equation (35), given the solution for x from (33) must give $k^B > 0$,which requires that government debt be sufficiently scarce, that is $\bar{b}$ must be sufficiently small. We need to check that inequality (14) holds which, given (34), it does.

An additional condition we need for existence of an equilibrium with low effort by banks, is that banks not want to choose high effort, given equilibrium prices. We want to consider what the payoff for a bank would be from deviating to high effort in a low-effort equilibrium, and determine conditions under which this payoff would be less than or equal to zero. In deviating, note that a bank will choose to acquire enough skin-in-the-game, that is risky assets not backing bank deposits, so as to signal to the regulator that it is actually choosing high effort. The regulator will then adjust the bank's deposit insurance premium accordingly.

It is sufficient to show that, if a bank deviates, choosing high effort, given equilibrium prices, earns zero present-value expected profits, and cannot make depositors better off, then the bank has no incentive to deviate. That is, under these conditions the bank could alter the deposit contract so the depositors are just as well off as in equilibrium, with the bank earning present-value expected profits that are at most zero.

First note that a depositor's expected utility, the objective function (22), can be expressed, using (20), (21), (23), and (32), as

$$EU = u(x) - xu'(x), \tag{36}$$

which is strictly increasing in x, for $x < x^*$, which holds in equilibrium given sufficient scarcity of safe assets. So, as long as a deviation to high effort cannot increase x, the DM consumption of a depositor, the bank will not choose to deviate. If a bank were to deviate, given p and r^b from (32) and (34), then from the bank's optimization problem, (22) subject to (20), (21), and (23), if

$$\omega < \frac{\sigma\left(\phi_1 - \phi_0\right)^2}{\sigma\phi_1 - \phi_0^2}, \tag{37}$$

then the deviating bank will invest in a portfolio consisting only of risky assets, and x^d,the DM consumption of a depositor in the deviating bank, is determined by

$$u'(x^d) = \frac{\sigma\left(\phi_1 - \phi_0\right) - \omega\phi_0}{\phi_1\left(\phi_1 - \phi_0 - \omega\right)}, \tag{38}$$

and, given (37), $x^d > x$, so the bank will choose to deviate, as the deviation earns zero present-value expected profits and makes depositors better off. However, if

$$\omega \geq \frac{\sigma\left(\phi_1 - \phi_0\right)^2}{\sigma\phi_1 - \phi_0^2}, \tag{39}$$

then it is optimal for a deviating bank to hold a portfolio consisting entirely of government bonds, and we will then have $x^d = x$, so it is optimal for banks not to deviate. Therefore, inequality (39) is the additional condition we need for existence of the low-effort equilibrium. This gives us a critical value for the cost of high effort, ω,such that, if the cost of effort exceeds this critical value, then it is optimal for banks to choose low effort in the low-effort equilibrium.

3.2 High Effort Equilibrium

Next, if banks choose high effort, or $i = 1$,then (29) and (32) give

$$u'(x) = \frac{\sigma(\phi_1 - \phi_0) - \omega\phi_0}{\phi_1(\phi_1 - \phi_0 - \omega)} \tag{40}$$

Then, (33) and (28) give

$$r^b = \frac{1}{\beta} - \frac{\psi(\phi_1 - \phi_0)(\sigma + \omega - \phi_1)}{\beta[\sigma(\phi_1 - \phi_0) - \omega\phi_0]}, \tag{41}$$

and, given equilibrium in the market for government bonds, and using binding constraints (20) and (21), as well as (34), we obtain

$$k^B = \frac{x(\phi_1 - \phi_0)}{\phi_1(\phi_1 - \phi_0 - \omega)} - \frac{\bar{b}\psi(\phi_1 - \phi_0)}{\sigma(\phi_1 - \phi_0) - \omega\phi_0} \tag{42}$$

As in the low-effort equilibrium, we are constructing an equilibrium in which there is some investment in risky assets in equilibrium, that is $k^B > 0$, so from (42) this requires that $\bar{b}$ be sufficiently small. That is, safe assets must be sufficiently scarce to provide the incentive for production of risky assets.

Similar to the analysis for the low-effort equilibrium, we can show that a bank will not have an incentive to deviate by choosing low effort in the high-effort equilibrium, if and only if (37) holds.

3.3 Effects of Changes in Information Frictions

In this environment, banks are subject to two information frictions, in that banks can misrepresent safe assets, at a cost, and banks' effort is unobservable (moral hazard). Though the first friction is perhaps irrelevant for actual regulated banks, it is useful to see how this friction affects regulated bank behavior in the model, as we can use these insights later when we examine narrow banking structures. And the second friction – moral hazard – is typically thought to play an important role in bank regulation, and is also thought to matter for narrow banking issues.

First, in the low-effort equilibrium, consider an increase in ψ,which increases the cost of misrepresenting safe assets. This has no effect on DM exchange, as x is unaffected, from (33), as x is determined by the risky asset technology. However, from (34) and (35), an increase in ψ reduces the real rate of return on bonds, and also reduces the quantity of risky assets held by banks in equilibrium. That is, an increase in ψ,because it lessens the private information friction, makes safe assets more useful in backing bank deposits, and acts to increase the liquidity premium associated with government debt, thus reducing the real interest rate on government bonds. Since government bonds are more effective as collateral, this causes substitution away from risky assets in banks' asset portfolios.

With low effort, an increase in ω,the cost of high effort – a measure of the severity of banks' moral hazard problems – has no effect, at the margin. But, since high ω implies that low effort is chosen, and low effort implies that high effort is chosen, from (37) and (39), if there were a high effort equilibrium, a large enough increase in ω would imply a switch of all banks to low effort.

Next, in a high-effort equilibrium, from (40)-(42), we get the same qualitative effects of an increase in ψ as in the low-effort equilibrium. That is, higher ψ has no effect on x, but r^b and k^B decrease, for the same reasons. For an increase in ω, from (41) the real rate of interest on government bonds falls, as the increase in ω induces substitution from risky to safe assets, and thus increases the liquidity premium on government bonds, reducing the real interest rate. From (42), the effect on the quantity of risky assets could go either way. There are two effects. First, because high effort is more costly, this increases the fraction of risky assets that is not backing deposits at banks, so for a given quantity of banking activity a bank needs to hold more risky assets. But, second, banks will tend to substitute from risky assets to safe assets, which reduces the demand for risky assets. The net effect, from (42), depends in part on the quantity of government debt supplied, $\bar{b}$.

3.4 Efficiency

We will use the sum across agents of equilibrium lifetime utilities as our welfare measure, to evaluate equilibrium outcomes relative to what is socially efficient. The sum of equilibrium lifetime utilities across agents is proportional to

$$W^i = u(x^i) - x^i + k^{Bi}\left(-\sigma - \omega i + \phi_i\right), \tag{43}$$

for $i = 0, 1$, where $i = 0$ ($i = 1$) denotes an equilibrium in which banks choose low (high) effort. In (43), $u(x^i) - x^i$ denotes total surplus in DM transactions, where x^i is the amount a buyer consumes in a DM meeting, while $k^{Bi}\left(-\sigma - \omega i + \phi_i\right)$ is the net expected benefit from production of risky assets, that is minus the cost of production, plus the discounted expected payoff. Otherwise, production and consumption in the CM net out in the welfare calculation.

Then, using (35) and (42), welfare in the low and high effort equilibria, respectively, are given by

$$W^0 = u(x^0) - x^0 - \left(\frac{x^0}{\phi_0} - \frac{\psi\bar{b}}{\sigma}\right)\left(\sigma - \phi_0\right), \tag{44}$$

and

$$W^1 = u(x^1) - x^1 - \left[\frac{x^1\left(\phi_1 - \phi_0\right)}{\phi_1\left(\phi_1 - \phi_0 - \omega\right)} - \frac{\bar{b}\psi\left(\phi_1 - \phi_0\right)}{\sigma\left(\phi_1 - \phi_0\right) - \omega\phi_0}\right]\left(\sigma + \omega - \phi_1\right), \tag{45}$$

where x^0 solves (33) for $x = x^0$, and x^1 solves (38) for $x = x^1$. Note that, inequalities (37) and (39) tell us when high-effort and low-effort equilibria exist, respectively. But we can also take the welfare measures W^1 and W^0 to denote welfare when banks must choose high effort or low effort (they are forced by the social planner), respectively. Then, in the high-effort case, banks have to signal that they are choosing high effort by having sufficient skin-in-the-game.

Proposition 1: If $\omega = 0$, then $W^1 > W^0$.

Proof: When $\omega = 0$, from (44), (45), (33), and (40), we can write

$$W^i(x^i) = u(x^i) - u'(x^i) + b\psi \left(1 - \frac{1}{u'(x^i)}\right), \tag{46}$$

for $i = 0, 1$. From (33), and (40), note that $x^1 > x^0$, since $\phi_1 > \phi_0$. Then, differentiate (46) with respect to x^i, obtaining

$$\frac{dW^i}{dx^i} = u''(x) \left[-x + \frac{\bar{b}\psi}{[u'(x^i)]^2}\right]. \tag{47}$$

Then, since we have assumed that $\bar{b}$ is sufficiently small that $k^{Bi} > 0$ for $i = 1, 2$, in equilibrium, and from (35) and (42), we can write, with $\omega = 0$,

$$k^{Bi} = \frac{1}{\phi_i}\left[x - \frac{\bar{b}\psi}{u'(x^i)}\right],$$

and we have assumed that $\bar{b}$ is sufficiently small that $k^B > 0$. Then, since $u'(x^i) > 0$, we have $\frac{dW^i}{dx^i} > 0$. Therefore $W^1 > W^0$ when $\omega = 0$.

Therefore, from Proposition 1, if the cost of effort is zero, in which case there exists an equilibrium with high-effort banks, and there does not exist an equilibrium with low-effort banks, from (37) and (39), then if banks were forced to choose low effort, this would lower welfare.

Proposition 2: The welfare difference $W^1 - W^0$ is strictly decreasing in ω, for $\omega \geq 0$.

Proof: First, note from (44) that W^0 is independent of ω, as the cost of high effort does not matter in the low-effort equilibrium. So we need only show that W^1 is strictly decreasing in ω. Differentiating (45), we get

$$\begin{aligned}\frac{\partial W^1}{\partial \omega} = &\left[u'(x^1) - 1 - \frac{(\phi_1 - \phi_0)(\sigma + \omega - \phi_1)}{\phi_1(\phi_1 - \phi_0 - \omega)}\right]\frac{\partial x^1}{\partial \omega} \\ &- \frac{x^1(\phi_1 - \phi_0)(-\phi_0 + \sigma)}{\phi_1(\phi_1 - \phi_0 - \omega)^2} + \frac{\bar{b}\psi(\phi_1 - \phi_0)\phi_1(\sigma - \phi_0)}{[\sigma(\phi_1 - \phi_0) - \omega\phi_0]^2}\end{aligned} \tag{48}$$

Then, using (40), we can rewrite (48) as

$$\frac{\partial W^1}{\partial \omega} = \frac{(\phi_1 - \phi_0)(\sigma - \phi_0)}{(\phi_1 - \phi_0 - \omega)[\sigma(\phi_1 - \phi_0) - \omega\phi_0]} \\ X\left[-\frac{x^1[\sigma(\phi_1 - \phi_0) - \omega\phi_0]}{\phi_1(\phi_1 - \phi_0 - \omega)} + \frac{\bar{b}\psi\phi_1(\phi_1 - \phi_0 - \omega)}{[\sigma(\phi_1 - \phi_0) - \omega\phi_0]}\right] \quad (49)$$

Finally, using (40), we can rewrite (49) as

$$\frac{\partial W^1}{\partial \omega} = \frac{(\phi_1 - \phi_0)(\sigma - \phi_0)}{(\phi_1 - \phi_0 - \omega)[\sigma(\phi_1 - \phi_0) - \omega\phi_0]}\left[-x^1 u'(x^1) + \frac{\bar{b}\psi\phi_1}{u'(x^1)}\right]$$

Then, since $k^B > 0$ in the equilibrium with high effort, therefore from (42) and (40), $\frac{\partial W^1}{\partial \omega} < 0$, as $u'(x^1) > 1$.

So, from Propositions 1 and 2, welfare is higher in the high-effort equilibrium, than if banks were required to choose low effort, for low ω.

Proposition 3: When $\omega = \frac{\sigma(\phi_1 - \phi_0)^2}{\sigma\phi_1 - \phi_0^2}$, $W^1 - W^0 = 0$.

Proof: First, note that, if $\omega = \frac{\sigma(\phi_1 - \phi_0)^2}{\sigma\phi_1 - \phi_0^2}$, then $x^0 = x^1 = x$, so from (44) and (45),

$$W^1 - W^0 = -\frac{x(\phi_1 - \phi_0)\left[(\sigma - \phi_1)\left(\sigma\phi_1 - \phi_0^2\right) + \sigma\left(\phi_1^2 - 2\phi_1\phi_0 + \phi_0^2\right)\right]}{\phi_1\left[(\phi_1 - \phi_0)(\sigma\phi_1 - \phi_0^2) - \sigma(\phi_1^2 - 2\phi_1\phi_0 + \phi_0^2)\right]} \\ + \frac{\bar{b}\psi(\phi_1 - \phi_0)\left[(\sigma - \phi_1)\left(\sigma\phi_1 - \phi_0^2\right) + \sigma\left(\phi_1^2 - 2\phi_1\phi_0 + \phi_0^2\right)\right]}{\sigma(\phi_1 - \phi_0)(\sigma\phi_1 - \phi_0^2) - \phi_0\sigma(\phi_1^2 - 2\phi_1\phi_0 + \phi_0^2)} \\ + \left(\frac{x}{\phi_0} - \frac{\psi\bar{b}}{\sigma}\right)(\sigma - \phi_0) \quad (50)$$

Then, simplifying, we obtain

$$W^1 - W^0 = -\frac{x(\sigma - \phi_0)}{\phi_0} + \frac{\bar{b}\psi(\sigma - \phi_0)}{\sigma} + \left(\frac{x}{\phi_0} - \frac{\psi\bar{b}}{\sigma}\right)(\sigma - \phi_0) = 0.$$

So, from Propositions 1-3, (37) and (39), the equilibrium allocation is efficient, in the sense that, if a social planner were to require that banks choose low effort when a high effort equilibrium exists and a low effort equilibrium does not exist ((37) holds), then welfare will fall. Similarly, if a social planner were to require that banks choose high effort when a low effort equilibrium exists and a high effort equilibrium does not exist ((39) holds), then welfare will fall.

This result is perhaps surprising, given the conventional wisdom that deposit insurance creates a moral hazard problem, whereby deposit insurance causes banks to take on too much risk — an inefficiency that needs to be corrected through additional government intervention (Kareken and Wallace 1978, Boyd and Rolnick 1989, Dewatripont and Tirole 1993, Cooper and Ross 2002). Given our assumptions here, principally that the deposit insurer can monitor a bank's quantity of risky assets, and verify that the bank has skin-in-the-game – risky assets that are not backing deposit liabilities – it is in the bank's interest to signal to the deposit insurer, through having sufficient skin-in-the-game, that effort is high. This is a self-imposed capital constraint and, again perhaps surprisingly, banks will impose the socially appropriate capital constraints on themselves in equilibrium.

3.5 Government-Imposed Capital Constraint

What happens if the government imposes a capital requirement on banks in this environment? Conventional wisdom holds that deposit insurance induces a moral hazard problem that capital requirements can correct. But we already know that this will go wrong in the context of our model, as deposit insurance does not induce a moral hazard problem in banking in this environment. So, in this subsection we aim to characterize the inefficiency that can be produced by a government-imposed capital requirement on banks.

Suppose a bank faces a capital constraint — either self-imposed or imposed by the government — requiring that a fraction γ of risky assets cannot be backing for a bank's deposits. This implies that, instead of (11), the collateral constraint for the bank in the state where risky assets pay off is

$$r^b b - \frac{(1-\psi)b}{\beta} + (1-\gamma)r^k k^B - d_1 - \frac{\delta\alpha_{i'}\left(d_1 - d_0\right)}{1-\delta\alpha_{i'}} \geq 0. \tag{51}$$

Then, the bank's problem is to solve (22) subject to $\pi \geq 0$, where the present value payoff to the bank, π, is given by (16), and subject to (20) and (51).

So, from the bank's problem, and market-clearing, following a similar analysis to that in the beginning of this section, (28) and (32) hold, and instead of (29) we get, using (32),

$$-\sigma - i\omega + \gamma\phi_i + (1-\gamma)\phi_i u'(x) = 0. \tag{52}$$

So, suppose that the government imposes a capital requirement γ^g. Then, in an equilibrium with low effort, with $i = 0$ in (52), $\gamma = \gamma^g$, and x is determined by

$$u'(x) = \frac{\sigma - \gamma^g\phi_0}{(1-\gamma^g)\phi_0}, \tag{53}$$

and, given the solution for x from (53), equation (28) determines the real interest rate on government debt, r^b, in equilibrium.

In a low-effort equilibrium, the bank must not have an incentive to choose high effort, but deviating to high effort implies a non-positive present-value net gain for the bank, from (16), (20) and (51), if and only if

$$-\omega + \gamma^g\left(\phi_1 - \phi_0\right) \leq 0. \tag{54}$$

A high-effort equilibrium somewhat more complicated. If the government-imposed capital requirement binds, then this works similarly to the low-effort case. High effort is incentive compatible with a binding government capital requirement if and only if

$$-\omega + \gamma^g (\phi_1 - \phi_0) \geq 0. \tag{55}$$

But, if (55) does not hold, then a bank can impose a higher capital requirement on itself so as to signal high effort, just as we analyzed previously when there was no government capital requirement. Then, if (55) does not hold, the bank can choose high effort, and impose on itself a capital requirement as in (19), that is $\gamma = \frac{\omega}{\phi_1 - \phi_0}$. So, in general, we can say that, if a bank chooses high effort then the capital requirement is

$$\gamma = \max\left[\gamma^g, \frac{\omega}{\phi_1 - \phi_0}\right]. \tag{56}$$

Given high effort in equilibrium, that is $i = 1$ in (52), we get

$$u'(x) = \frac{\sigma + \omega - \gamma\phi_1}{(1-\gamma)\phi_1}, \tag{57}$$

with r^b determined by equation (28), given the solution for x, from (57).

Proposition 4: With a government-imposed capital requirement γ^g : (i) If $\omega \leq \gamma^g(\phi_1 - \phi_0)$, then the equilibrium is high-effort with a binding government-imposed capital constraint; (ii) If $\gamma^g(\phi_1 - \phi_0) < \omega \leq \omega^*$, then the equilibrium is high effort with a non-binding government imposed capital constraint; (iii) If $\omega > \omega^*$, then the equilibrium is low effort. Here, ω^* solves

$$\frac{\sigma - \gamma^g\phi_0}{(1-\gamma^g)\phi_0} = \frac{\sigma(\phi_1 - \phi_0) - \omega^*\phi_0}{\phi_1(\phi_1 - \phi_0 - \omega^*)} \tag{58}$$

(iv) ω^* is increasing in γ^g.

Proof: (i) If $\omega \leq \gamma^g(\phi_1 - \phi_0)$, then from (54) low effort is not incentive compatible, but from (55) high effort is incentive compatible with a binding government-imposed capital requirement γ^g. So the equilibrium must be one with high effort. (ii) If $\omega > \gamma^g(\phi_1 - \phi_0)$ then, from (54), low effort is incentive compatible, and from (56) high effort is incentive compatible if the bank self-imposes a higher capital requirement than does the government. The choice of high or low effort for the bank, in this case, then hinges on whether high or low effort gives higher expected utility to the bank's depositors, given a zero present-value expected payoff for the bank. From (22), (16), (20), and (51), we can show that the expected utility of depositors, given a zero present-value expected payoff for the bank, is given by (36), which is strictly increasing in x. So, the bank will choose the effort quantity for which x (DM consumption for depositors) is larger. With high effort, (40) holds, while with low effort, (53) holds. So, high effort is chosen if

$$\frac{\sigma\left(\phi_1-\phi_0\right)-\omega\phi_0}{\phi_1\left(\phi_1-\phi_0-\omega\right)} \leq \frac{\sigma-\gamma^g\phi_0}{(1-\gamma^g)\phi_0}, \tag{59}$$

and low effort is chosen if

$$\frac{\sigma\left(\phi_1-\phi_0\right)-\omega\phi_0}{\phi_1\left(\phi_1-\phi_0-\omega\right)} > \frac{\sigma-\gamma^g\phi_0}{(1-\gamma^g)\phi_0}. \tag{60}$$

So, if $\omega=\gamma^g(\phi_1-\phi_0)$,then the left-hand side of (59) is equal to $\frac{\sigma-\gamma^g\phi_0}{(1-\gamma^g)\phi_1} < \frac{\sigma-\gamma^g\phi_0}{(1-\gamma^g)\phi_0}$, so high effort is chosen for $\omega=\gamma^g(\phi_1-\phi_0)$. As well, if $\omega\rightarrow\phi_1-\phi_0$, then the left-hand side of (59) goes to infinity, and so low effort is chosen. But the left-hand side of (59) is strictly increasing and continuous in ω, so there exists a unique solution $\omega=\omega^*$ to (59) with equality such that high effort is chosen for $\omega\leq\omega^*$, and low effort is chosen for $\omega>\omega^*$. (iv) The right-hand side of (59) is strictly increasing in γ^g, while the left-hand side of (59) is strictly increasing in ω. So, given the proof of (iii), ω^* is strictly increasing in γ^g.

From (58), note that

$$\omega^* > \frac{\sigma\left(\phi_1-\phi_0\right)^2}{\sigma\phi_1-\phi_0^2},$$

so from (37), (39), and Proposition 4, the cutoff value for ω such that banks choose low effort rather than high effort for ω greater than the cutoff value, is larger when there is a government-imposed capital requirement. So the capital requirement tends to encourage high effort, as we might expect. But what are the implications for welfare?

Proposition 4: In high-effort equilibria and low-effort equilibria, without the government-imposed capital requirement, with a binding government imposed capital requirement, and with a government-imposed capital requirement that does not bind, we can express welfare as a function of x and parameters,

$$W=u(x)-xu'(x)+\psi\bar{b}\left[1-\frac{1}{u'(x)}\right], \tag{61}$$

and in equilibrium $k^B>0$ if and only if

$$x-\frac{\psi\bar{b}}{u'(x)}>0. \tag{62}$$

Proof: First, consider the case where low effort is chosen with a binding government-imposed capital requirement in equilibrium. Then, aggregate welfare is proportional to

$$W=u(x)-x+k^B\left(\phi_0-\sigma\right). \tag{63}$$

That is, aggregate welfare is proportional to period total surplus in DM meetings between buyers and sellers, $u(x) - x$, plus the net present-value payoff from risky assets created during the period. Then, using (20), (51), and (28), we can substitute for k^B in equation (63), obtaining

$$W = u(x) - x + \left[\frac{x - \frac{\psi b}{u'(x)}}{(1-\gamma^g)\phi_0} \right] (\phi_0 - \sigma) \,. \tag{64}$$

Then, rearranging (64), we get

$$W = u(x) - \left[\frac{\sigma - \gamma^g \phi_0}{(1-\gamma^g)\phi_0} \right] x + \frac{\psi b}{u'(x)} \left[\frac{\sigma - \gamma^g \phi_0 - (1-\gamma^g)\phi_0}{(1-\gamma^g)\phi_0} \right] \tag{65}$$

Then, substituting using (53) in (65) gives

$$W = u(x) - xu'(x) + \psi \bar{b} \left[1 - \frac{1}{u'(x)} \right].$$

Further, using (20), (51), and (28), we can express the quantity of risky assets per bank depositor as

$$k^B = \frac{x - \frac{\psi b}{u'(x)}}{(1-\gamma^g)\phi_i}.$$

Proposition 4 is useful in part because it tells us that, no matter which type of equilibrium holds, aggregate welfare can be expressed as the same function of x, the quantity of DM consumption for buyers. Further, if we differentiate (61), we get

$$\frac{dW}{dx} = u''(x) \left\{ -x + \frac{\psi \bar{b}}{[u'(x)]^2} \right\}. \tag{66}$$

Our maintained assumption is that $\bar{b}$ is sufficiently small that $k^B > 0$ in equilibrium. That is, government debt is sufficiently scarce that the production of risky assets is always profitable. Then, from Proposition 4, inequality (62), and given that $u'(x) > 1$ in equilibrium, from (66) we have $\frac{dW}{dx} > 0$. This will allow us to easily compare welfare across equilibria – basically, greater exchange in the DM (higher x) implies higher welfare.

To help organize our thinking about the welfare effects of the government capital requirement, Figure 1 shows what types of equilibria exist, given ω (on the vertical axis), the cost of high effort for a bank, and γ^g, the capital requirement. Note that $0 \leq \omega < \phi_1 - \phi_0$, and $0 \leq \gamma^g < 1$. In region 1, low effort is chosen with and without the capital requirement, while in region 2 high effort is chosen by banks, with a self-imposed capital requirement, under a government capital requirement, while low effort is chosen without the government capital requirement. In region 3, high effort is chosen, with a binding government capital requirement, while low effort is chosen if there is no government capital requirement, while in region 4, a self-imposed capital requirement and high effort is chosen by banks, with and without the government capital requirement. Finally, in region 5, high effort is chosen with and without the government capital requirement, but the the government capital requirement binds when it is imposed.

For each case, one through five, let x^g denote DM consumption under the government capital requirement, and let x^n denote DM consumption with no government capital requirement.

Case 1: From (53) and (33), we get

$$u'(x^g) - u'(x^n) = \frac{\gamma^g (\sigma - \phi_0)}{(1-\gamma^g)\,\phi_0} > 0,$$

so $x^g < x^n$, and welfare is higher without the government capital requirement.

Case 2: From (53) and (7aa), we get

$$u'(x^g) - u'(x^n) = \frac{-\sigma (\phi_1 - \phi_0)^2 + \omega \left(\sigma\phi_1 - \phi_0^2\right)}{\phi_0\phi_1 (\phi_1 - \phi_0 - \omega)} > 0,$$

since in case 2, we have

$$\omega > \frac{\sigma (\phi_1 - \phi_0)^2}{\sigma\phi_1 - \phi_0^2}.$$

So, $x^g < x^n$, and welfare is higher without the government capital requirement.

Case 3: From (57) and (33),

$$u'(x^g) - u'(x^n) = \frac{(\sigma + \omega)\,\phi_0 - \sigma\phi_1 + \gamma^g\phi_1 (\sigma - \phi_0)}{\phi_0\phi_1 (1-\gamma^g)} > 0,$$

by virtue of the fact that, in case 3,

$$\omega > \frac{\sigma (\phi_1 - \phi_0)^2}{\sigma\phi_1 - \phi_0^2},$$

and

$$\gamma^g > \frac{\sigma (\phi_1 - \phi_0)}{\sigma\phi_1 - \phi_0^2}.$$

So, $x^g < x^n$, and welfare is higher without the government capital requirement.

Case 4: In this case, the equilibrium allocations are identical with and without the government capital requirement, as banks choose high effort in either case, and the government capital requirement does not bind in equilibrium. Thus, welfare is unaffected by the government intervention.

Case 5: From (57) and (40),

$$u'(x^g) - u'(x^n) = \frac{\sigma + \omega - \gamma^g\phi_1}{(1-\gamma^g)\phi_1} - \left[\frac{\sigma (\phi_1 - \phi_0) - \omega\phi_0}{\phi_1 (\phi_1 - \phi_0 - \omega)}\right] > 0,$$

as the expression on the right-hand side of the above inequality is increasing in γ^g, equals zero for

$$\gamma^g = \frac{\omega}{(\phi_1 - \phi_0)},$$

and in case 5,

$$\gamma^g > \frac{\omega}{(\phi_1 - \phi_0)}.$$

So, at best, in case 4, the government capital requirement causes no change in the equilibrium allocation or in welfare, but this occurs because the government capital requirement does not bind, and banks signal that effort is high by imposing an even higher capital requirement on themselves. In the other cases, the government capital requirement reduces welfare. The government capital requirement either reduces the effective stock of assets available to back bank deposits, when the government capital requirement does not affect effort choice by banks (cases 1 and 5), or causes the bank to inefficiently choose high effort (cases 2 and 3). Thus, the capital requirement either serves to unnecessarily constrain banks in ways that reduce welfare, or it encourages high effort when this is not warranted. Indeed, the government capital requirement can serve to decrease the probability that each bank fails (regions 2 and 3 in Figure 1), while reducing welfare. Greater stability, in the sense of a lower incidence of bank failure, need not be a welfare improvement.

We obtain these results because, in the absence of government-imposed capital requirements, banks efficiently signal high effort by self-imposing a capital constraint. Thus, government attempts to reduce bank risk-taking with more stringent capital requirements can be successful in reducing risk and the probability of bank failure, but this is counterproductive in terms of welfare.

4 Coexistence of Regulated Banking and Narrow Banking

Now that we have some knowledge of how regulated and unregulated banking works in this model, we can move on to address issues related to narrow banking. Suppose that a bank can choose to be regulated or unregulated. If unregulated, the bank must be narrow, in the sense that it is restricted to holding government debt to back its deposit liabilities. However, regulators do nothing to assure that the narrow bank is holding genuine safe assets, so narrow banks borrow against only a fraction of the government debt they hold, so as to demonstrate that the assets are good. Other than the structure of its asset portfolio, a narrow bank functions like a regulated bank, solving the problem

$$\max_{a^n, b^n, d^n} \left[-a + u\left(\beta d^n\right) \right] \tag{67}$$

subject to the bank's present-value-payoff constraint

$$a^n - b^n + \beta \left[r^b b^n - d^n \right] \geq 0, \tag{68}$$

and the collateral constraint

$$r^b b^n - \frac{(1-\psi) b^n}{\beta} - d^n \geq 0. \tag{69}$$

Variables in the problem (67) subject to (68) and (69) are defined as previously, but with superscript n denoting variables related to the narrow bank's balance sheet. Note that, in (69), we take into account the narrow bank's incentive to fake its holdings of government debt. Then, letting x^n denote optimal DM consumption of narrow bank depositors, x^n solves

$$r^b = \frac{\psi + (1-\psi)u'(x^n)}{\beta u'(x^n)}. \tag{70}$$

Assume that the regulated banking sector has insured deposits, and a regulatory capital requirement on risky assets. So that we can allow for all possible cases, let $i = 0$ and $i = 1$ denote, respectively, low-effort and high-effort choice by regulated banks, and let γ denote the fraction of risky assets that is not backing banks' deposit liabilities – either a self-imposed or binding regulatory capital requirement. Then, for regulated banks, let x^r denote the quantity of DM consumption for regulated bank depositors. Then, from our analysis in the previous section, we have

$$u'(x^r) = \frac{\sigma + \omega i - \gamma\phi_i}{(1-\gamma)\,\phi_i}. \tag{71}$$

with

$$\gamma = \max\left[\frac{\omega}{\phi_1 - \phi_0}, \gamma^g\right],$$

when $i = 1$, and $\gamma = \gamma^g$ when $i = 0$. Also, let χ denote the equilibrium fraction of buyers who hold deposits in the regulated banking system, while $1 - \chi$ is the fraction holding deposits with narrow banks. We can show that the period utility of buyers who deposit in regulated banks and narrow banks, respectively, is given by

$$U(x) = u(x) - xu'(x),$$

for $x = x^n, x^r$, and note that $U(x)$ is strictly increasing in x. So, for any equilibrium with $0 < \chi < 1$, we have $x^r = x^n$. That is, in equilibrium, depositors have to be indifferent between regulated and narrow banks, and this requires that they offer claims to the same quantity of DM consumption for depositors.

From a narrow bank's collateral constraint, (69), which we assume binds, and (70), we can write a narrow bank's demand for government debt, as a function of DM consumption for narrow bank depositors,

$$b^n = \frac{x^n u'(x^n)}{\psi}. \tag{72}$$

Similarly, a regulated bank's demand for government debt can be written as a function of DM consumption for regulated bank depositors and the bank's quantity of risky assets,

$$b^r = \frac{x^r u'(x^r) - u'(x^r)(1-\gamma)\phi_i k^B}{\psi}. \tag{73}$$

In equilibrium, the total demand for government debt, from narrow and regulated banks, must equal the supply, that is

$$\chi b^r + (1-\chi) b^n = \bar{b}, \tag{74}$$

and

$$x^r = x^n = x. \tag{75}$$

So, from (72), (73), (74), and (75), we get

$$u'(x) \left[x - (1-\gamma) \phi_i \chi k^B \right] = \psi \bar{b}. \tag{76}$$

And, from (71) and (75),

$$u'(x) = \frac{\sigma + \omega i - \gamma \phi_i}{(1-\gamma)\,\phi_i}. \tag{77}$$

Then, equation (77) determines x, and equation (76) determines χk^B, given x. So, the aggregate stock of risky assets, χk^B, is determinate, but the fraction of regulated banks in the banking system, χ, is indeterminate, as is the quantity of risky assets per regulated bank. Though χ is indeterminate, there is a lower bound on the size of the regulated banking sector, since we require that $b^r \geq 0$ (safe asset holdings of regulated banks must be non-negative), so from (73) and (76),

$$\chi \geq 1 - \frac{\psi \bar{b}}{x u'(x)}.$$

That is, since only regulated banks can hold risky assets, the regulated banking sector must be large enough to absorb the stock of risky assets forthcoming at market prices.

So, perhaps surprisingly, if the proportional cost of faking safe assets is the same for regulated and narrow banks, then permitting a banking sector with narrow banks, is irrelevant, even if the bank regulator imposes binding and inefficient capital constraints on risky assets. There is no effect on the allocation of resources or economic welfare from permitting narrow banks. It is possible to have some safe assets migrate from the regulated banking sector to the narrow banking sector, with no effect on total banking activity or on the level of service delivered by the banking sector to depositors. We get this result because regulated banks and narrow banks effectively have the same ability to transform safe assets into retail payments instruments. Though inefficient government-imposed capital requirements affect the allocation of resources, this has no implications for the viability of narrow banks or the size of the narrow banking sector, as capital requirements in this model affect only how efficiently risky assets are intermediated.

Note that we would get the same irrelevance result for any level of ψ. For example we would have irrelevance if $\psi < 1$, so that regulated and narrow banks have an incentive to fake safe assets. As well, we could have $\psi = 1$, which could be interpreted as an environment in which banking regulators can costlessly monitor regulated bank effort, and where narrow banks are monitored by regulators in the same way.

A more interesting case, and one which captures some elements of the potential competition between stablecoins and regulated banks, is to assume that the costs of faking safe assets are different for regulated banks and narrow banks. That is, suppose that the cost of faking assets for a regulated bank is ψ^r, while the cost for narrow banks is ψ^n, where $\psi^n < 1 = \psi^r$. With the structure of regulation we have assumed thus far, this would make narrow banking nonviable. Narrow banks could not survive as the costs of signaling that safe assets are genuine would imply a deposit contract that for narrow banks that would be inferior to the deposit contract offered by a regulated bank.[3]

To make the problem more interesting, suppose that regulated banks face a leverage constraint – of the type faced by retail banks in practice – rather than a capital requirement. In the model, the leverage constraint specifies that a regulated bank must hold a fraction ρ of each asset quantity, safe and risky, that is not backing bank deposits. This implies that, instead of the collateral constraints (20) and (51) for a regulated bank, we have

$$r^b b(1-\rho) - d_0 \geq 0, \tag{78}$$

and

$$r^b b(1-\rho) + (1-\rho^r) r^k k^B - d_1 - \frac{\delta\alpha_{i'}\left(d_1 - d_0\right)}{1-\delta\alpha_{i'}} \geq 0. \tag{79}$$

where

$$\rho^r = \max\left[\rho, \frac{\omega}{\phi_1 - \phi_0}\right], \tag{80}$$

if $i = 1$, and $\rho^r = \rho$ if $i = 0$. So, similar to the case with a capital constraint on regulated banks, a regulated bank may choose to impose a tighter constraint with respect to risky assets so as to signal high effort.

Then, similar to (77), for the regulated bank,

$$u'(x^r) = \frac{\sigma + \omega i - \rho^r \phi_i}{\left(1-\rho^r\right)\phi_i}, \tag{81}$$

for $i = 0, 1$, and we obtain the same set of possibilities as in Figure 1, except replacing γ^g with ρ, with three cases: low effort with a binding regulatory constraint; high effort with a nonbinding regulatory constraint; and high effort with a binding regulatory constraint. Then, as in Proposition 3, there exists ω^* solving

$$\frac{\sigma - \rho\phi_0}{(1-\rho)\phi_0} = \frac{\sigma\left(\phi_1 - \phi_0\right) - \omega^*\phi_0}{\phi_1\left(\phi_1 - \phi_0 - \omega^*\right)},$$

[3]Narrow banking would certainly be viable if the cost of faking safe assets were higher for narrow banks than for regulated banks. In that case, all safe assets would migrate to the narrow banking sector in equilibrium. One might argue that the narrow bank is simply structured and therefore easy to monitor, but that does not seem plausible. Generally, monitoring by large groups of small depositors rather than a regulator is thought to be relatively poor, and part of the motivation for regulation (the "representation hypothesis" — see Dewatripont and Tirole 1993). For a regulated bank, the safe-asset portion of the bank's portfolio is indeed simple, and easy for the regulator to monitor.

and the three cases are: (i) If $\omega \leq \rho(\phi_1 - \phi_0)$, then the equilibrium is high-effort with a binding government-imposed leverage constraint for risky assets; (ii) If $\rho(\phi_1 - \phi_0) < \omega \leq \omega^*$, then the equilibrium is high effort with a non-binding government-imposed leverage constraint for risky assets; (iii) If $\omega > \omega^*$, then the equilibrium is low effort.

In equilibrium, the quantity of DM consumption for a bank depositor determines the net utility payoff from holding a bank deposit, so all buyers will receive the same DM consumption, x, in equilibrium. As well, since only regulated banks can hold risky assets, therefore $x = x^r$, and from (81) x solves

$$u'(x) = \frac{\sigma + \omega i - \rho^r \phi_i}{(1 - \rho^r)\, \phi_i}, \tag{82}$$

where ρ^r is determined by (80).

Then, there can be two types of equilibria: (i) Narrow banks are not viable, and there are only regulated banks in equilibrium; (ii) Narrow banks and regulated banks coexist, with narrow banks holding all the safe assets, and regulated banks holding all the risky assets. In the first type of equilibrium, from the regulated bank's problem, (22) subject to (78), (79), and (80), and $\pi \geq 0$, where π is given by (16), we obtain

$$r^b = \frac{1}{\beta\left[\rho + (1-\rho)u'(x)\right]}, \tag{83}$$

which must hold in equilibrium as regulated banks hold the entire stock of government bonds. There exists a breakeven real rate of interest on government debt, r^*, for narrow banks, such that given the market value of x that must be delivered by a deposit contract, if $r^b > r^*$, then a narrow bank will issue deposit contracts, while if $r^b \leq r^*$, it will not. From (70),

$$r^* = \frac{\psi + (1-\psi)u'(x)}{\beta u'(x)}. \tag{84}$$

So, in this equilibrium, we require $r^b \geq r^*$, or from (83) and (84),

$$u'(x) - \left[\psi + (1-\psi)u'(x)\right]\left[\rho + (1-\rho)u'(x)\right] \geq 0. \tag{85}$$

Then, (85) holds if and only if

$$\psi > 1 - \rho$$

and

$$u'(x) \leq \frac{\psi\rho}{(1-\psi)(1-\rho)} \tag{86}$$

So, if $\omega \leq \rho\left(\phi_1 - \phi_0\right)$, then (86) and (82) imply

$$\psi \geq 1 - \frac{\rho\phi_1}{\sigma + \omega}, \tag{87}$$

if $\rho\left(\phi_1-\phi_0\right)\leq\omega\leq\omega^*$, then similarly,

$$\psi\geq\frac{(1-\rho)y}{\rho+(1-\rho)y}, \tag{88}$$

where

$$y=\frac{\sigma\left(\phi_1-\phi_0\right)-\omega\phi_0}{\phi_1\left(\phi_1-\phi_0-\omega\right)}, \tag{89}$$

and if $\omega\geq\omega^*$, then

$$\psi\geq 1-\frac{\rho\phi_0}{\sigma}. \tag{90}$$

So, in general, for this equilibrium to exist, it must be sufficiently costly for a narrow bank to fake its safe asset portfolio, and there must be a sufficiently stringent leverage constraint for regulated banks. That is, note from (87)-(90) that the lower bound on ψ is strictly decreasing in ρ.

Then, solving for an equilibrium, x is determined by (82), and then from (78) and (79), and (83), we get

$$k^B=\frac{-\left(1-\rho\right)\bar{b}+x\left[\rho+(1-\rho)u'(x)\right]}{(1-\rho^r)\phi_i\left[\rho+(1-\rho)u'(x)\right]},$$

which solves for k^B given x.

Then, similarly, in the case

$$\psi\leq 1-\rho,$$

or

$$\psi>1-\rho$$

and

$$u'(x)\geq\frac{\psi\rho}{(1-\psi)(1-\rho)},$$

there exists an equilibrium in which narrow banks hold the entire stock of government debt, while regulated banks hold the entire stock of risky assets. In this equilibrium, again letting χ denote the fraction of buyers who deposit in regulated banks, (82) solves for x, and then, from the narrow bank's binding collateral constraint and market-clearing in the bond market, we obtain

$$\chi=1-\frac{\bar{b}(1-\rho)}{x\left[\rho+(1-\rho)u'(x)\right]},$$

and from the regulated bank's binding collateral constraints,

$$k^B=\frac{x}{(1-\rho^r)\phi_i}.$$

Thus, if narrow banking is permitted to coexist with regulated banks, narrow banking is viable if regulated and narrow banks face the same information costs, or it is less costly for narrow banks to fake safe assets, but regulated banks face binding and inefficient leverage constraints. In the first case, narrow banking is irrelevant, in that it does not affect the equilibrium allocation or welfare. In the latter case, welfare would be higher without narrow banks and leverage requirements.

So, in this environment, narrow banking does not represent a desirable alternative to banking with deposit insurance. As regards stablecoins, this may indicate that the survival of such arrangements reflects inefficiency in the regulated banking sector, rather than a need for specific regulation of stablecoins.

5 Regulation Requiring All Banks to be Narrow

An alternative setup, consistent with some historical narrow banking proposals – Friedman's 100% reserve requirement for example – is a regulation that requires banks to be narrow, and eliminates deposit insurance. Given this restriction, all banks solve (67) subject to (68) and (69). Then, assuming that the collateral constraint (69) binds, and the proportional cost for a narrow bank of faking its portfolio of safe assets is ψ, the gross real return on government debt must satisfy

$$r^b = \frac{\psi + (1-\psi)u'(x^n)}{\beta u'(x^n)}, \tag{91}$$

in equilibrium, and from (69), and (91), x^n solves

$$u'(x^n)x^n = \psi \bar{b}. \tag{92}$$

Note, because $-\frac{xu''(x)}{u'(x)} < 1$, that x^n decreases with the supply of government bonds, $\bar{b}$.

We want to compare this equilibrium outcome to what happens in a world with only regulated banks and deposit insurance. As in our previous analysis, aggregate welfare is increasing in the quantity of DM consumption for bank depositors. With regulated banks and deposit insurance, in a low-effort equilibrium, from (33) and (35),

$$u'(x^r) = \frac{\sigma}{\phi_0}, \tag{93}$$

and

$$k^B = \frac{1}{\sigma}\left[x^r u'(x^r) - \psi \bar{b}\right]. \tag{94}$$

And, in a high-effort equilibrium, from (40) and (42),

$$u'(x^r) = \frac{\sigma(\phi_1 - \phi_0) - \omega\phi_0}{\phi_1(\phi_1 - \phi_0 - \omega)}, \tag{95}$$

and

$$k^B = \left[\frac{\phi_1 - \phi_0}{\sigma(\phi_1 - \phi_0) - \omega\phi_0}\right]\left[x^r u'(x^r) - \psi \bar{b}\right]. \tag{96}$$

So, for $\bar{b}$ sufficiently small, from (92), (93), and (95), $x^r > x^n$ holds, and the narrow banking restriction must reduce welfare. Further, from (92), (94), and (96), $k^B > 0$ in the regulated banking equilibrium if and only if $x^r > x^n$. That is, in circumstances in which government debt is sufficiently plentiful that narrow banking is efficient, regulated banks would choose to be narrow, without the narrow banking restriction.

A narrow banking restriction in general acts to make banks less risky than is efficient. If safe assets are sufficiently scarce, then risky assets can be put to good use by the banking system, in backing transactions deposits. If all banks are required to be narrow, then there is no investment in risky assets, but as a result the quantity of transactions is inefficiently low. So a narrow banking restriction is not an improvement relative to a system with deposit insurance, in this environment. Like a regime with deposit insurance, narrow banking removes aggregate risk for bank depositors, but does so in an inefficient manner relative to a deposit insurance system.

6 Conclusion

Conventionally, deposit insurance is viewed as a potentially welfare-improving government intervention. But, deposit insurance is thought to induce a moral hazard problem, reflected in excessive bank risk-taking. Moral hazard might then be corrected through regulatory means, such as capital requirements. But, advocates of narrow banking arrangements argue that bank deposits can be safe, and costly banking regulation can be eliminated, if there is a niche for banks that hold only safe assets, either in parallel with regulated banks, or because all banks are restricted to be narrow.

In this paper, a model was constructed in which banking is subject to three frictions: limited commitment, moral hazard with respect to risky asset holdings, and potential misrepresentation of safe assets. In contrast to conventional wisdom, deposit insurance does not engender inefficiency, because banks construct their asset portfolios so as to mitigate moral hazard – effectively, though self-imposed capital requirements, or skin-in-the-game. Regulatory capital requirements encourage banks to choose high effort, and tend to reduce the probability of bank failure, but welfare will fall if the government-enforced capital requirements bind.

With respect to narrow banking, two key questions that we ask are: (i) Is narrow banking viable? (ii) If narrow banking is viable, does it increase welfare? Regulations such as leverage requirements, which act to increase the cost of safe asset holdings for regulated banks, give narrow banks a profit opportunity. But, if narrow banks are deemed by depositors to have an advantage in faking safe assets, then narrow banks may not be viable. A regulation like Friedman's 100% reserve requirement (Friedman 1960) makes banks safe, but reduces welfare.

These results might make us skeptical as to the viability of unregulated stablecoin arrangements. A stablecoin is essentially a bank, claiming to be a narrow bank. But, if stablecoin holders have a poor ability to monitor the assets held by the stablecoin "bank," then stablecoin banking arrangements are not efficient. In our model, stablecoin issue is not profitable unless insured banks are inefficiently regulated.

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Figure 1: Equilibria with a Government-Imposed Capital Requirement