How Should Governments Create Liquidity?

Timothy Jackson[1], George Pennacchi[2]

Abstract

Safe assets (liquidity) can be created by an economy's private banking system and also by its government. Our model shows that some banks create liquidity with low debt and efficient loan monitoring while other banks use high, tranched debt and inefficient loan monitoring. Government liquidity can also differ, either by the government directly issuing debt or by insuring bank deposits. Directly issued government debt allows for greater private liquidity, more efficient bank lending, and greater welfare for savers. Government insurance of bank deposits crowds out private liquidity but leads to greater bank lending and profits.

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[1]Economics Group, University of Liverpool; timjackson100@hotmail.co.uk; Chatham Building, L69 7ZH, UK; +44 (0)151 795 3000

[2]Department of Finance, University of Illinois; gpennacc@illinois.edu; 515 E. Gregory Drive Box 25, Champaign, IL 61820 USA

1. Introduction

Risk-averse investors value safe, default-free assets for the certainty of their returns, but the easy-to-value quality of these assets also makes them liquid in transactions. The money-like nature of safe assets provides a liquidity premium that lowers investors' required return. Importantly, the quantity of an economy's safe assets or 'liquidity' is not exogenous. Safe assets can be created by private financial intermediaries (e.g., Gorton and Pennacchi (1990)) and also by a government (e.g., Krishnamurthy and Vissing-Jorgensen (2012)).

This paper studies the relationships between private liquidity created by a banking system and public liquidity created by a government. It models various ways that safe, liquid assets can be produced by banks and a government and shows how these different ways effect the financial system. In particular, the paper finds that the specific method chosen by a government to create liquidity will change the amount of private liquidity created by banks, the amount and efficiency of bank lending, and also the welfare of individuals in the economy.

Our model first shows that banks provide liquidity in different ways. Some banks will choose to create safe, liquid deposits by limiting their leverage and efficiently monitoring their assets (loans) to preserve asset recovery values in bad states of the world. Other banks will choose to create safe deposits by issuing risky junior debt to increase the assets that back liquid senior deposits. With this more levered senior-junior debt structure, bank equityholders have less 'skin in the game' and fail to monitor assets efficiently.

We also model the different methods that a government creates safe assets. One is by directly issuing its own debt, such as Treasury securities, to the public. These securities may be held directly by individuals or held by a 'narrow bank,' such as a Treasury-only money market fund, to back individuals' safe deposit accounts. A second indirect way is for the government to insure private debt, with the premier example being government insurance of bank deposits. For either method, the government's supply of safe assets is limited by its capacity to raise future taxes that cover its liabilities.

Our results show that a government's choice of direct liquidity versus indirect liquidity has major economic consequences. Directly-issued government debt allows for greater private liquidity, more efficient bank lending, and greater welfare for the economy's savers. This direct public liquidity has minimal effects on the private banking system but provides savers more safe assets which raise their welfare as long as the safe asset liquidity premium exceeds any direct costs of taxation needed to finance the government's debt.

In contrast, indirect government liquidity in the form of deposit insurance crowds out private liquidity because insured deposits displace many safe bank deposits that would have been privately created in the absence of insurance. Relative to direct liquidity, the smaller quantity of safe assets reduces saver welfare. A counter effect is that insured deposits' greater liquidity premium reduces banks' cost of funding, thereby raising their profits and expanding lending. However, average lending efficiency is worse when deposit insurance coverage is sufficiently generous.

Our paper contributes to a literature on the private and public provision of safe assets.[3] Prior research, including Gorton and Pennacchi (1990) and Dang et al. (2017), notes that safe assets are especially valuable for making transactions due to their information-insensitivity. Safe assets' 'money-like' liquidity premium is empirically documented by several studies including Krishnamurthy and Vissing-Jorgensen (2012), Sunderam (2015), Nagel (2016), and Perignon et al. (2017).

Research shows that safe assets can be created privately by levered financial intermediaries that invest in risky assets and issue limited amounts of safe debt. Examples include deposit-issuing banks (e.g., Diamond (2019) and Ahnert and Perotti (2018)) and special purpose vehicles that issue senior and junior tranched securities (e.g., DeMarzo and Duffie (1999) and DeMarzo (2005)). Related to this research, we find that banks with relatively low costs of monitoring loans choose to create safe deposits using low leverage that incentivizes efficient monitoring. Other banks with relatively high monitoring costs create safe senior deposits using high leverage that includes risky junior debt. This finding contrasts with DeAngelo and Stulz (2015) who argue that high leverage is optimal for banks that create liquidity. Our point is that in some cases low leverage is best to create liquidity, and while in other cases high leverage is used, not all of this high leverage is liquid.

Most research that analyzes the co-existence of private and public liquidity concentrates on issues of financial stability. Holmström and Tirole (1998) study an economy where firms experience uncertain needs for

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[3]See Gorton (2017) for an in-depth review of this literature.

future financing and show that a government with taxing power can improve welfare by issuing state contingent bonds that help meet these needs. Similarly, Bolton et al. (2009) examine ways that a government can improve on investment efficiency by intervening to support trade in different maturity investment projects. More closely related to our model is Stein (2012) whereby banks raise funds from savers who especially value safe assets. A bank can lower its cost of funding by issuing safe short-term deposits but the consequence is potential asset firesales needed to repay these deposits. Government intervention in the form of central bank reserve requirements can limit short-term deposits and mitigate the negative externality of firesales.

Our model also assumes that banks have an incentive to issue safe deposits in order to reduce their cost of funding, but our analysis differs. First, our banks are special not only by creating safe liquid deposits but also, like Diamond (1984), by monitoring to improve loan returns. These two functions interact to determine how much liquidity and loans that banks supply. Second, we study the economic effects of the two major ways that governments supply liquidity: direct issuance of debt and deposit insurance. The former is the focus of most prior work, but the effects of deposit insurance on liquidity has received little attention.[4] We focus on financial system architecture by examining how a government's choice of liquidity affects private liquidity, bank lending and lending efficiency, and economic welfare.

The next section introduces our basic model and considers a fully-private banking system that serves as a benchmark for studying different choices of public liquidity creation. Section 3 considers a banking system where the government directly issues debt while Section 4 examines a banking system with indirect government liquidity via deposit insurance. Section 5 compares the economic consequences of the polar cases of a government only directly issuing debt versus only insuring deposits, while Section 6 considers a more realistic hybrid environment where a government does both types of liquidity creation simultaneously. Section 7 briefly discusses the robustness of our model, and Section 8 concludes.

2. Liquidity in a Fully-Private Banking System

Prior to examining how various forms of government liquidity creation affect the financial system, it is important to understand how fully-private intermediaries create liquidity. Therefore, this section analyzes a private banking system with no government intervention.

2.1. Basic Model Assumptions

Consider a single-period economy with agents that are located across a continuum of separate local markets and who obtain utility from end-of-period consumption. These agents receive initial endowments that can be invested to produce the end-of-period consumption good. There are two investment technologies whose returns are subject to only aggregate (macroeconomic) risk.[5] Investment returns are determined by the realization of one of three end-of-period states. A 'good' state occurs with probability p_g, a 'bad' state occurs with probability p_b, and a 'catastrophe' state occurs with probability $p_c = 1 - p_g - p_b$.

One investment technology is a non-intermediated risky investment that is available to all agents and is in perfectly elastic supply. A unit investment returns $R_r/p_g > 0$ only in the good state and 0 in the bad and catastrophe states, implying that this technology's expected return is R_r. The other superior investment technology can be accessed only through lending intermediaries called 'banks.' One type of agent, a 'banker,' is capable of owning and managing a bank. The other type of agent, a 'saver,' has initial endowment to invest and especially values safe assets due to their money-like 'liquidity' services.

Each local market has a single risk-neutral banker who receives an initial endowment of k that can be invested in the bank. The bank can raise additional funds from the savers in its local market in the form of standard, non-state-contingent debt contracts.[6] Bank debt, which we refer to as 'deposits,' can differ

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by seniority, allowing banks to issue both senior and junior (subordinated) deposits. Each market has a continuum of 'small' savers whose total initial endowment equals 1. Savers also receive end-of-period wage income of ω that cannot be pledged or traded. Let $\gamma \leq 1$ denote the total amount of deposits issued by a local market's bank. Thus, a bank's beginning-of-period assets equal $(\gamma + k) \leq (1 + k)$.[7]

Banks are special due to their superior lending technology that funds identical projects in perfectly elastic supply. In the good state, each loan's end-of-period return per unit lent equals its promised return of $R_l > R_r/p_g$. In the bad state, loans default but have a strictly positive recovery value. In the catastrophe state, loans default with zero recovery value.

The banker is able to improve each loan's recovery value in the bad state by exerting costly, beginning-of-period effort to monitor the borrower.[8] Importantly, this effort, denoted by e, is not directly observable by the public nor is it contractible or verifiable by a court. Let $e \in \{0, 1\}$ be the banker's choice of monitoring effort. If $e = 1$, the bad state recovery value is d_1; otherwise, the bad state recovery value is d_0, where $0 < d_0 < d_1 < 1$.[9]

Monitoring effort diminishes a banker's utility at a fixed marginal cost. To generate an elastic supply of effort, liquidity, and lending, the cost of monitoring is assumed to differ across banks. Let banker i's cost of monitoring effort per unit loan be $c_i \in [\underline{c}, \bar{c}]$ where $f(c)$ is the continuous density of banks at cost level c in this interval. Assume that $\bar{c} \leq p_b [d_1 - d_0]$ so that even the highest cost bank would benefit from monitoring if it were contractible.

Savers derive utility from their expected end-of-period consumption but also obtain utility from holding 'money-like' safe assets or liquidity. This assumption is akin to the Sidrauski (1967) 'money-in-the-utility function,' and we follow Stein (2012) and Krishnamurthy and Vissing-Jorgensen (2012) who generalize this specification to safe assets. It is a reduced-form way of modeling safe asset liquidity services based on a richer model such as Gorton and Pennacchi (1990): safe assets' information-insensitivity makes them attractive transactions medium because trading losses to better-informed agents are avoided. Specifically, we assume the representative saver's utility is

$$U = E[C] + \lambda_q m_q + \lambda_f m_f, \tag{1}$$

where $E[C]$ is the saver's expected end-of-period consumption, m_q is the saver's initial holdings of 'quasi-safe' assets, and m_f is the saver's initial holdings of 'fully-safe' assets. The constants λ_q and λ_f represent the utility bonuses or 'liquidity premia' from holding quasi-safe and fully-safe assets, respectively, where $0 < \lambda_q < \lambda_f$.

Quasi-safe assets are defined as paying their promised return in the good and bad states, but not the catastrophe state, making their probability of not defaulting $\wp \equiv p_g + p_b$. Let R_q be these assets' expected return, so if they have zero recovery value in the catastrophe state then their promised return is $R_q/\wp$. Examples include money market instruments such as A1/P1-rated commercial paper and wholesale, uninsured bank certificates of deposit.[10] In contrast, fully-safe assets pay their promised return, denoted as R_f, in all three states. While a fully-private banking system cannot produce fully-safe assets, we later consider how a government can do so because of its special power to tax non-pledgeable wage income. Examples of fully-safe assets include Treasury securities and government-insured deposits.

Since each local market has a single banker but a continuum of competitive local savers, all surplus from issuing deposits accrues to the banker in the form of bank profits. Savers' access to the risky technology, which has an expected return of R_r, determines their reservation utility. Consequently, the utility function (1) implies that a saver is indifferent between holding risky, quasi-safe, and fully-safe assets when $R_r = R_q + \lambda_q = R_f + \lambda_f$, so that $R_r > R_q > R_f$. This implication is consistent with empirical findings that

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may be justified by information asymmetries across markets since we will assume savers know their local bank's leverage and monitoring cost, information that may be unknown to non-local agents and deter inter-market debt. Appendix C.4 considers inter-market debt.

[7]As will become clear, due to the bank's superior investment technology, the banker has the incentive to invest the entire endowment k as bank equity.

[8]Rather than 'monitoring,' banker effort could be considered 'credit screening' that finds loan applicants whose projects have higher recovery value.

[9]Alternatively, the binary effort choice could be two strictly positive values where the lesser is a base level of verifiable and contractible effort. This would better-justify our assumption that $R_l > R_r/p_g$ and $d_0 > 0$. Also, Appendix C.1 allows effort to be a continuous choice. These alternative specifications for effort produce nearly identical results.

[10]These assets might be considered a 'near-money' or 'shadow money' (Moreira and Savov (2017)).

liquidity premia lower required returns on quasi-safe private debt (Sunderam (2015), Perignon et al. (2017)) and fully-safe public debt (Krishnamurthy and Vissing-Jorgensen (2012), Nagel (2016)).

2.2. A Bank's Capital Structure Decision

A bank has an incentive to issue safe deposits because their liquidity premium lowers savers' required return and the bank's cost of funding. Since loans return zero in the catastrophe state, a private bank can, at best, issue quasi-safe deposits that reduces its funding cost by λ_q. There are two potential ways to maximize quasi-safe deposits. One is to improve the recovery value of loans in the bad state by monitoring. But for depositors to believe that monitoring will occur, the bank must have an incentive to exert unobserved monitoring effort by restricting its leverage such that it receives the marginal benefit from its costly effort.

The second way that a bank can increase its quasi-safe deposits is by 'tranching' its debt by issuing both senior deposits and junior (subordinated) deposits. Designed appropriately, senior deposits can be made quasi-safe due to the additional assets funded by junior deposits. To see this, let R_s be the promised return on senior deposits and let the amount of these deposits, γ^s, be such that the bank has sufficient loan recovery value in the bad default state to pay them in full. If the amount of junior deposits is γ^j, then for a given bad state recovery value, d_e, where $e \in \{0, 1\}$, the amount of quasi-safe senior deposits satisfies:

$$(\gamma^s + \gamma^j + k)d_e \geq \gamma^s R_s = \gamma^s R_q/\wp, \tag{2}$$

where the equality in condition (2) follows because the required promised return on quasi-safe deposits is $R_q/\wp$. Equivalently, this condition holds when senior deposits are below a critical value, $\bar{\gamma}^s$, which is increasing in effort, e, and other forms of bank funding, $\gamma^j + k$:

$$\gamma^s \leq \bar{\gamma}^s \equiv \frac{(\gamma^j + k)d_e}{R_q/\wp - d_e}. \tag{3}$$

Due to their superior lending technology, bankers will always choose to invest their entire endowment, k, as their bank's equity capital. However, bankers' profit-maximizing choices of leverage and effort may result in savers' junior deposits being either quasi-safe or default-risky. We next consider the possible equilibrium behavior of bankers and savers.

2.3. Equilibrium

An *equilibrium* is defined as follows. First, a bank(er) announces that it will issue γ^s in senior deposits and γ^j in junior deposits where $\gamma \equiv \gamma^s + \gamma^j \leq 1$, so that its total assets equal $\gamma^s + \gamma^j + k$. Second, the promised returns on these senior and junior deposits, R_s and R_j, respectively, are set. Third, the bank chooses its unobserved effort level, e. An equilibrium are values of γ^s, γ^j, and e that maximize the bank's profits and promised deposit returns R_s and R_j that satisfy senior and junior depositors' participation constraints given the bank's choices of γ^s, γ^j, and e.

To solve for possible equilibria, note that since bank i has monitoring cost c_i, its profit maximization problem can be written as:

$$\max_{\gamma^j, \gamma^s, e} \quad p_g \left[(\gamma + k)R_l - \gamma^s R_s - \gamma^j R_j\right] + p_b \max\left[(\gamma + k)d_e - \gamma^s R_s - \gamma^j R_j, 0\right] - c_i e(\gamma + k), \tag{4}$$

subject to the following three constraints. First, its total deposits cannot exceed 1:

$$\gamma^s + \gamma^j \leq 1. \tag{5}$$

Second, condition (2) is satisfied so that senior deposits are quasi-safe: $R_s = R_q/\wp$. Third, junior depositors' participation constraint is satisfied:

$$R_j \geq \begin{cases} \frac{R_r - \frac{p_b}{\gamma^j}\left[(\gamma^s + \gamma^j + k)d_{e*} - \gamma^s R_q/\wp\right]}{p_g} & \text{if } (\gamma^s + \gamma^j + k)d_{e*} - \gamma^s R_q/\wp < \gamma^j R_q/\wp, \\ R_q/\wp & \text{otherwise.} \end{cases} \tag{6}$$

Note that the expected profits given in (4) reflect the possibility of default in the bad state but the certainty of default in the catastrophe state due to loans' zero recovery value. Also, the junior depositors' participation constraint (6) reflects either default in the bad state (the first line on the right-hand side) or no default in the bad state (the second line on the right-hand side). In the former case, junior depositors' required expected return is R_r, but in the latter case it is R_q since junior deposits are quasi-safe.

2.4. Deposits and Profits if a Bank Monitors

To solve this problem, first consider a bank's deposit choice and expected profits if it chooses to monitor its loans; that is, $e = 1$. Given condition (2), a necessary condition for a bank to choose costly monitoring is that bank equity receives a positive return in the bad state:

$$(\gamma^s + \gamma^j + k)d_1 - \gamma^s R_q/\wp - \gamma^j R_j|_{d_{e*}=d_1} > 0. \tag{7}$$

If this condition holds, junior deposits would be quasi-safe and no different from senior deposits. Consequently, a bank that monitors does not benefit from issuing more than one class of deposits, so with no loss of generality we can set $\gamma^j = 0$ and $\gamma^s = \gamma$.

However, a sufficient condition for bank i to choose monitoring requires that the present value of its equity's bad-state return in (7), $p_b[(\gamma + k)d_1 - \gamma R_q/\wp]$, exceed its cost of monitoring, $c_i(\gamma + k)$. Equivalently, this sufficient condition requires that total deposits, γ, not exceed

$$\gamma_1(c_i) \equiv k\frac{p_b d_1 - c_i}{p_b R_q/\wp - (p_b d_1 - c_i)}. \tag{8}$$

Moreover, since quasi-safe deposits are the low-cost source of funding, a profit-maximizing bank that monitors would choose this maximum deposit level, resulting in profits of

$$\pi_1(c_i) = (\gamma_1(c_i) + k)[p_g R_l + p_b d_1 - c_i] - \gamma_1(c_i)R_q. \tag{9}$$

Note that since $\gamma_1(c_i)$ is a decreasing function of c_i, so is $\pi_1(c_i)$.

2.5. Deposits and Profits if a Bank Does Not Monitor

If inequality (7) does not hold, a bank lacks the incentive to monitor, implying that junior deposits are default-risky and require an expected return of R_r. Since senior deposits are quasi-safe and require an expected return of $R_q < R_r$, the bank has the incentive to issue the maximum level of quasi-safe senior deposits, equal to $\gamma^s = \bar{\gamma}^s|_{d_{e*}=d_0} \equiv \bar{\gamma}_0^s$. An implication is that junior deposits are paid 0 in the bad state and their promised return is R_r/p_g.[11] Denoting the no-monitoring bank's expected profits as π_0, we have

$$\pi_0 = p_g\left[(\gamma^j + \bar{\gamma}_0^s + k)R_l - \bar{\gamma}_0^s R_q/\wp - \gamma^j R_r/p_g\right]. \tag{10}$$

Given that the promised payment on the loan exceeds the promised payments on deposits, equation (10) is strictly increasing in γ^j, implying that the maximum is at the corner solution $\gamma^j = 1 - \bar{\gamma}_0^s$.[12] Thus, this no-monitoring effort bank chooses maximum total leverage, $\gamma = \gamma^j + \gamma^s = 1$, where quasi-safe senior deposits are maximized at

$$\gamma_0^s = \frac{(1 - \bar{\gamma}_0^s + k)d_0}{R_q/\wp - d_0} = \frac{(1 + k)d_0}{R_q/\wp}. \tag{11}$$

Therefore, this no-monitoring effort bank's maximum expected profits equals

$$\pi_0 = (1 + k)[p_g R_l + p_b d_0] - (1 - \gamma_0^s)R_r - \gamma_0^s R_q. \tag{12}$$

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[11] The fact that in equilibrium junior deposits receive nothing in the bad state makes their payoff similar that of the banker's inside equity, k. In this sense, junior deposits might be considered similar to outside equity. However, the effort incentive of the banker depends his/her inside equity, so issuing more junior deposits is not equivalent to the banker increasing inside equity.

[12] Specifically, $\partial \pi_0/\partial \gamma^j$ is positive when the bank's interest rate margin $[R_l - R_r/p_g](\gamma^j + k) + [R_l - R_q/\wp]\bar{\gamma}_0^s > 0$, which we assume holds.

2.6. Cost Threshold for Monitoring

Note that equation (9) indicates that π_1 is declining in c_i while equation (12) indicates that π_0 is independent of a bank's monitoring cost. Assuming that

$$\pi_1(\bar{c}) < \pi_0 < \pi_1(\underline{c}), \tag{13}$$

then there exists a unique threshold value c^* such that $\pi_0 = \pi_1(c^*)$, given by

$$c^* = p_b \left[d_1 - \frac{\pi_0/k - p_g R_l}{\pi_0/k - p_g R_q/\wp} R_q/\wp \right]. \tag{14}$$

The next proposition summarizes these results on equilibrium in a fully-private banking system.

Proposition 1. *If bank i's cost of monitoring is $c_i < c^*$, it issues only quasi-safe senior deposits equal to $\gamma_1(c_i)$, monitors its loans, and has expected profits equal to π_1 in equation (9). Instead, if its cost is $c_i > c^*$, it issues quasi-safe senior deposits of γ_0^s in equation (11), issues default-risky junior deposits of $1 - \gamma_0^s$ with promised payment R_r/p_g, does not monitor its loans, and has expected profits equal to π_0 given in equation (12).*

Thus, while all banks lower their funding costs by creating quasi-safe deposits, they do so in very different ways. Banks with low monitoring costs choose low leverage and efficient monitoring while banks with high costs choose maximum leverage, do not monitor, and tranche their deposits. Obviously the low-cost banks earn higher profits due to the value they create by monitoring. But high-cost banks create quasi-safe assets via a type of financial engineering that has grown rapidly in recent decades, namely, securitization. Securitization vehicles hold loans as assets and issue various tranches of senior, subordinated, and equity securities. They embody our model's highly-levered private bank that fails to monitor efficiently. Indeed, a large body of research, including Keys et al. (2010) and Purnanandam (2011), finds a lack of efficient credit screening/monitoring and greater loan losses when loans are held by securitization vehicles.

Proposition 1 also addresses the question of whether banks will optimally choose high leverage if the deposits that they issue are liquid. DeAngelo and Stulz (2015) argue that banks will be highly levered, but our answer to this question is more nuanced. For deposits to be liquid, they must be safe. Some (low-cost) banks will optimally create safe deposits with low leverage and efficient monitoring that improves their loan returns. For other (high-cost) banks, high leverage is optimal. But in this case only part of their leverage (senior deposits) is safe and liquid while the other part of leverage (junior deposits) is risky and illiquid.[13]

We close this section by computing the aggregate utility of the banking system, which will be a welfare benchmark for comparing banking systems with government-provided liquidity.

2.7. Utility of Savers and Bankers

A saver's expected end-of-period consumption equals wage income, ω, plus investment returns. Investments include quasi-safe deposits, default-risky deposits, and, in markets where $\gamma < 1$, direct investments in the risky technology. The expected return on quasi-safe deposits is R_q while the expected return on default-risky deposits and the risky technology is R_r. However, due to the utility bonus from quasi-safe assets of $\lambda_q \equiv R_r - R_q$, the expected utility for all investments is R_r. Hence, each saver's expected utility for all local markets is

$$U = \omega + R_r, \tag{15}$$

which reflects our assumption that the continuum of consumers act competitively and all surplus is captured by each market's monopoly banker. In particular, the average expected utility of these risk-neutral bankers, U_b, equals average bank profits:

$$U_b = \int_{\underline{c}}^{c^*} \pi_1(c_i) f(c_i) dc_i + \pi_0 \int_{c^*}^{\bar{c}} f(c_i) dc_i. \tag{16}$$

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[13]Berger and Bouwman (2009) empirically measure the relationship between bank liquidity creation and leverage. Consistent with our model, they find a mixed relationship that tends to be positive for small banks but negative for large banks.

Equations (15) and (16) are the benchmarks for welfare in a fully-private banking system.

3. Direct Government Liquidity

A government differs from private creditors due to its taxing authority, which is a channel for potentially improving welfare. This section considers how a government can create liquidity by directly issuing debt backed by future tax revenue.

3.1. Direct Government Liquidity Assumptions

The government is assumed to have the power to tax up to a proportion $\bar{t} < 1$ of each saver's end-of-period non-pledgeable wage, ω, but taxing is costly in that savers incur direct costs of paying taxes that diminish their utility by a proportion η of the amount collected.

Now suppose that at the beginning of the period the government issues Treasury securities. Since end-of-period tax revenue is available in all states, limited amounts of these securities can be fully safe so that savers require a return of R_f per unit investment.[14] Treasury securities could be sold directly to savers or to 'narrow banks' that use them to back liquid deposit-like accounts held by savers. Such narrow banks could operate exactly as do today's 'Treasury-only' money market mutual funds. Alternatively, they could operate as the proposed narrow banks that would own government debt and issue interest-paying central bank digital currency (CBDC) deposits.[15]

The government is assumed to sell Treasury securities uniformly across the local markets. The maximum amount sold per market, γ^d, is limited by the government's tax revenue:

$$\gamma^d = \frac{\bar{t}\omega}{R_f}, \tag{17}$$

where $\bar{t}\omega < R_f$ is assumed, so that $\gamma^d < 1$. For example, if each market has a narrow bank, γ^d is the maximum fully-safe deposits issued per narrow bank to savers.

Since each market continues to have a banker with a superior lending technology, 'broad' banks that make loans continue to operate similar to the private banks of our model of Section 2. Importantly, the savings available to these broad banks depends on how the government uses its revenue from selling Treasury securities. It is assumed that the government instantly rebates its revenue from Treasury sales, γ^d, back to savers as a lump sum at the beginning of the period. Such a debt-financed rebate does not change the savings available to each broad bank, which remains at 1.[16] It only increases savers' holdings of liquid public debt.

3.2. Equilibrium and Utility with Direct Liquidity

Since the government's proceeds from Treasury sales are instantly rebated to savers as a lump-sum transfer, the constraint on deposits raised by broad banks remains at $\gamma \leq 1$. Therefore, *the behavior of broad banks is exactly the same as banks in the fully-private system analyzed in Section 2*, resulting in bank profits under direct liquidity $U_b^{DL} = U_b$.

Relative to the fully-private system, savers now possess additional fully-safe (narrow bank) deposits that raise utility by $\gamma^d R_r$. However, they also incur end-of-period tax costs of $(1+\eta)\gamma^d R_f$ in all states. Consequently, savers' utility under direct liquidity equals

$$U^{DL} = U + \gamma^d R_r - (1+\eta)\gamma^d R_f = U + \gamma^d \left[\lambda_f - \eta R_f\right]. \tag{18}$$

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[14]Our model assumes a homogeneous class of government debt while, in reality, government debt varies in maturity. Longer-maturity government debt may be subject to short-run interest rate risk. Infante (2020) analyzes how repurchase agreements backed by long-term Treasuries can substitute for short-term Treasuries, such as Treasury bills, to meet the demand for liquid, money-like assets.

[15]Bank for International Settlements (2018), Norges Bank (2018), and Brunnermeier and Niepelt (2019).

[16]This would be comparable to a debt-financed tax cut or credit. Alternative uses of Treasury proceeds are that the government invests them in the risky investment technology (Appendix C.2) or offers to deposit them in broad banks (Appendix C.3). We focus on a debt-financed rebate because it leaves all investment decisions to private agents and isolates the pure effects of the government's direct provision of liquidity. However, the two alternatives have many qualitatively similar implications to the case studied in this section.

The following proposition summarizes this section's results.

Proposition 2. *A system where the government directly issues debt leads to: 1) broad bank behavior that is identical to that of a fully-private system; 2) total utility that exceeds that of a fully-private system if $\lambda_f > \eta R_f$.*

Thus, our main finding is that direct issuance of public debt can have no impact on the operations of a fully-private banking system but increases welfare if the debt's fully-safe liquidity premium exceeds the direct costs of taxes needed to finance that debt.

4. Indirect Government Liquidity

As an alternative to directly issuing public debt, this section considers indirect public liquidity creation via government deposit insurance.

4.1. Deposit Insurance Assumptions

Consider a government that offers fairly-priced deposit insurance backed by its end-of-period revenue from taxing savers' wage income.[17] To make deposits fully safe, the government must limit insurance such that it has sufficient tax capacity to cover losses in the worst-case catastrophe state when bank assets are worthless. Specifically, assume insurance is limited to small 'retail' deposits, equal to a proportion γ^r of total savings in each banking market.

The government assesses a fair premium payable by each bank at the end of the period, equal to ϕ per promised payment on insured deposits.[18] Thus, if a bank issues the maximum amount of insured deposits, its promised payment to insured depositors and the deposit insurer is $\gamma^r R_f (1 + \phi)$, where ϕ varies based on each bank's default risk.[19] However, a bank might issue less than γ^r of insured deposits, and its behavior will qualitatively differ depending on whether its monitoring cost, c_i, is low, moderate, or high. Let us first take the deposit insurance limit of γ^r as given and analyze each type of bank's profit-maximizing choice of insured deposits. Then by aggregating over all banks' insured deposits, one can determine the maximum level of γ^r that is supported by the government's taxing power.

4.2. Deposits and Profits if a Bank Monitors

As in a fully-private system, a deposit-insured bank with a small cost of monitoring may choose to restrict its total leverage in order to have the incentive to monitor. Banks whose restricted leverage exceeds the maximum of insured deposits, γ^r, are designated as 'low-cost' banks and denoted with the subscript L. When charged a fair insurance premium, these banks choose to issue the maximum γ^r of insured deposits having funding cost R_f with the remaining $\gamma - \gamma^r$ of quasi-safe, uninsured deposits having funding cost of R_q. Relative to a fully-private system, the lower-cost insured deposits raise the maximum leverage that preserves the bank's incentive to monitor. Appendix A.1 shows that low-cost bank i's fair insurance premium equals $\phi_1 = p_c/(1 - p_c)$, and it chooses total deposits equal to

$$\gamma_{1,L}^{DI}(c_i) = \gamma_1(c_i) + \gamma^r (R_q - R_f) \frac{p_b/\wp}{p_b R_q/\wp - [p_b d_1 - c_i]} > \gamma_1(c_i). \tag{19}$$

This low-cost bank's expected profits are

$$\pi_{1,L}^{DI}(c_i) = (\gamma_{1,L}^{DI} + k)[p_g R_l + p_b d_1 - c_i] - \gamma_{1,L}^{DI} R_q + \gamma^r (\lambda_f - \lambda_q) > \pi_1(c_i), \tag{20}$$

which exceed its expected profits in the absence of deposit insurance. Profits are higher because insured deposits' funding cost is lower due to their higher fully-safe liquidity premium.

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[17]Because our intent is to study the novel effects of government liquidity via deposit insurance, we ignore the well-known distortions due to insurance typically being subsidized in practice. See Pennacchi (2010).

[18]This promised payment makes ϕ analogous to a credit spread on uninsured debt. The government makes a lump sum payment to savers in states where aggregate premiums exceed aggregate insurance losses.

[19]As in practice, the insurer is assumed to have the same seniority (bankruptcy claimant status) as senior uninsured depositors and receives the proportion $\gamma^r/(\gamma^r + \gamma^s)$ of any asset recovery value.

Other banks with somewhat greater monitoring costs need to further restrict their leverage to $\gamma \leq \gamma^r$ in order to have an incentive to monitor. This type of deposit-insured bank is referred to as 'moderate-cost' and denoted with subscript M. With fairly-priced insurance premium ϕ_1, these banks have an incentive to issue only insured deposits due to their least funding cost of R_f. Similar to low-cost banks, moderate-cost banks' maximum leverage that preserves their incentive to monitor is higher compared to that for the case of no deposit insurance. Appendix A.2 shows that this maximum leverage for moderate-cost bank i equals

$$\gamma_{1,M}^{DI}(c_i) = k\frac{p_b d_1 - c_i}{p_b R_f/\wp - (p_b d_1 - c_i)} > \gamma_1(c_i), \tag{21}$$

which takes the same form as γ_1 in equation (8) except that the smaller value R_f replaces R_q in the denominator. Given this higher leverage, profits for these moderate-cost banks are

$$\pi_{1,M}^{DI}(c_i) = (\gamma_{1,M}^{DI} + k)[p_g R_l + p_b d_1 - c_i] - \gamma_{1,M}^{DI} R_f > \pi_1(c_i), \tag{22}$$

which is, of course, greater than profits in the fully-private, no-insurance case.

4.3. Deposits and Profits if a Bank Does Not Monitor

Recall that in the absence of deposit insurance, banks with relatively high monitoring costs choose not to monitor ($e = 0$), use maximum leverage ($\gamma = 1$), and tranche their deposits such that the promised payment on senior deposits equals the bank's asset return in the bad state (γ_0^s given by equation (11)). Let us refer to such banks as 'high-cost' banks and consider their behavior when offered deposit insurance.

For simplicity and realism, assume that γ^r is such that $\gamma^r R_f \geq \gamma_0^s R_q/\wp = (1+k)d_0$ so that the promised payment on maximum insured deposits exceeds the bank's bad state asset return when it chooses maximum leverage and no monitoring.[20] Consequently, a bank that issues maximum insured deposits has no incentive to issue senior deposits. Hence, the main effect of fairly-priced deposit insurance is that high-cost banks choose to replace γ_0^s of quasi-safe senior deposits having funding of R_q with γ^r of insured deposits having the lower funding cost of R_f. Maximum leverage continues to be profitable, so that $1 - \gamma^r$ of uninsured deposits replace $1 - \gamma_0^s$ of junior deposits, both having a funding cost of R_r.

Based on the above logic, Appendix A.3 shows when charged the fair insurance premium of $\phi_0 = [(1 - p_g)R_f - p_b(1+k)d_0]/(p_g R_f)$, high-cost banks have expected profits of

$$\pi_0^{DI} = \pi_0 + \gamma^r \lambda_f - \gamma_0^s \lambda_q > \pi_0, \tag{23}$$

which exceed profits under a fully-private system due to the relatively lower funding cost of fully-safe insured deposits.

4.4. The Maximum Level of Deposit Insurance

Note that only moderate-cost banks issue deposits below γ^r, and their proportion of all banks is determined by two monitoring cost thresholds. One threshold, denoted c_{DI}^*, is where the profits of moderate-cost and high-cost banks are equal, $\pi_{1,M}^{DI}(c_{DI}^*) = \pi_0^{DI}(\gamma^r)$, which implies:

$$c_{DI}^*(\gamma^r) = p_b\left[d_1 - \frac{\pi_0^{DI}(\gamma^r)/k - p_g R_l}{\pi_0^{DI}(\gamma^r)/k - p_g R_f/\wp}R_f/\wp\right]. \tag{24}$$

The other threshold determines the boundary between low- and moderate-cost banks, equal to the monitoring cost c^m that satisfies $\gamma_{1,M}^{DI}(c^m) = \gamma^r$.

Given these proportions of different types of banks as a function of γ^r, and noting that all banks' assets equal zero in the catastrophe state, the government's maximum end-of-period insurance liability $L(\gamma^r)$ equals

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[20]The opposite case of more restricted deposit insurance coverage is considered in Section 6.

the the total of insured deposits:

$$L(\gamma^r) = \underbrace{\int_{\underline{c}}^{c^m} \gamma^r R_f \cdot f(c_i)dc_i + \int_{c^m}^{c^*_{DI}} \gamma^{DI}_{1,M}(c_i)R_f \cdot f(c_i)dc_i}_{\text{Liability for monitoring banks, } L_1(\gamma^r)} + \underbrace{\int_{c^*_{DI}}^{\bar{c}} \gamma^r R_f \cdot f(c_i)dc_i.}_{\text{Liability for no-monitoring banks, } L_0(\gamma^r)} \tag{25}$$

For insured deposits to be fully safe, $L(\gamma^r)$ cannot exceed the government's tax capacity:

$$L(\gamma^r) = \bar{t}\omega. \tag{26}$$

Equating the right-hand sides of equations (25) and (26) and using equation (24) determines the equilibrium values of c^*_{DI} and γ^r. See Appendix A.4 for computing the solution.

4.5. Cost Threshold for Monitoring

Recall that for a fully-private system, c^* given in equation (14) is the monitoring cost such that $\pi_1(c^*) = \pi_0$. Now consider the level of deposit insurance, γ^r, that would make the cost threshold for monitoring under deposit insurance, c^*_{DI}, the same as c^*. For $c^*_{DI} = c^*$, it would need to be that the increase in profits under deposit insurance relative to the fully-private system is the same whether a bank with cost c^* chooses to monitor or not monitor.

Now note from equation (23) that the increase in profit under deposit insurance, relative to a fully-private system, for a bank that does not monitor equals:

$$\pi^{DI}_0 - \pi_0 = \gamma^r \lambda_f - \gamma^s_0 \lambda_q, \tag{27}$$

which is increasing in γ^r and independent of c_i. Then consider the relative increase in profit for a bank with $c_i = c^*$ that does monitor. Since under deposit insurance a bank that is indifferent between monitoring or not is a moderate-cost bank, the increase in profit for this bank under deposit insurance relative to a fully-private system is

$$\pi^{DI}_{1,M}(c^*) - \pi_1(c^*) = \left\{ \gamma^{DI}_{1,M}(c^*) - \gamma_1(c^*) \right\} [p_g R_l + p_b d_1 - c^* - R_f] + \gamma_1(c^*)(R_q - R_f). \tag{28}$$

Since equation (21) shows that $\gamma^{DI}_{1,M}(c^*)$ is independent of γ^r, so is equation (28). Thus, the γ^r that equates $\left(\pi^{DI}_0 - \pi_0\right)$ in equation (27) to $\left(\pi^{DI}_{1,M}(c^*) - \pi_1(c^*)\right)$ in equation (28) equals

$$\gamma^{r*} = \frac{\left(\pi^{DI}_{1,M}(c^*) - \pi_1(c^*)\right) + \gamma^s_0 \lambda_q}{\lambda_f}. \tag{29}$$

Therefore, γ^{r*} is the deposit insurance limit such that $c^*_{DI} = c^*$. An implication is that for deposit insurance limits exceeding γ^{r*}, the bank with monitoring cost c^* strictly prefers to not monitor when offered deposit insurance. Consequently, under deposit insurance the monitoring cost threshold must be such that $c^*_{DI} < c^*$ when $\gamma^r > \gamma^{r*}$.

4.6. Utility under Deposit Insurance

As defined in equation (25), let $L_1(\gamma^r)$ and $L_0(\gamma^r)$ be the insurer's catastrophe state liabilities for banks that monitor and banks that do not, respectively. Also define the insurer's net liability in the bad state as $L_b \equiv L_0(\gamma^r) - \gamma^r(1+k)d_0 \int_{c^*_{DI}}^{\bar{c}} f(c_i)dc_i - \phi_1 L_1(\gamma^r)$, where the first two terms reflect the insurer's losses net of recovery value for the high-cost banks that fail and the last term reflects the insurance premium received from banks that monitor and do not fail. Then savers' utility under deposit insurance can be computed as

$$\begin{aligned} U^{DI} &= U + p_g \left[\phi_1 L_1(\gamma^r) + \phi_0 L_0(\gamma^r) \right] - p_b \left[L_b + \eta L_b^+ \right] - p_c(1+\eta)\bar{t}\omega, \\ &= U - \eta(p_b L_b^+ + p_c \bar{t}\omega), \end{aligned} \tag{30}$$

where $L_b^+ \equiv \max[L_b, 0]$ indicates that savers bear direct costs of taxation in the bad state only when the government insurer has a net positive cost.

Note that the first line of equation (30) equals savers' private system utility plus the expected values of the insurer's good-state premium revenue and net insurance and taxation costs in the bad and catastrophe states. Since insurance is fairly priced, the second line shows that utility relative to the private system is reduced by only the direct costs of taxes.

Bankers' utility equals the weighted average of low-, moderate- and high-cost bank profits:

$$U_b^{DI} = \int_{\underline{c}}^{c^m} \pi_{1,L}^{DI}(c_i)f(c_i)dc_i + \int_{c^m}^{c_{DI}^*} \pi_{1,M}^{DI}(c_i)f(c_i)dc_i + \int_{c_{DI}^*}^{\bar{c}} \pi_0^{DI} f(c_i)dc_i > U_b. \tag{31}$$

Recall that equations (20), (22), and (23) show that banks of each type have higher profits under deposit insurance relative to a fully-private system. Therefore, deposit insurance raises bankers' utilities at the expense of direct costs of taxes borne by savers.

This section's results are summarized in the next proposition.

Proposition 3. *Relative to a fully-private system, a system where the government provides fairly-priced deposit insurance leads to: 1) greater profits and lending for all banks; 2) a smaller proportion of banks that efficiently monitor when the deposit insurance limit exceeds γ^{r*} given by equation (29); 3) lower utility for savers due to direct costs of taxation.*

Banks profit and lend more due to the lower funding cost provided by insured deposits' fully-safe liquidity premium. However, the downside is that sufficiently generous deposit insurance leads to less efficient monitoring and increases savers' direct costs of paying taxes needed to back the insurance. It is also interesting to note that, though deposit insurance is fairly priced, riskier high-cost banks all choose maximum deposit insurance coverage while safer moderate-cost banks do not, consistent with adverse selection in insurance.

5. Comparing Methods of Government Liquidity Provision

Sections 3 and 4 analyzed banking systems with government liquidity using a fully-private system as the benchmark. We now re-assess these results to draw conclusions on the relative merits of government direct liquidity versus deposit insurance based on their performance in terms of total bank lending, monitoring efficiency, total liquidity provision, and welfare.[21]

5.1. Lending and Monitoring

In our model there is a tradeoff between the aggregate quantity of loans and the average efficiency that loans are monitored. To incentivize efficient monitoring, a bank with limited insider equity creates sufficient 'skin-in-the-game' by restricting leverage and, in turn, total lending.[22] In contrast, a bank that forgoes monitoring can maximize its leverage and lending. Importantly, the profitability of efficient lending versus greater total lending varies across systems that differ by their government's method of liquidity creation.

Proposition 2 showed that when a government provides direct liquidity, broad banks monitor and lend the same as in a fully-private banking system. Combing this result with Proposition 3 allows us to conclude that deposit-insured banks will monitor the least, and lend the most, if insurance coverage is sufficiently generous. Deposit insurance, even when fairly-priced, lowers banks' cost of funding by the fully-safe liquidity premium and induces more (inefficient) lending compared to uninsured banks.

5.2. Liquidity Creation

Governments providing direct or indirect liquidity face the same constraint that future revenue securing fully-safe deposits cannot exceed tax capacity. Thus, the quantity of fully-safe deposits under the two regimes is the same, equal to an average of $\bar{t}\omega/R_f$ per local market.

Differences emerge between the two regimes with regard to quasi-safe deposits. Under direct liquidity, all broad banks issue quasi-safe deposits. In contrast, Section 3 showed that under sufficiently generous deposit

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[21]See Appendix B for numerical comparative statics of aggregate performance for these two systems.

[22]This qualitative result would hold in more general models where expanding inside equity is increasingly costly due to agency costs or a tax disadvantage.

insurance, only low-cost insured banks issue quasi-safe deposits in excess of insured deposits. For all bank types, insured deposits crowd out quasi-safe deposits, with full crowding out for moderate- and high-cost banks.

Why does a system of direct government liquidity produce the same quantity of fully-safe deposits as under a system of indirect deposit insurance but far more quasi-safe deposits? The intuition is as follows. Note that a government's power to tax allows it to create assets that are default-free in all future states, even the catastrophe state. An uninsured bank, on the other hand, creates quasi-safe assets that are default-free in all states except the catastrophe state. By insuring this bank's deposits, a government starts with a financial structure that produces quasi-safe assets and adds safety in only one additional (catastrophe) state, which is a small amount of safety at the margin. In this sense, government deposit insurance is inefficient relative to direct government liquidity that is produced from scratch outside of the broad banking system and does not replace quasi-safe deposits.

5.3. Welfare

Equation (18) shows that savers' utility under direct liquidity, U^{DL}, exceeds that of a fully-private system when $\eta < \frac{\lambda_f}{R_f}$. Savers benefit by owning fully-safe deposits in narrow banks, in addition to quasi-safe deposits in broad banks as in a fully-private system. These extra fully-safe deposits raise their utility as long as the fully-safe liquidity premium covers the direct costs of taxes needed to finance the government's debt. Krishnamurthy and Vissing-Jorgensen (2012) estimate the convenience yield on Treasury bills to be $\lambda_f = 0.73\%$ while the OECD (2019) estimates the direct cost of tax collection for the U.S. to be $\eta = 0.4\%$.[23] While this figure omits distortive costs of taxation, it does suggest a potential for improving the welfare of savers from direct liquidity issuance.

By contrast, equation (30) shows that saver utility under indirect government liquidity, U^{DI}, is always less than that under a fully-private banking system by the direct cost of taxes needed to finance deposit insurance, $\eta(p_b L_b^+ + p_c \bar{t}\omega)$. Similar to Holmström and Tirole (1998) these direct costs of taxes are state contingent and hence less than those under direct liquidity which requires that taxes finance debt in all states. However, unlike direct liquidity, under deposit insurance savers do not benefit from a fully-safe liquidity premium to offset these tax costs. The intuition for the difference relates to our finding that less total liquidity is produced under deposit insurance: savers hold deposits only in insured banks. Although these deposits are fully-safe, the benefits of the fully-safe liquidity premium accrue to the banks in the form of a lower cost of funding. Savers are left with only the direct costs of taxes financing the deposit insurance.

Because the benefits of the fully-safe liquidity premium accrue to deposit-insured banks, equation (31) shows that bankers' utility under indirect liquidity is strictly higher than bankers' utility in a fully-private system, which Proposition 2 shows equals banker utility under direct liquidity. Hence, $U_b^{DI} > U_b = U_b^{DL}$.

Consequently banks are better off, but savers are likely to be worse off, under indirect liquidity relative to direct liquidity. Which regime is optimal depends on how banker and saver utility is weighted in overall social welfare. A social planner may prefer an interior solution that blends both direct and indirect liquidity, the topic of the next section.

6. Analysis of a Hybrid System

In most economies, governments directly issue debt and also insure bank deposits, perhaps because some insurance is necessary to avoid bank runs. Moreover, some governments, such as the U.S., insure the debt of government-sponsored enterprises (GSEs) that make loans and issue liquid debt.[24] Hence, this section analyzes a more realistic 'Hybrid' model with both direct- and indirect-liquidity. The tilde notation indicates variables for this hybrid system.

The government is assumed to provide direct liquidity by selling Treasury securities of amount $\tilde{\gamma}^d < \gamma^d$ to each market's narrow bank and also offer limited deposit insurance coverage, $\tilde{\gamma}^r$, to each market's loan-making 'broad' bank. Equating the government's maximum liability to tax capacity, the maximum level of

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[23] Equals the tax administration's operating cost per revenue collected (OECD (2019) Annex A Table D3).

[24] These GSEs might be considered to be 'shadow banks' and include mortgage lenders Fannie Mae and Freddie Mac, as well as the Federal Home Loan Banks which lend to banks.

deposit insurance, $\tilde{\gamma}^r$, must satisfy

$$L(\tilde{\gamma}^r) + \tilde{\gamma}^d R_f = \bar{t}\omega, \tag{32}$$

where $L(\cdot)$ is the total liability of the insurer in the catastrophe state given by equation (25) but where the integration limits reference the hybrid case and will be discussed below.

6.1. Insured Bank Behavior and Profits

Let us consider the change in insured bank behavior as a government starts from the system of only deposit-insured banks analyzed in Section 4 and gradually increases direct liquidity. Equation (32) indicates that an increase in $\tilde{\gamma}^d$ above zero must lead to a decline in deposit insurance coverage relative to the system with only deposit-insured banks; that is, $\tilde{\gamma}^r < \gamma^r$. Recall that deposit-insured banks can be classified by their cost of monitoring as high-, moderate-, and low-cost. Let us discuss the reaction of each of these three types of bank.

Starting from the system of generous deposit insurance coverage analyzed in Section 4, high-cost banks which do not monitor initially respond to a decline in $\tilde{\gamma}^r$ by issuing more uninsured deposits at the higher funding cost of R_r, which leads to a reduction in their profits, $\tilde{\pi}_0^{DI} < \pi_0^{DI}$. With a further rise (*fall*) in direct liquidity (*insurance coverage*), eventually the bank's promised payment on insured deposits plus its fair insurance premium falls below the bad state recovery value: $\tilde{\gamma}^r R_f (1 + \phi) < (1 + k)d_0$. Appendix A.5 shows that the bank reacts to minimize its loss of profits by issuing some quasi-safe senior deposits along with risky junior deposits and pays a fair insurance premium of $\phi_1 = p_c/(1 - p_c)$.

The effect of greater direct liquidity on low-cost banks which limit leverage and monitor is that they also issue fewer insured deposits and more quasi-safe deposits. Since the cost of quasi-safe deposits, R_q, exceeds that of fully-safe insured deposits, R_f, these banks have declines in profits and in the maximum leverage that preserves monitoring $\tilde{\gamma}_{1,L}^{DI} < \gamma_{1,L}^{DI}$.

Moderate-cost banks, defined as restricting their insured deposits to below the insurance limit, are not affected at the margin as direct liquidity increases and $\tilde{\gamma}^r$ declines. Since a reduction in $\tilde{\gamma}^r$ leaves the profits of moderate-cost banks unchanged but reduces the profits of high-cost banks, it follows that the cost threshold determining whether banks choose to monitor must initially rise relative to the system with only deposit-insured banks: $\tilde{c}_{DI}^* > c_{DI}^*$.

However, reduced insurance coverage causes some moderate-cost banks to switch to low-cost banks and issue both insured and quasi-safe deposits, implying that the cost threshold separating these banks increases with greater direct liquidity: $\tilde{c}^m > c^m$. Eventually, further declines in coverage imply that no moderate-cost banks exist. Once this happens, the bank that is just indifferent as to whether it should monitor will choose between being a low-cost or high-cost bank, both of which are experiencing profit declines with less insurance coverage.

Consistent with Proposition 3, once insurance coverage is insufficiently generous, a further decline in coverage can cause low-cost bank profits to fall more than high-cost bank profits, leading low-cost banks to switch to high-cost banks; that is, $\tilde{c}_{DI}^*$ declines and fewer banks monitor. Hence, declines in insurance coverage can lead to a non-monotonic relationship in the proportion of banks that monitor.

6.2. Lending and Liquidity Creation

As was just discussed, initial declines in insurance coverage lead to fewer high-cost banks which do not monitor. But once deposit insurance is insufficiently generous and no moderate-cost banks exist, further declines can increase the proportion of high-cost banks. Since these banks choose maximum leverage, the total volume of lending initially declines but later rises. Hence, the non-monotonic relationship between insurance coverage and monitoring leads to an inverse non-monotonic relationship between insurance coverage and total lending.

The quantity of fully-safe deposits under a hybrid system, equal to sum of narrow bank deposits plus deposits covered by government insurance, is the same as that under systems of pure deposit insurance or pure direct liquidity since each system's fully-safe assets are limited by the same government tax capacity, $\bar{t}\omega$. However, the quantity of quasi-safe deposits rises under a hybrid system as direct liquidity increases. The reason is due to the increase in quasi-safe deposits issued by high-cost and low-cost banks, and fewer moderate-cost banks that do not issue quasi-safe deposits.

6.3. Utility

As discussed in Section 6.1, bank profits for all types of banks decline in a hybrid system relative to those under a system with only deposit insurance and no direct liquidity. Banker utility, $\tilde{U}_b$, aggregates these profits and takes the form of equation (31) except that variables and integration limits now refer to the hybrid case. Utility is intermediate between the fully-private case and the pure deposit insurance case and declines as banks lose insured deposits as their lowest cost source of funding.

Saver utility under the hybrid system equals that of a fully-private system, U, plus the following three components. First, based on the analysis of Section 3.2, utility rises from savers' additional holdings of fully-safe direct liquidity (narrow bank deposits) but declines by the amount of taxes needed to finance this liquidity, resulting in a net utility gain equal to the fully-safe direct liquidity premium, $\tilde{\gamma}^d \lambda_f$. Second, the analysis of Section 4.6 shows that savers' holdings of insured deposits represents a zero net utility gain because their fully-safe liquidity premium raises bankers' profits and the fair premiums and taxes needed to insure these deposits have a net zero value. Third, savers' utility is reduced by the direct costs of taxes whenever net taxes are positive in each of the three states. Net taxes in the good, bad, and catastrophe states can be written as $[\tilde{\gamma}^d R_f + L_g]$, $[\tilde{\gamma}^d R_f + L_b]$, and $\bar{t}\omega$, respectively, where L_g and L_b represent the government's net deposit insurance liability in the good and bad states, respectively.[25] Combining these three components, the utility of savers equals

$$\tilde{U} = U + \tilde{\gamma}^d \lambda_f - \eta \left(p_g [\tilde{\gamma}^d R_f + L_g]^+ + p_b [\tilde{\gamma}^d R_f + L_b]^+ + p_c \bar{t}\omega \right). \tag{33}$$

In summary, a hybrid system generalizes the extremes of pure direct liquidity and pure deposit insurance systems. Not surprisingly, the implications of this more realistic system regarding total liquidity, lending, lending efficiency, and utility are intermediate between the two polar systems.

6.4. Hybrid Illustrations

This section illustrates the hybrid regime using parameter values reported in Table 1. The fully-safe return is 1.01, the expected quasi-safe return is 1.02, and the expected risky return is 1.03, which implies a liquidity premium of 100 basis points for each increase in safety. The promised loan return is assumed to be 1.15, and the probabilities of the good, bad, and catastrophe states are 90%, 9%, and 1%, respectively. Banker capital per unit of market savings, k, is set at 10%. For banks that monitor, the return in the default state, d_1, is set at $0.8 \times R_l = 0.92$, while the no monitoring effort bank default-state return, d_0, is set at $0.4 \times R_l = 0.46$. The maximum tax rate $\bar{t}$ equals 40% of end-of-period endowment of $\omega = 2$.[26] Finally, the direct cost of tax collection, η, is set at 0.4% based on OECD (2019). We assume that the density of bank monitoring costs is distributed uniform throughout, $f(c_i) = \frac{1}{\bar{c}-\underline{c}}$.

Figure 1 illustrates a series of hybrid systems where the proportion of fully-safe assets in the form of direct liquidity ranges along the horizontal axis from 0 to 100 percent, or equivalently, from a system of 100 percent deposit insurance to a system of 100 percent direct liquidity. The first panel shows that while a pure deposit insurance system has the lowest proportion of monitored loans, the relationship is non-monotonic as it first rises and then falls with increases in direct liquidity. In turn, total lending is highest with 100 percent deposit insurance, but there is a range where total lending rises as direct liquidity increases.

The second panel of Figure 1 shows how greater direct liquidity reduces the effect that deposit insurance has in crowding out private liquidity (quasi-safe assets). However, more direct liquidity increases the direct costs of tax collection needed to finance the government's directly-issued debt. The third panel demonstrates that greater direct liquidity raises saver utility but lowers banker utility (bank profits). As discussed earlier, the benefits of the fully-safe liquidity premium accrue to savers under direct liquidity but to banks under deposit insurance.

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[25]$L_g = -\phi_1 L_1(\tilde{\gamma}^r) - \phi_{01} L_0(\tilde{\gamma}^r)$ equals minus the insurance premiums collected in the good state where L_1 and L_0 are defined in equation (25) but with variables and integration limits referencing the hybrid case. $\phi_{01} = \phi_0$ if, as discussed in Section 6.1, high-cost banks default on insured deposits in the bad state. Otherwise, $\phi_{01} = \phi_1$. If high-cost banks default on insured deposits in the bad state, then L_b is the same as that given in Section 4.6 but with variables and integration limits referencing the hybrid case. Otherwise, $L_b = L_g$.

[26]The assumed endowment leads to a reasonable level of maximum insured deposits, γ^r.

7. Model Robustness

This section discusses the robustness of our model's results to some reasonable changes in assumptions. The model's assumption that bank loans are worthless in the catastrophe state is stark. If, instead, loans have a positive minimum recovery value, a government's deposit insurance losses would be lower and, for a given tax capacity, a government could create more fully-safe deposits under deposit insurance. However, a positive recovery value in the catastrophe state would allow uninsured broad banks to issue fully-safe deposits using a senior-junior deposit tranching structure. As a result, when the maximum fully-safe deposits of narrow banks and broad banks are combined, there would continue to be no difference in the total supply of fully-safe deposits under direct liquidity versus deposit insurance.

The model assumes savers gain utility from holding safe assets, which is a reduced form way of capturing safe assets' money-like transactions benefits. Liquidity premia for fully-safe and quasi-safe deposits are fixed in our model, but one might expect that they decline with the economy's supply of safe deposits. Since we show that the amount of fully-safe deposits is independent of how the government supplies liquidity, the direct effects of fully-safe deposit supply on liquidity premia should not differ across direct liquidity or deposit insurance regimes. Yet because the quantity of quasi-safe deposits are greater under direct liquidity, their liquidity premium would be lower under that regime. Moreover, if quasi-safe and fully-safe deposits are substitute transactions vehicles, the equilibrium fully-safe liquidity premium might also be smaller under direct liquidity.

The greater quantity of quasi-safe assets under direct liquidity raises saver utility in our model. But richer models that incorporate additional frictions can lead to a banking system that over-issues quasi-safe deposits (Gersbach (1998), Hart and Zingales (2011)), creating negative externalities such as fire-sale costs when a crisis occurs (Stein (2012)). When deposits are not fully safe, coordination failures can lead to inefficient bank run equilibria as in Diamond and Dybvig (1983) and Goldstein and Pauzner (2005).

While our model neglects these adverse consequences of quasi-safe deposits, it also does not account for potential costs of government liquidity. It was assumed that a government always respects its limit on tax capacity so that its debt and bank deposit guarantees are fully-safe. But as Reinhart and Rogoff (2009) document, history provides numerous examples of sovereign government defaults. Even without default, government liquidity in the form of deposit insurance may create inefficiencies due to bank risk-shifting.[27] Mitigating this moral hazard may require costly bank regulation. So while we acknowledge that our model misses potential costs of private liquidity, it also neglects other costs of government liquidity. A more complete modeling of these costs is needed to provide a definitive answer to the question of how governments should create liquidity.

8. Conclusions

A financial system's quantity of safe assets (liquidity) is not exogenous, but is still subject to constraints. The amount of liquid liabilities that can be created by private, uninsured banks is limited by their assets' recovery values in bad states of nature. Recovery values can be enhanced if a bank limits its leverage, thereby instilling incentives for it to efficiently monitor borrowers. Alternatively, a private bank can maximize its leverage and not monitor borrowers but create liquid senior deposits using the extra collateral funded by junior debt. This alternative production of liquidity has become increasingly popular with the growth of securitization vehicles that issue senior and junior tranched securities backed by loans. Collateralized loan obligations (CLOs) are just one recent example.

The amount of liquidity provided by a government is limited by its future taxing capacity, since ultimately taxes must fund its liabilities. Importantly, the method that a government uses to create its liquid assets has consequences for private liquidity creation. Government liquidity created via bank deposit insurance crowds out private liquidity but maximizes bank lending due to insured deposits' liquidity premium that reduces banks' cost of funding. However, sufficiently generous deposit insurance can dull loan monitoring incentives.

In contrast, a system where a government creates liquidity by directly issuing its debt avoids crowding out private liquidity and maintains banks' better incentives to monitor loans. Yet since loan-making banks'

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[27]Our model assumes deposit insurance is risk-sensitive and fairly priced. In practice, deposit insurance tends to be risk-insensitive and under-priced, which can worsen risk-shifting incentives.

cost of funding is higher, they do not match the quantity of lending made by government-insured banks. Hence, banker utility is lower under direct government liquidity but savers' utility is likely to be higher because they benefit from the greater liquidity premium of directly held debt.

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