Private Money Creation, Liquidity Crises, and Government Interventions*

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Abstract

We study the joint supply of public and private liquidity. If monitoring low-risk projects is costly, financial intermediaries supply risky securities which are illiquid in bad states of nature, and the economy is vulnerable to liquidity crises. Government interventions in the form of asset purchases and deposit insurance are equivalent (in the sense that they sustain the same equilibrium allocations) and can improve welfare depending on the costs and other limitations on raising taxes. Restricting intermediaries to invest in low-risk projects eliminates liquidity crises but reduces welfare.

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1 Introduction

The 2007-2008 financial crisis has highlighted the existence of two main classes of money-like securities that can provide liquidity services. The first class includes safe financial assets such as Treasury securities, whereas the second class includes several types of liabilities of the so-called shadow banking system. This second group of securities were not completely safe because of a lack of appropriate backing in intermediaries' balance sheets. At the height of the crisis, these securities lost not only value but also the ability to provide liquidity services.

In response to these events, the US government increased the direct supply of public liquidity as well as the support and backing of the liquidity supplied by private intermediaries. The first set of interventions included the asset purchase programs of the Federal Reserve. The second set of interventions included the increase in the deposit insurance limit and the Temporary Liquidity Guarantee Program offered by the Federal Deposit Insurance Corporation (FDIC). In addition, after the crisis, the regulation of financial intermediaries has been made more stringent with the objective of making private intermediaries safe and reduce the likelihood and depth of future crises.

Motivated by these events, this paper uses a general equilibrium model to provide a unifying analysis of the interaction between private and public liquidity and of three key policies implemented in response to the 2007-2008 financial crisis: central bank's asset purchases and expansion of the public liquidity provision, government guarantees of private money, and capital requirements. To clarify the forces behind our results, we make some stark assumptions to keep the model very simple and tractable.

In the model, a financial friction forces agents to use debt securities for transaction purposes. In line with the historical evidence in Gorton (2016), riskless debt in our model (which we refer to as safe assets) always provides liquidity, whereas risky debt (pseudo-safe assets) does so only in normal times, that is, when it is not defaulted on. This is a key distinction with a common approach used in the literature. Motivated by Gorton and Pennacchi (1990), some closely related papers use models in which only risk-free securities provide liquidity (Greenwood, Hanson, and Stein, 2015; Magill, Quinzii, and Rochet, 2016; Stein, 2012).

We focus on three main questions. First, we study whether liquid assets should be supplied by the government or by private financial intermediaries– a classic question

in macroeconomics (Sargent, 2011).[1] Second, if an active role of the government is optimal, we ask how the government should intervene. That is, should the supply of public liquidity be backed by taxes or by a portfolio of private securities held by the central bank? Or perhaps, should the government just provide a guarantee of private money through some form of deposit insurance? Third, if some supply of private money by financial intermediaries is optimal, should the intermediaries be subject to regulation, such as deposit insurance or other restrictions to limit the risk of their liabilities?

Our simple framework gives rise to a rich set of predictions. First, in the *laissez-faire* equilibrium, liquidity crises happen when pseudo-safe securities are defaulted on and thereby lose their liquidity value. Second, if the government faces a limit on taxation, the best policies are those in which government liquidity and government interventions complement the supply of liquidity by private intermediaries. Interestingly, we show that deposit insurance—which supports the value of private securities in crisis times—is equivalent to a policy in which the government backs a large supply of debt by purchasing a portfolio of risky securities. That is, these two policies allow the economy to achieve the same allocation and thus the same welfare. Third, forcing intermediaries to avoid default by investing in low-risk, low-productive projects eliminates liquidity crises but reduces welfare.

Financial intermediaries in our model can supply liquid assets by investing in risky or safe projects. Investment in risky projects allows intermediaries to offer pseudo-safe assets, whereas investments in safe projects allow intermediaries to offer safe assets. However, safe projects are more costly because a fraction of the investment is lost in monitoring and screening projects. As a result, issuing pseudo-safe debt that is subject to default allows financial intermediaries to save on such monitoring costs. The logic is similar to that in Geanakoplos (1997, 2003) in which the possibility of default is a way to economize on scarce and costly collateral.

The monitoring cost creates an incentive for intermediaries to supply pseudo-safe assets. In bad states, these securities default and therefore there is a shortage of liquidity. In addition, depending on the policy and parameters, some safe debt might also be supplied. This debt is always liquid and thus trades at a premium because of the shortage of liquidity in bad states.

The possibility of liquidity crises opens up a role for the government interventions. We study government provision of public liquidity, government guarantees of intermediaries' debt (i.e., deposit insurance), and regulation of intermediaries' investments.

[1] See Aguirre (1985) and Aguirre and Infantino (2013) for a comprehensive review on the debate.

If fiscal capacity is large, government provision of public liquidity improves *laissez-faire* and achieve the first best. In this case, government debt can be backed by taxes. If instead fiscal capacity is limited, the government can purchase pseudo-safe securities created by private intermediaries (either directly or through the central bank) and use them to back its debt. That is, the return received on private pseudo-safe securities provides a stream of revenues, which in turn is used to repay the public debt. In this case, a sufficiently large fiscal capacity is only needed in the bad states in which private debt is defaulted on.

If the limited fiscal capacity is modeled as an upper bound on average taxation, the government can achieve the first best, despite the bound. In contrast, it it is modeled as a state-contingent limit on taxes, the first best cannot be achieved because the tax constraint is binding in the bad state.

Deposit insurance subject to an appropriate fee can also increase welfare. Under this policy, the debt of private intermediaries is riskless and thus provides liquidity even in bad states. The fiscal capacity required to pay for the insurance in bad states is the same as under the policy of government purchases of pseudo-safe securities. This is because the consolidated balance sheet of all the agents that supply liquidity (i.e., government and financial intermediaries) is identical under the two policies. It is thus irrelevant, in the sense of Wallace (1981), whether the government supports liquidity with deposit insurance or direct purchases of pseudo-safe securities.

We then turn to the regulation of financial intermediaries. We study a policy that forces all intermediaries to invest in safe projects in order to avoid default in low states. This policy is a natural candidate in models in which intermediaries issue risky debt and their default reduces the availability of liquid assets. However, we show that this policy always reduces welfare. Our objective is to warn against the negative effects of very aggressive regulation. We argue that this policy can be reinterpreted, in a more general model, as capital requirements like those suggested by Admati and Hellwig (2013) and Kashkari (2016), and that it is not beneficial if equity is costly.

To sum up, our policy analysis suggests that public interventions that complement the supply of private liquidity are beneficial in order to obtain a desired level of liquidity. In contrast, policies that excessively limit intermediaries' risk-taking ability reduce welfare.

1.1 Related literature

Our analysis complements a recent literature that has studied the role of liquidity in macro models with financial intermediaries. Examples include Bianchi and Bigio (2016), Bigio (2015), Gertler and Kiyotaki (2010), Moreira and Savov (2016), and Quadrini (2014). In Bigio (2015), entrepreneurs obtain liquidity by selling capital, but asymmetric information makes this process costly. In our model, liquidity creation is affected by the monitoring cost in screening safe projects. In Moreira and Savov (2016), the liquidity transformation of the banking sector produces both safe and pseudo-safe securities. However, the main objective of their analysis is to study the macroeconomic consequences of liquidity shortages due to uncertainty shocks. In Quadrini (2014), intermediaries' liabilities play an insurance role for entrepreneurs subject to idiosyncratic productivity shocks.

With respect to the above literature, the novelty of our paper is to analyze the coexistence between private and public liquidity and the advantage of one form of liquidity over the other in terms of efficiency. In this sense, our work is related to the classic debate, in macroeconomics, about the supply of private versus public liquidity (see Sargent, 2011, for a summary). The lack of policy interventions in the *laissez-faire* equilibrium can be reinterpreted as the suggestion of supporters of the free banking theory, such as Hayek (1976), which emphasize the benefits of deregulation. The large supply of public liquidity backed by taxes or by a portfolio of private securities is related to the proposals of Friedman (1960), which instead argue that liquidity should be controlled by the government. In addition, the regulation that forces intermediaries to invest in safe projects is akin to the real bills theory, according to which intermediaries should invest only in risk-free assets. More recently, a related paper by Sargent and Wallace (1982) compares the real-bills doctrine with the quantity theory of money in an overlapping generations model.[2] However, the tension they emphasize is between achieving efficiency in the supply of inside money versus stabilizing the price level, and thus their focus differs from ours.

Our paper is also related to the New Monetarist literature which studies liquidity. In our model, agents have quasi-linear preferences and have periodic access to a centralized market with no frictions, as in Lagos and Wright (2005). Our key contribution is the endogenous relative supply of safe and pseudo-safe private money in an environment with aggregate risk, and the policy analysis that arises in this framework. Some papers like Geromichalos et al. (2007) and Lagos and Rocheteau (2008)

[2]Bullard and Smith (2003) also use an overlapping generations model to study the role of outside and inside money in achieving efficiency.

implicitly incorporate private money by allowing physical capital to be used for transactions, but they do not include risk, whereas Lagos (2010) includes aggregate risk but his focus is on the equity premium puzzles and other asset pricing implications. Williamson (2012) studies the coexistence between public liquidity and private money issued by intermediaries. In his model, aggregate risk is absent and idiosyncratic risk can be diversified away, so that intermediaries are always solvent even if they issue no equity and their private money is riskless. In contrast, we include aggregate risk and intermediaries' default, which produce non-negligible interactions with the riskiness and liquidity of private money combined with policy.[3] Rocheteau (2011) includes different types of private money in his model, but their supply is exogenous and his focus is on adverse selection problems. Andolfatto et al. (2016) analyze a model in which intermediaries use physical capital to back the issuance of claims that are always liquid. Their objective is to study the optimal rate of inflation, and thus their focus differs from ours.

The banking literature is rich with models that analyze liquidity creation in the spirit of the seminal contribution of Gorton and Pennacchi (1990).[4] The closest papers are Greenwood, Hanson, and Stein (2015) and Magill, Quinzii, and Rochet (2016). These works assume that liquidity services are provided only by risk-free securities, whereas in our framework, risky securities can also be liquid. As a result, our model can study the determination of the liquidity and risk properties of private debt jointly as a function of the characteristics of financial intermediaries and the policy environment. In addition, there are some other important differences with respect to the above two papers.

In Magill, Quinzii, and Rochet (2016), only private debt can provide liquidity services and, therefore, the focus of their analysis is to study how government policies can enhance the supply of private liquidity. In our model, instead, government debt also has liquidity value. Despite these differences, both models predict that the central bank can achieve the first best by issuing safe securities and backing them by purchasing risky assets. In our model, this is a consequence of the direct liquidity role of public debt, whereas in their context it is a way to increase the funds channeled to investments.

In Greenwood, Hanson, and Stein (2015), government short-term debt has liq-

[3]The model of Williamson (2012) is richer than ours in other dimensions that we abstract from. He studies banks as providers of liquidity risk in the spirit of Diamond and Dybvig (1983), the usage of money for illegal activities, and the implications for optimal inflation.

[4]See also Dang et al. (2017) and Gu et al. (2013) for other approaches in which banks that supply safe, liquid assets emerge endogenously.

uidity value, whereas long-term debt does not; however, short-term debt entails refinancing risk. Nevertheless, tilting the maturity structure by overissuing short-term government debt is optimal. More short-term government debt lowers the liquidity premium on liquid assets, which in turn reduces a fire-sale externality related to private money creation.[5] We instead consider a broader set of government policies: provision of public liquidity backed by the central bank's earnings on its portfolio of assets, government guarantees of private money, and regulation of intermediaries' investments.

Some recent papers that study the structure of the financial sector assume that risky debt can have a liquidity premium, similar to our model, but they abstract from public liquidity. In Gennaioli et al. (2012), investors perceive debt to be risk free because of a behavioral assumption. In Gale and Gottardi (2017) and Gale and Yorulmazer (2016), intermediaries' liquidity creation trades off the benefit of a liquidity premium on deposits with costs of default.

Finally, our work is also motivated by the recent literature spurred by the work of Caballero (2006) which emphasizes the shortage of safe assets as a key determinant of the imbalances of the global economy. Examples include Caballero and Farhi (2016), Caballero and Simsek (2017), and Farhi and Maggiori (2016). As in Caballero and Farhi (2016), we stress the importance of fiscal capacity for the supply of safe government securities and, in general, the role of other forms of backing (assets, equity) as the primary source of liquidity creation.

The rest of this paper is organized as follows. Section 2 presents the model. Sections 3 and Section 4 discuss the equilibrium with costless and costly risk-free investments, respectively, and Section 5 discusses the effects of government intervention. Section 6 concludes.

2 Model

We present a simple two-period general equilibrium model in which we show all our results analytically. The economy features three sets of actors: households, financial intermediaries, and government.

At time 0, households can invest their wealth in three types of securities: safe private debt issued by intermediaries that invest in safe projects, pseudo-safe private debt issued by intermediaries that invest in risky projects, and government debt.

[5]Woodford (2016) also argues that quantitative-easing policies can mitigate incentives for risk taking of private intermediaries by reducing the liquidity premia in the economy.

At time 1, there are two states of nature: the high state denoted with h, that occurs with probability $1-\pi$, and the low state denoted by l, that occurs with probability π, with $0 < \pi < 1$. Private safe debt issued at time 0 is backed by safe, risk-free investments and never defaulted. Pseudo-safe debt is instead backed by risky investments which completely lose their value in the low state. Therefore, pseudo-safe securities are fully defaulted on in the low state. In contrast, government debt is always safe.

At time 1, part of the consumption expenditure of households must be financed with debt securities. That is, households are subject to a liquidity constraint, and liquidity services are provided by the debt securities purchased at $t = 0$. Since pseudo-safe securities are fully defaulted on in the low state, they do not provide any liquidity service in that state.

Our model focuses on the role played by liquidity in facilitating households' consumption. In this sense, we follow the tradition of many papers that study liquidity as a mean to finance households' consumption, such as Diamond and Dybvig (1983), Gorton and Pennacchi (1990), Lagos and Wright (2005), and Lucas and Stokey (1987). We follow this approach to keep the model simple and tractable, even though we could reformulate our results in a more general framework. For instance, we could use the approach of liquidity-in-the utility function, similar to Krishnamurthy and Vissing-Jorgensen (2012), Nagel (2016), and Stein (2012), which would capture a more general role for liquidity beyond that of facilitating transactions. We could also assume that liquidity is used by firms to finance their production process before output is produced and sold, as in Bigio (2015) and Jermann and Quadrini (2012). However, we believe that our approach is the simplest and most transparent way to deliver our results, whereas these alternative frameworks would complicate the analysis without altering the main message of the paper.

We now turn to the description of the agents that live in the economy and their choices.

2.1 Households

Households have the following preferences:

$$X + (1-\pi)\left[\ln C_h + X_h\right] + \pi\left[\ln C_l + X_l\right], \tag{1}$$

where X denotes consumption at time 0. At time 1 households consume two goods, and the consumption is possibly contingent on the realization of the aggregate state:

C_h and C_l for the first good, and X_h and X_l for the second good. Consumption of C_h and C_l are subject to a liquidity constraint, as we discussed below, whereas consumption of X_h and X_l are not, similar to Lucas and Stokey (1987).[6]

At time 0, households face the following budget constraint:

$$Q^B B + Q^S S + Q^D D + X \leq \bar{Y} + Q^B \bar{B}. \tag{2}$$

Households have an endowment $\bar{Y}$ of goods, begin time 0 with government bonds $\bar{B}$, which they can trade at price Q^B. They can use these resources to consume X or to invest in a portfolio of securities which includes government bonds B, traded at price Q^B, safe private securities S, issued by the intermediaries at price Q^S, and pseudo-safe private securities D, issued by intermediaries at price Q^D.

We model government debt, safe debt, and pseudo-safe debt as zero-coupon securities with a face value of one. Government debt and private safe securities are risk-free and thus pay one unit in both the high and low state. On the contrary pseudo-safe securities are risky. Their payoff is one in state h and zero in state l, because they are fully defaulted in state l.

At time 1, consumption C_h and C_l must be financed with the debt securities purchased at $t = 0$. Safe debt always provides liquidity services, whereas pseudo-safe debt provides liquidity only in state h. Therefore, purchases of C_h and C_l are subject to the following liquidity constraints

$$C_h \leq B + S + D \tag{3}$$

because all three securities are fully repaid in state h, and

$$C_l \leq B + S \tag{4}$$

because securities D are fully defaulted on in state l and therefore do not provide any value to be used in exchange of goods.[7] Consumption of goods X_h and X_l in period 1 are subject to the following budget constraints

$$X_h \leq B + S + D + \Pi_h - C_h - T_h \tag{5}$$

$$X_l \leq B + S + \Pi_l - C_l - T_l \tag{6}$$

[6]We use quasi-linear preferences at $t = 1$, following the approach of Lagos and Wright (2005).

[7]We assume that B provides liquidity services, in line with the empirical evidence of Krishnamurthy and Vissing-Jorgensen (2012), who document a positive liquidity premium on government debt. Moreover, our assumption of perfect substitution between B and non-defaulted private intermediaries' debt is motivated by the results of Nagel (2014), who estimates a high elasticity of substitution between public and private liquidity.

in state h and l respectively in which T_h and T_l are state-contingent lump-sum taxes and Π_h, Π_l state-contingent intermediaries' aggregate profits.[8]

It is worth emphasizing that constraints (3) and (4) capture the special properties that some debt securities have in the modern financial system due to the liquidity services they provide. These securities have been broadly labeled "safe assets," and a recent literature has modeled them as riskless (see, among others, Caballero and Fahri, 2016; Fahri and Maggiori, 2016; Diamond, 2016; Li, 2017; Magill, Quinzii, and Rochet, 2016; Stein, 2012; Woodford, 2016). However, as discussed by Gorton (2016), the historical evidence shows that debt securities that provide liquidity services are not necessarily risk free. We capture this fact by allowing risky debt securities (i.e., pseudo-safe assets) to provide liquidity services as long as they are not in default. In some countries such as the U.S. and the U.K., these risky and liquid securities have been issued by private intermediaries, whereas government debt has been essentially risk free. Moreover, throughout the history of financial systems, these private debt securities have taken the form of goldsmith notes, bills of exchange, bank notes, demand deposits, certificates of deposit, commercial paper, money market mutual fund shares, and securitized AAA debt.[9]

Consumption and portfolio choices follows from the maximization of (1) under the constraints (2), (3), (4), (5), (6).

The optimal consumption of C_h and C_l are given by

$$C_h = \frac{1}{1+\mu_h} \qquad C_l = \frac{1}{1+\mu_l}, \tag{7}$$

respectively, where μ_h and μ_l are the Lagrange multipliers associated with the liquidity constraints (3) and (4). Since $\mu_h, \mu_l \geq 0$, it follows that $C_h, C_l \leq 1$ and, thus, $C_h = C_l = 1$ at the first best. The first-best allocation follows from the fact that the marginal utility of consumption of both X_h and X_l is one, whereas the marginal utility of consumption of C_h and C_l is $1/C_h$ or $1/C_l$, respectively.

To conclude the characterization of the household's problem, we derive the demand for government debt and intermediaries' debt. This demand is affected by the

[8]We allow X_h and X_l to be negative, and thus they can be reinterpreted as consumption net of labor supply. It is possibly to extend the model so that X_h and X_l are positive. For instance, in an infinite-horizon formulation, households would get an endowment of goods every period (i.e., not only in period 0, but also in period 1) and this endowment could be used to finance the consumption of X_h and X_l.

[9]Some recent changes in the money market mutual funds (MMMFs) industry are in line with the structure of our model in which debt securities have a special liquidity role. Chen et al. (2017) document a large drop in the demand for some classes of MMMFs (i.e., prime and muni institutional MMMFs) that must now compute their net asset values based on market valuations, rather than keeping them fixed at \$1 per share.

liquidity value provided by these assets, captured by the Lagrange multiplier μ :

$$Q^B = Q^S = 1 + (1-\pi)\mu_h + \pi\mu_l, \tag{8}$$

$$Q^D = (1-\pi)(1+\mu_h). \tag{9}$$

Private debt D provides liquidity services only in state h when it is not defaulted. An implication of (8) and (9) is that $Q^B = Q^S \geq Q^D$. Crucially, liquidity services provide benefits not only to households but also to the issuer of the debt security because they lower borrowing costs. We return to this point later in the analysis.

2.2 Financial intermediaries

There is an infinite number of small financial intermediaries that can choose the type of debt security, safe or pseudo-safe. Since intermediaries are small and thus marginal with respect to the supply of each market, they take prices Q^S and Q^D as given. Without loss of generality, we assume that each intermediary can supply only one type of security, although a given security can be supplied by infinitely many intermediaries.

Intermediaries can choose which type of capital to invest in. There are two types of capital. A riskless capital which has a unitary payoff in each state of nature but requires an extra investment τ for each unit of capital. This additional cost can be interpreted as a monitoring cost to control the safety of capital, motivated by Diamond (1984). The second type of capital is instead risky and pays $A_h > 1$ in state h and $A_l = 0$ in state l, with a unitary expected payoff, i.e. $(1-\pi)A_h = 1$.

We assume that intermediaries have limited liability in period 1. As a result, they default on their own debt if the payoff of capital is not sufficient to cover the debt obligations.

At time 0, intermediaries that issue safe debt S invest in riskless capital K^S subject to the budget constraint

$$(1+\tau)K^S = Q^S S. \tag{10}$$

At time 1, their profits are not contingent on the realized state of nature and given by

$$\Pi_h^S = \Pi_l^S = K^S - S. \tag{11}$$

Substituting K^S from the budget constraint (10) into (11), the optimal supply of safe debt is positive insofar

$$Q^S \geq (1+\tau),$$

and it is zero otherwise.

Intermediaries issuing pseudo-safe securities D invest in the risky capital subject to the budget constraint

$$K^D = Q^D D. \tag{12}$$

Profits in state h are given by

$$\Pi_h^D = A_h K^D - D.$$

Profits in state l are zero because the payoff of risky capital is zero and debt is fully defaulted, following the limited liability assumption. As a consequence, the supply of pseudo-safe debt is positive insofar as the price satisfies

$$Q^D \geq 1 - \pi$$

and is zero otherwise.

Intermediaries are free to choose in which security market to enter according to the maximum profits that they can obtain. They enter the market of safe securities if the expected profits in that market are higher than those of pseudo-safe securities, and vice versa.

2.3 Government

The government includes both the Treasury and the central bank. For expositional simplicity, here we consider the simple case in which the balance sheet of the government is composed of only liabilities: short-term zero-coupon bonds B, which can be interpreted as Treasury debt or the central bank's reserves. In Section 5, we discuss the case in which the government invests in privately issued securities, possibly through the central bank, and guarantees the debt issued by private intermediaries.

The liabilities of the government, B, are free of risk because the government raises enough taxes to back them. An alternative interpretation can be given if we extend the analysis to a monetary economy with a constant price level in which government debt is backed by central bank's liabilities. Indeed, central bank liabilities define the unit of account for the monetary system and are thus free of risk by definition; that is, the central bank can repay its liabilities by "printing" new reserves.[10]

At time 0, the government maintains constant the initial level of debt, that is $B = \bar{B}$. At time 1, the outstanding level of debt is paid by taxes, $B = T_h$ in the high state and $B = T_l$ in the low state.

[10]See Woodford (2000, 2001).

In the analysis of the equilibrium with no policy interventions (Sections 3 and 4), we assume that the government has no limit or restrictions on taxation and thus can fully repay any outstanding level of debt. When we analyze government policies in Section 5, we instead introduce some limit on taxation, altough we will continue to assume that the government can fully repay its initial stock of debt $\bar{B}$.

3 Equilibrium with no monitoring costs

We now solve for the equilibrium in the benchmark scenario in which there are no monitoring costs to invest in risk-free projects, that is, $\tau = 0$. We also assume that the government has no limits or restrictions on taxation and thus can fully repay its debt $\bar{B}$. As a result, the only friction is the liquidity constraint. In this case the first best can be achieved through either private or public liquidity.

To solve for the equilibrium, we first note that free entry abates to zero all profits and implies that the supply of safe and pseudo-safe debt is positive at their respective prices

$$Q^S = (1 + \tau), \tag{13}$$

$$Q^D = 1 - \pi. \tag{14}$$

The next proposition shows that in equilibrium safe securities are supplied in an enough quantity to satiate the market of liquidity.

Proposition 1 *In the model with no monitoring costs ($\tau = 0$), there is complete satiation of liquidity, $\mu_h = \mu_l = 0$, and consumption is at the first best, $C_h = C_l = 1$. The quantity of financial intermediaries' safe debt is given by*

$$S \geq \max(1 - B, 0), \tag{15}$$

which is issued at the price $Q^S = 1$.

The economy achieves the first best because the supply of safe assets is sufficiently large. This can be achieved in two ways. If $B \geq 1$, the government achieves the first best by supplying a large quantity of public liquidity, which can be interpreted as a way to implement the Friedman rule. If instead $B < 1$, private money issued by intermediaries is crucial to complement the supply of public liquidity and achieve the first best. We elaborate more on the second case.

When $B < 1$, the efficiency result of Proposition 1 is a direct implication of the competition mechanism of the model, which allows financial intermediaries to decide

the type of money to supply. To understand this point and prove the proposition, suppose by contradiction that there is no supply of safe debt. Instead, assume that intermediaries only provide pseudo-safe assets. As a result, in the low state, pseudo-safe securities default and thus consumption can be financed with public liquidity only. Using (4) and (7), the Lagrange multiplier of the liquidity constraint in the low state is positive,

$$\mu_l = \frac{1}{B} - 1 > 0,$$

and thus there is a shortage of liquidity in that state. In contrast, equilibrium in the supply and demand of pseudo-safe securities, which require both (14) and (9) to hold, implies that the Lagrange multiplier of the liquidity constraint is zero in the high state, $\mu_h = 0$. That is, the supply of pseudo-safe assets is large enough to satiate liquidity needs in the high state, and thus there is no shortage of liquidity in that state. Now consider a generic intermediary deciding which security to issue. Suppose that the intermediary chooses to issue safe debt, which never defaults. Consumers attach a high value to safe securities because the liquidity premium in the low state is positive; this high value is reflected in the price $Q^S = (1 + \pi\mu_l)$ that they are willing to pay. The high Q^S implies that the intermediary can borrow at a lower cost and, thus, its profits are positive in both states: $\Pi_h^S = \Pi_l^S = \pi\mu_l > 0$. Thus, issuing safe securities S is profitable. This result contradicts the initial conjecture that there exists an equilibrium in which safe debt is not supplied by any intermediary.

To sum up, intermediaries supply safe private securities up to the point at which the liquidity premium is driven to zero in all states, $\mu_h = \mu_l = 0$. That is, free entry into the market ensures that all rents are eliminated. The supply of safe securities is enough to complement the amount of public liquidity (as described by (15)) and reach efficiency, $C_h = C_l = 1$. Moreover, the supply of pseudo-safe securities can be positive in equilibrium and their price is just given by the present discounted value of their expected payoffs. However, the supply of these assets is irrelevant for welfare.

We close this section by comparing Proposition 1 with some related literature that studies liquidity. In versions of the Lagos and Wright (2005) model in which physical capital can be used for payment (e.g., Geromichalos et al., 2007; Lagos, 2010; and Lagos and Rocheteau, 2008), a sufficiently large supply of capital satiates the demand for liquidity. The result of Proposition 1 is similar in spirit. Even though capital does not provide liquidity directly in our model, it is used by intermediaries to back their supply of private money. In equilibrium, intermediaries choose to hold a sufficiently large quantity of capital as backing and thus can issue enough private money to

satiate the demand for liquidity. Thus, the key difference with this literature is that intermediaries endogenously choose the amount of capital that is used as backing and the riskiness of private money. This result reflects the similarities between our approach and that of Geanakoplos and Zame (2002, 2014) because the physical capital held by intermediaries in our model serves the same role as collateral in their model.

3.1 Discussion

The results of the model with costless monitoring ($\tau = 0$) are in line with the view of Hayek (1974) and Friedman (1960).

In Hayek (1974), the process of competition leads the private sector to supply a sufficiently large quantity of the best available type of liquid assets, namely, safe assets. The competitive market structure in our model is indeed in the spirit of Hayek's (1974, p. 43).[11] If safe securities were not provided, households would attach a premium to them because such securities relax the liquidity constraint during crises (i.e., when the low state in the model realizes). Therefore, intermediaries would find it convenient to supply safe debt because the premium paid by households reduces intermediaries' financing costs. Free entry then ensures that there are enough safe securities so that the households' liquidity constraint is never binding. As a result, the interest of households is perfectly aligned with that of financial intermediaries. Indeed, the premium on safe assets, which reflects a lack of liquidity from the society's point of view, creates incentives for profit-maximizing intermediaries to supply safe securities. To this end, intermediaries will raise enough equity to absorb any loss they can incur on their risky assets.

Unfettered competition achieves efficiency without the need for any type of regulation, in contrast with the real-bills doctrine. Intermediaries should not be restricted to hold safe, but illiquid assets. They optimally choose to do so.[12]

Friedman (1960)'s proposal can also achieve the first best. According to this view, the government should have the monopoly power in the supply of liquidity. This objective can be reached if the government passes regulation to achieve a narrow banking system; that is, intermediaries are forced to satisfy a 100% reserve requirement. In the context of our model, intermediaries would buy government safe debt B instead of capital, so the budget constraint (10) would be replaced by $Q^B B = Q^S S$. If this

[11] See also Hayek (1948, ch. V) for a critical analysis of the assumption of perfect competition.

[12] Were risky assets only available, competition would force intermediaries to raise enough equity to absorb any possible loss. As a result, the supply of private money would be safe also in this context.

were the case, private intermediaries would not perform any liquidity creation, because their debt would be backed by liquid government reserves, instead of illiquid safe securities. As a result, the overall supply of liquid assets in the economy would be determined solely by the amount of government debt, B. Note that in turn the government has to back its debt and interest payments, which is achieved by collecting taxes (in Section 5, we explore an additional approach to provide backing, based on the active management of the central bank's balance sheet). A benevolent government that implements a narrow banking system can nevertheless achieve the first best, by setting taxes $T \geq 1$, so that government debt is in the amount $B \geq 1$. However, if the government is not benevolent, it would be in its own self-interest to reduce liquidity in order to drive up the liquidity premium and obtain rents.

4 Equilibrium in the full model with monitoring costs

We now turn to the analysis of the full model in which intermediaries face a positive monitoring costs to invest in risk-free projects, $\tau > 0$. We also maintain the assumption, discussed in Section 2.3, that the government can fully repay its initial debt $\bar{B}$ because it does not face any limit on taxes.

The main result of this more general framework is that pseudo-safe securities—those that default and lose liquidity in the low state—are now supplied by intermediaries and, thus, the amount of privately issued liquidity is lower than in the baseline model with no monitoring costs. In addition, depending on policies and parameters, pseudo-safe and safe debt can coexist in equilibrium; when that is the case, some intermediaries supply pseudo-safe debt, whereas others supply safe debt, even though these intermediaries are ex ante identical.

We present the results in two steps. We first show that the equilibrium must be characterized by a positive supply of pseudo-safe assets, and then we characterize the full equilibrium.

Proposition 2 *Assume that financial intermediaries face a per-unit cost $\tau > 0$ to monitor safe capital. If there exists an equilibrium in which intermediaries supply debt securities, then there must be a positive supply of pseudo-safe debt securities, that is, $D > 0$.*

If there exists an equilibrium in which intermediaries are active and issue debt, there are three possible scenarios: either all intermediaries issue safe debt, or all

intermediaries issue pseudo-safe debt, or some intermediaries issue safe debt and some others issue pseudo-safe debt. Thus, we can prove Proposition 2 by showing that the scenario in which all intermediaries issue only safe debt S is not an equilibrium. We proceed by contradiction. Suppose that all intermediaries issue safe debt in equilibrium. In this case, equating demand (8) and supply (13) it follows that $\mu_h = \mu_l = \tau > 0$. To offset the monitoring cost, the liquidity premium on safe debt must be positive – if the liquidity premium were zero, intermediaries would make negative profits because of the cost τ. Note that a positive liquidity premium is associated with a level of consumption below the first best in some state. Furthermore, the fact that there are only safe securities which are equally liquid in both states implies that consumption is equalized across states. Therefore, $C_h = C_l < 1$; in particular, it is crucial that $C_h < 1$, so that, using (7), the Lagrange multiplier of the liquidity constraint in state h is also positive: $\mu_h > 0$. We can now identify a profitable deviation which leads us to conclude that the scenario with only safe debt cannot be an equilibrium. Given $\mu_h > 0$, households are willing to pay a liquidity premium on a security that relaxes the liquidity constraint (3) in the high state. Now consider an intermediary that issues a pseudo-safe debt D. This intermediary earns positive profits in the high state (and zero profits in the low state) because pseudo-safe securities include a liquidity premium:

$$\Pi_h^D = \mu_h D > 0. \tag{16}$$

Thus, the intermediary has an incentive to deviate and issue pseudo-safe debt.

More generally, the previous analysis can be extended to show that any scenario in which $\mu_h > 0$ cannot be an equilibrium because there would exist profitable deviations to increase the supply of pseudo-safe securities. Thus, the Lagrange multiplier in the high state must be zero in equilibrium, $\mu_h = 0$.

We now characterize the full equilibrium. We focus on the case in which the government issues a limited amount of public liquidity (i.e., $B < 1$), and we return to the analysis of government policy in Section 5.

Proposition 3 *If financial intermediaries face a per-unit cost $\tau > 0$ to monitor safe capital and the government issues debt $B < 1$, then:*

1. *In the high state, there is full satiation of liquidity and thus $C_h = 1$ and $\mu_h = 0$, whereas in the low state*

$$C_l = \max\left\{\frac{\pi}{\pi+\tau}, B\right\} < 1 \quad \textit{and} \quad \mu_l = \min\left\{\frac{\tau}{\pi}, \frac{1}{B} - 1\right\}$$

2. *The prices and supply of safe securities are*

$$Q^S = (1 + \pi\mu_l) > 1, \quad S = \max\left(\frac{\pi}{\pi + \tau} - B, 0\right)$$

and the price and supply of pseudo-safe securities are

$$Q^D = (1 - \pi) < 1, \quad D \geq 1 - B - S > 0.$$

3. *The government imposes taxes* $T_h = T_l = B$ *at* $t = 1$.

As an implication of Proposition 2, the equilibrium displays a positive supply of pseudo-safe securities. Note, however, that there is room for safe debt to be supplied in equilibrium, in addition to pseudo-safe debt. Indeed, with pseudo-safe debt, liquidity is lower in the low state in comparison to the high state. As a result, securities that provide liquidity in the low state will trade at a premium. If this premium is large enough to cover the cost τ, intermediaries issue safe securities. Whether the premium on safe intermediaries' debt is large or not depends in turn on the amount of public liquidity. A large supply of public liquidity implies a low liquidity premium on safe debt (recall that public liquidity is risk free); thus, issuing safe debt is not profitable for intermediaries. That is, a sufficiently high level of public debt crowds out the production of privately issued safe money by influencing the liquidity premium on default-free obligations. In contrast, a low supply of public liquidity creates a profitable opportunity for intermediaries to issue some safe debt.

Proposition 3 has implications for characterizing how a liquidity crunch occurs in our model. This happens in the low state because pseudo-safe securities do not have appropriate backing in that state and, thus, lose their liquidity value. Since there is a shortage of the only assets that are liquid in the low state (i.e., safe assets), the demand for goods C_l drops because of the liquidity constraint (4), and thus consumption C_l decreases too.

We conclude with a brief comparison with the literature that studies the liquidity of private money and crises, such as Lester et al. (2012), Li et al. (2012), Rocheteau (2011), and Williamson (2012). In these papers, policy and financial frictions have an impact on liquidity, as in our model. However, their results are mostly derived in frameworks with no aggregate risk, and in which private money is either riskless or has exogenous risk. The novelty of Proposition 3 is related to the the endogenous composition of the stock of private money as a function of policy and parameters. That is, the stock of private money includes only pseudo-safe assets if B is sufficiently large, or both safe and pseudo-safe assets if B is small.

5 Government intervention

The possibility of liquidity crises that arise in the *laissez-faire* equilibrium opens up a possible role for government intervention. The amount of liquidity is large enough only in the high state, whereas the economy experiences a liquidity crunch in the low state.

We study general government policies related to debt issuance, real taxes, and the active management of the balance sheet of the central bank. Our model points out that the origin of a liquidity crisis is in the insufficient backing of private securities, which are defaulted on in bad states. We argue that the first best can be reestablished by offsetting the lack of private backing in bad times with government backing.

As a first step, we consider a large supply of public liquidity backed by higher taxes at all times. This intervention entirely crowds out the production of safe private debt but nonetheless achieves efficiency. However, it is not feasible if there are costs associated with or limits on taxation.

We then present two policies that implement the first best even if the government faces a limit on average taxation: asset purchases by the central bank, and actuarially-fair deposit insurance. These policies exploit the backing provided by intermediaries in good times and, thus, require government backing only in bad times. In our two-period model, the government must increase taxes in bad times. If instead we extend the analysis to an infinite-horizon model, the government could increase either taxes or debt in bad times. In other words, government backing in bad times can be provided by higher current taxes or by higher debt to be repaid with higher future taxes. In all cases, the present discounted value of taxes must increase in bad times.

Crucially, asset purchases and deposit insurance are equivalent, in the spirit of Wallace (1981). That is, the path of taxes required under the two policies is identical, because the consolidated balance sheet of the government and private intermediaries (i.e., of all the agents that supply liquidity) is identical under the two policies.

If we instead impose a more stringent limit on taxes in low states, government policies do not implement the first best, but they might nonetheless improve welfare. The equivalence between asset purchases and deposit insurance extends to this case. Interestingly, if the government uses deposit insurance, the equilibrium is characterized by a coexistence of government debt, pseudo-safe debt issued by uninsured intermediaries and subject to default, insured debt issued by intermediaries that invest in risky projects, and, possibly, safe debt issued by uninsured intermediaries. The coexistence of insured and uninsured intermediaries in the model resembles the

coexistence of regulated commercial banks and unregulated shadow banks in practice.

Finally, we study a regulation that forces all intermediaries to invest in safe projects. This policy reduces welfare because issuing pseudo-safe securities backed by investments in risky projects allow intermediaries to economize on the monitoring cost.

Overall, our policy analysis suggests that the best policies are those that complement private liquidity with either public liquidity or public support of private liquidity, whereas extreme form of regulation of intermediaries' investments are not beneficial.

5.1 Optimal government policy with no limit on taxes

This section characterizes the optimal government policy when there is no limit on the ability to raise lump-sum taxes. The optimal policy requires that the government issues a large supply of public debt B and, thus, imposes large taxes T_h and T_l at $t = 1$ to back the debt. As a result, households can attain the first-best level of consumption using public liquidity only. The next proposition formalizes this result.

Proposition 4 *If financial intermediaries face a per-unit cost $\tau > 0$ of monitoring safe capital, the optimal government policy is to set $B \geq 1$, achieving the first best.*

With no limit on lump-sum taxes, the government has an advantage in supplying liquidity. That is, the government is essential in that the efficient allocation can be attained only with its participation. Moreover, optimal issuance of public liquidity entirely crowds out the supply of privately issued safe assets. The reason is that intermediaries' safe debt, S, is costly because it requires monitoring, whereas the government's safe money has no costs associated with backing through taxes.

The result of Proposition 4 is well known and in line with Friedman's proposal (Friedman, 1960) and other studies of public and private liquidity (e.g., Rocheteau, 2011). The government provides interest-bearing liquidity and pays it through taxes. Moreover, abundant public liquidity eradicates any return wedge among securities with the same risky characteristics. It is worth emphasizing that the solution of this subsection relies on two critical assumptions: first, that the government is benevolent; second, that it does not face any limit on raising taxes. The next subsections propose solutions that overcome possible constraints on raising taxes.

5.2 Optimal government policy with limit on taxes: central bank's balance sheet

We now turn to the analysis of public liquidity supply when the government faces a limit on the average taxes that it can collect at $t = 1$, where average taxes are $(1 - \pi)T_h + \pi T_l$.

To keep the analysis simple and without loss of generality, we assume that the limit on taxes is

$$(1 - \pi)\, T_h + \pi T_l \leq \bar{B} < 1. \tag{17}$$

where $\bar{B} \geq 0$ is the initial level of debt at the beginning of $t = 0$. The upper bound in (17) corresponds to the average taxes that the government would have to collect if it did not implement any policy at $t = 0$. The result can be generalized to the case of a less restrictive limit on taxes.

Notwithstanding the limit in (17), we show that an appropriate policy of asset purchases allows the economy to achieve the first best, $C_h = C_l = 1$. Under this policy, the government supplies a large amount of public money, $B > \bar{B}$, and purchases private intermediaries' pseudo-safe debt through the central bank. The pseudo-safe debt held by the central bank pays a return in the high state, allowing the government to reduce taxes in that contingency. Instead, in the low state, the private pseudo-safe securities are defaulted on and, thus, government debt requires backing through taxes. This policy is related to the second proposal of Friedman (1960), who suggested backing the supply of interest-bearing reserves (in our model, B) through the portfolio of assets held by the central bank (in our model, private intermediaries' pseudo-safe debt).[13]

Let the central bank purchase the quantity D^c of pseudo-safe securities. At time 0 the budget constraint of the government is

$$Q^B \bar{B} = Q^B B - Q^D D^c. \tag{18}$$

The budget constraint of the government at time 1 is

$$B = T_h + D^c \tag{19}$$

$$B = T_l \tag{20}$$

in the high and low state, respectively.

To achieve the first best, the government must issues an amount $B = 1$ of public

[13]Even though our policy proposal is related to that of Friedman, it is slightly different because the original proposal considered only the possibility of investing in safe securities.

money. If indeed the government is able to implement the first best, the households' first-order conditions imply that the pricing of public money and pseudo-safe securities are $Q^B = 1$ and $Q^D = 1 - \pi$. Given these results, the budget constraint at $t = 0$, equation (18), implies that the government can purchase private pseudo-safe debt in the amount of

$$D^c = \frac{(1 - \bar{B})}{(1 - \pi)} > 0. \tag{21}$$

Given this, the state-contingent budget constraints at $t = 1$, equations (19) and (20), imply that taxes are

$$T_h = 1 - \frac{1 - \bar{B}}{1 - \pi} \tag{22}$$

$$T_l = 1 \tag{23}$$

and thus average taxes are $(1 - \pi)T_h + \pi T_l = \bar{B}$. That is, the limit in (17) is satisfied.

The next proposition summarizes this result.

Proposition 5 *Assume that financial intermediaries face a per-unit cost $\tau > 0$ to monitor safe capital and the government follows a state-contingent tax rule T_h and T_l in the high and low state, respectively, subject to the limit in (17). The government can achieve the first best by supplying public money $B = 1$, purchasing the amount of pseudo-safe securities D^c in (21) and setting taxes T_h and T_l to (22) and (23), respectively.*

The proposition shows that the government can achieve the first best even if there is a limit on average taxes. In the high state, pseudo-safe assets are fully repaid and thus provide a backing for public liquidity B. In the low state, however, pseudo-safe securities are defaulted on and thus provide an insufficient backing for public liquidity. In this case, taxes T_l must be increased to back public liquidity.

The requirement that taxes should be increased during a crisis can be relaxed if we extend the model to an infinite horizon and we allow government debt and taxes to vary over time. In this case, however, the present-discounted value of taxes must be raised during a crisis, even though the taxes collected during a crisis do not have to increase. In such an infinite-horizon formulation, the government can increase debt to $B > 1$ in the event of a crisis to keep taxes low at that time, and repay the higher debt by increasing future taxes when the economy recovers from the crisis.

The solution proposed in this section has interesting policy implications given the unconventional asset purchases undertaken by many central banks around the world. The rationale and duration for these purchases have been subject to an extensive

debate. Our analysis underlines that, even during normal times, central banks should continue to hold private securities for the purpose of fulfilling the liquidity needs of the economy and reducing the tax burden.[14] This view is in contrast to the conventional one that prescribes that central banks should mainly hold Treasury bills; under this approach, no reduction in the tax burden is possible.

Next, we discuss the robustness of Proposition 5. Even if the result of Proposition 5 might not be identical in some extensions of our model, we argue that the spirit of the exercise is preserved. For instance, if intermediaries' default is costly (i.e., deadweight losses are associated with bankruptcy processes), it might be optimal for the government to have a lower demand for D^c to avoid too many losses when intermediaries go bankrupt. As a result, the optimal supply of public liquidity might be smaller and the allocation $C_h = C_l = 1$ would not be optimal. Nonetheless, the spirit of Proposition 5 would be unchanged. The main implication of Proposition 5 is that the government should actively engage in the supply of public money using privately issued intermediaries' debt D^c as partial backing. The optimal holding of D^c is most likely not zero for reasonable extensions of our model.

Another constraint that could limit the purchases of private risky debt arises if we separate the central bank from the Treasury. By purchasing risky securities, the central bank faces income losses in the low state, where the risky assets default, while still having to pay interest on reserves. Therefore, it needs to be recapitalized by the Treasury. If the Treasury's support is not automatic, an additional trade-off between maintaining price stability and achieving the efficient supply of liquidity could emerge.[15] This problem can be overcome only if the central bank purchases risky private debt that is fully insured by the Treasury (such as agency mortgage-backed securities).

5.3 Optimal government policy with limit on taxes: deposit insurance and government guarantee programs

In this section, we propose an alternative government policy that allows the economy to achieve the first best even if the government is subject to the limit on taxes in equation (17). We refer to this policy as deposit insurance, even though we argue that it can interpreted, more generally, as any program that guarantees the liabilities

[14] In a different framework, Magill, Quinzii, and Rochet (2016) also argue for the continuation of unconventional asset purchases to normal times as a way to achieve efficiency, which in their case is related to the increase in the funds channeled to investments.

[15] See, among others, Sims (2000).

of financial intermediaries. We first study the policy in the context of the model and then elaborate on some limitations and extensions.

We consider deposit insurance that is actuarially fair. That is, the government charges intermediaries a fee for the insurance, and on average the policy does not provide any subsidy to intermediaries.

We denote the debt of insured intermediaries that invest in risky projects as $\hat{D}$ to distinguish it from the risky debt D that arises in the equilibrium of Proposition 3. Under deposit insurance, intermediaries' debt $\hat{D}$ is safe and therefore always provides liquidity services, even though intermediaries invest in risky projects. In the low state at $t = 1$, when the payoff of intermediaries' investments is zero, the government provides the insurance payment with a transfer to intermediaries. In the high state at $t = 1$, when intermediaries' projects produce a positive output, the government charges a proportional fee to intermediaries.

At $t = 0$, the budget constraint of intermediaries that invest in risky projects is similar to (12), but now $\hat{D}$ replaces D:

$$K^{\hat{D}} = Q^{\hat{D}} \hat{D} \tag{24}$$

where $K^{\hat{D}}$ denotes the investment in risky projects, and $Q^{\hat{D}}$ is the price of insured debt. Households' demand for $\hat{D}$ implies that the price of $\hat{D}$ is $Q^{\hat{D}} = Q^S = Q^B$, because insured debt is riskless and thus perfect substitute with the debt of safe intermediaries and of the government.

At $t = 1$, intermediaries' profits are

$$\Pi_h^{\hat{D}} = \max\left\{0,\ K^{\hat{D}}(A - \lambda_h) - \hat{D}\right\} \tag{25}$$

$$\Pi_l^{\hat{D}} = \max\left\{0,\ K^{\hat{D}}(0 - \lambda_l) - \hat{D}\right\} \tag{26}$$

where $\lambda_h > 0$ and $\lambda_l < 0$ denote the proportional fee and transfer from the government in the high and low state, respectively, while the lower bound on profits follows from limited liability.

The government budget constraint at $t = 0$ is the same as in the baseline model with no policy interventions. We focus on the case in which the government does not alter the supply of public debt with respect to the initial level, and thus $B = \bar{B}$. The budget constraint at $t = 1$ is

$$\bar{B} = T_h + \lambda_h K^{\hat{D}} \tag{27}$$

$$\bar{B} = T_l + \lambda_l K^{\hat{D}} \tag{28}$$

in the high and low state, respectively. Note that, under deposit insurance, the gov-

ernment increases taxes in the low state, T_l, to fulfill its guarantee of intermediaries' debt.

The equilibrium under deposit insurance can be characterized as an equivalence proposition, in the spirit of Wallace (1981). If an equilibrium exists under the asset purchase policy of Proposition 5, the same consumption allocation and prices can be sustained under a policy of deposit insurance with the same taxes. The logic of the proof is based on the fact that the consolidated balance sheet of the government and private intermediaries—that is, of the agents that supply liquidity in the economy—is the same under both policies.

To solve for the equilibrium, consider the government that collects the same taxes T_h and T_l as under the asset purchases policy studied in Section 5.2, which are given by equations (22) and (23). We can use (27) and (28) to solve for the values of the fee and of the transfer to intermediaries:

$$\lambda_h = \frac{1-\bar{B}}{K^{\hat{D}}} \frac{\pi}{1-\pi}$$

$$\lambda_l = -\frac{1-\bar{B}}{K^{\hat{D}}}.$$

Note that the average payment to intermediaries, which is defined by $(1-\pi)\lambda_h + \pi\lambda_l$, is zero, and thus the government does not provide any subsidy to intermediaries on average.

We can then show that the total amount of liquidity in the economy, $\bar{B} + \hat{D}$, allows the economy to achieve the first best. To do so, we plug the value λ_l into the expression for profits in the low state, (26), and we set profits equal to zero because of free entry, obtaining $\bar{B} + \hat{D} = 1$. Note that both public liquidity $\bar{B}$ and insured private debt $\hat{D}$ provide liquidity in both states, and thus households can achieve the first-best level of consumption $C_h = C_l = 1$. Profits in the high state, (25), and the budget constraint of intermediaries at $t = 0$, (24), can be used to solve for the equilibrium value of $K^{\hat{D}}$ and $\hat{D}$.

Crucially, since we are using the same taxes that the government imposes under asset purchases, the limit on average taxes in (17) is satisfied even under deposit insurance. The next proposition summarizes this result.

Proposition 6 *Assume that a policy of taxes T_h and T_l, asset holdings of the central bank D^c, bond supply $B = 1$, and consumption $C_h = 1$ and $C_l = 1$ are part of an equilibrium. There exist state-contingent, proportional taxes on intermediaries λ_h in state h and λ_l in state l that sustain the same equilibrium with the same state-*

contingent taxes T_h and T_l and a lower supply of public liquidity $\bar{B} < 1$. Under the tax scheme λ_h and λ_l, the debt of intermediaries that invest in risky projects is riskless.

In practice, deposit insurance is typically up to a limit. Nonetheless, during the acute phase of the 2008 crisis, the deposit insurance limit was increased in several countries, and other forms of government guarantee were introduced. In the U.S., the insurance limit was increased from $100,000 to $250,000. Moreover, the Federal Deposit Insurance Corporation (FDIC) set up the Temporary Liquidity Guarantee Program with the objective of bringing stability to financial markets and the banking industry. The program provided a full guarantee of noninterest-bearing transaction accounts and of the senior unsecured debt issued by a participating entity for about a year. Taken together, these two measures dramatically increased the fraction of liabilities of U.S. financial institutions that were guaranteed by the government. Similar policies were adopted in other countries, including some cases in which the coverage was unlimited, such as in Germany.[16]

We want to emphasize that the deposit insurance scheme provided by the government is actuarially fair because the average tax imposed on intermediaries is zero: $(1-\pi)\lambda_h + \pi\lambda_l = 0$. As long as the government runs a correctly-priced deposit insurance, it should be able to avoid any moral hazard that might instead arise when the insurance is subsidized. In this sense, our results suggest that regulatory agencies such as the FDIC should link the deposit insurance premium to each intermediaries' risk of default. This would not only reduce or avoid moral hazard, but also support the adequate level liquidity in the economy.

Finally, we point out that our model provides a role for deposit insurance that is different, although complementary, to the standard motivation related to bank runs. Following Diamond and Dybvig (1983), the bank runs literature highlights the importance of deposit insurance as a tool to eliminate bad equilibria driven by panics. In our model, crises are driven by fundamental shocks, and deposit insurance plays a key role at reducing the negative impact of such shocks.

5.4 Adding more restrictions on government intervention

In Sections 5.2 and 5.3, we have limited the action of the government by imposing a constraint on average taxes. Despite the limit, the government is able to implement policies that achieve the first best. These policies, though, require to set high taxes in the low state to offset the lack of private backing with government backing.

[16] See "Deposit Insurance Coverage," CESifo DICE Report 9 (4), 2011, 69-70.

In this section, we take the policy analysis one step further by imposing an additional limit on government actions. In addition to the limit on average taxes in (17), we assume that the government has to satisfy a state-contingent limit on taxation, that is, $T_h, T_l \leq \overline{T}$, where $\overline{T}$ satisfy $\bar{B} < \overline{T} < 1$. As the analysis in Sections 5.2 and 5.3 show, the state-contingent limit is binding in the low state, and thus we simply reformulate the limit as $T_l \leq \overline{T}$.

Under the limit $T_l \leq \overline{T}$, the first-best cannot be achieved by government policy. Nonetheless, we show that asset purchases and deposit insurance are still optimal, and the equivalence between these two policies shown by Proposition 6 is robust to the extension of this section.

We begin with the analysis of asset purchases. Government debt at $t = 0$ is $B < 1$, and the central bank purchases an amount $D^c < (1 - \bar{B})/(1 - \pi)$ of pseudo-safe securities, where the upper bound corresponds to the case that implements the first best as shown in Section 5. At time $t = 0$, the budget constraint of the government is

$$Q^D D^c \leq Q^B (B - \bar{B}),$$

which implies that the public debt issued at time 0 is

$$B = \bar{B} + \frac{1 - \pi}{1 + \pi\mu_l} D^c \tag{29}$$

because $Q^D = (1 - \pi)$ and $Q^B = 1 + \pi\mu_l$. To cover this debt, the government has to raise taxes in state h equal to

$$T_h = \bar{B} + \frac{1 - \pi}{1 + \pi\mu_l} D^c - D^c \tag{30}$$

because pseudo-safe securities are fully repaid by private intermediaries, whereas it has to raise taxes in state l equal to

$$T_l = \bar{B} + \frac{1 - \pi}{1 + \pi\mu_l} D^c < 1. \tag{31}$$

Under the asset purchase policy characterized by $D^c < (1-\bar{B})/(1-\pi)$ and $B < 1$, public liquidity is not sufficient to satiate the overall demand for liquidity. As a result, and similarly to the result of Propositions 2 and 3, households hold some pseudo-safe debt to finance part of the consumption in state h.[17]

Consumption in the high state is thus at the efficient level, $C_h = 1$, whereas

[17]Denoting with D the total supply of pseudo-safe securities, the central bank holds an amount D^c of them, and households hold the remaining amount $D - D^c$.

consumption in the low state is

$$\begin{aligned} C_l &= B + S \\ &= \bar{B} + \frac{1-\pi}{1+\pi\mu_l} D^c + S < 1 \end{aligned} \tag{32}$$

where the equilibrium level of S is the same as in Proposition 3, i.e. $S = \max\{\pi/(\pi+\tau) - B, 0\}$. The asset purchase policy crowds out the supply of safe securities S and, if the intervention is large, the supply of S is driven to zero. In addition, and similar to Section 3, the Lagrange multiplier of the liquidity constraint in the low state is $\mu_l = \min\{\tau/\pi,\, 1/B - 1\}$.

We can now use the limit on taxes in the low state, $T_l \leq \overline{T}$, to compute the maximum size of the asset purchase policy. Using (29), (31), and $\mu_l = \min\{\tau/\pi,\, 1/B-1\}$, it follows that $B = T_l = \overline{T} < 1$ and therefore

$$D^c = \begin{cases} \frac{1+\tau}{1-\pi}\left(\overline{T} - \bar{B}\right) & \text{if } \overline{T} < \frac{\pi}{\pi+\tau} \\ \frac{1+\pi\left(1/\overline{T}-1\right)}{1-\pi}\left(\overline{T} - \bar{B}\right) & \text{if } \overline{T} \geq \frac{\pi}{\pi+\tau}. \end{cases}$$

Moreover, we can use (30) to verify that the bound on average taxes, equation (17) is not violated:

$$(1-\pi)T_h + \pi T_l = \bar{B} - \pi\mu_l\left(\overline{T} - \bar{B}\right) < \bar{B} \tag{33}$$

where the inequality follows from the assumption $\overline{T} > \bar{B}$. The bound on average taxes is not binding because the government earns a liquidity premium on government bonds that reduces the amount of resources that must be collected using lump-sum taxes.

We can use equation (32) and the equilibrium value of D^c to solve for consumption in the low state. We obtain $C_l = \max\left\{\pi/(\pi+\tau), \overline{T}\right\}$. If $\overline{T} > \pi/(\pi+\tau)$, asset purchases increase liquidity and thus allow households to consume more in the event of crisis. If instead $\overline{T} < \pi/(\pi+\tau)$, consumption in the low state is the same as in economy without policy intervention, but welfare is nonetheless higher. This is because asset purchases crowd out the supply of safe securities S, which are costly because of the monitoring.

We now turn to the analysis of deposit insurance. We show that the level of consumption $C_h = 1$ and $C_l = \max\left\{\pi/(\pi+\tau), \overline{T}\right\}$ can be achieved with the same level of taxation if the government offers deposit insurance, thereby generalizing the results of Proposition 6 to the case in which the government cannot implement the first best.

Similar to Section 5.3, we use $\hat{D}$ to denote the debt of insured intermediaries

that invest in risky projects, and we continue to use D to denote uninsured debt of intermediaries that invest in risky projects. This distinction is now critical, because securities $\hat{D}$ and D coexist in the deposit-insurance equilibrium of this section. Deposit insurance allows the economy to achieve the same consumption allocation obtained with asset purchases if the supply of insured debt is $\hat{D} = \overline{T} - \bar{B}$ and the supply of uninsured debt is $D = 1 - \bar{B} - \hat{D} - S$, where safe debt S is the same as in Proposition 3.

As discussed in Section 5.3, the price of insured private debt is equal to the price of safe assets, and thus $Q^{\hat{D}} = 1 + \pi\mu_l$, where now this debt has a premium because consumption in the low state is not at the first best. As a result, the budget constraint (24) implies that insured intermediaries invest an amount $K^{\hat{D}} = (1 + \pi\mu_l)\left(\overline{T} - \bar{B}\right)$ in risky projects.

Plugging the values of $\hat{D}$ and $K^{\hat{D}}$ into the zero-profit condition of intermediaries in the low state (i.e., into (26) evaluated at $\Pi_l^{\hat{D}} = 0$) it follow that the proportional transfer to intermediaries in the low state is

$$\lambda_l = -\frac{1}{1 + \pi\mu_l}.$$

Similarly, we can use the zero-profit condition in the high state, the price of insured debt $Q^{\hat{D}}$, and the budget constraint of insured intermediaries (24) to solve for the proportional fee charged in the high state:

$$\lambda_h = \frac{\pi}{1 - \pi}\frac{1 + \mu_l}{1 + \pi\mu_l}$$

We can compute the average level of taxes by plugging λ_h and λ_l into (27) and (28) and rearranging to get:

$$(1 - \pi)T_h + \pi T_l = \bar{B} - \pi\mu_l\left(\overline{T} - \bar{B}\right)$$

which is the same value as in the asset-purchase case.

We can then summarize the equivalence between asset purchases and deposit insurance with the following proposition.

Proposition 7 *Assume that a policy of taxes T_h and T_l, asset holdings of the central bank $D^c \in \left[0, (1 - \bar{B})/(1 - \pi)\right)$, and bond supply B is part of an equilibrium. There exist state-contingent, proportional taxes on intermediaries λ_h in state h and λ_l in state l that sustains the same equilibrium with the same taxes T_h and T_l and lower supply of public liquidity, $\bar{B} < B$. Under the second policy, insured, safe debt issued by intermediaries that invest in risky projects coexist with uninsured debt issued by*

other intermediaries that invest in the same type of risky projects, along with public liquidity and possibly safe private debt.

We want to emphasize that the results of this section capture some important stylized facts of the modern financial system.

Under asset purchases, the central bank purchases risky securities in the model, and the consolidated fiscal-monetary authority faces losses if these securities are defaulted on. In practice, central banks that have purchased assets backed by private investments have targeted securities with no default risk; for instance, the Federal Reserve purchased agency mortgage-backed securities (MBS). However, these securities have no default risk because they are guaranteed by government-sponsored enterprises (i.e., Fannie Mae and Freddie Mac), which are in turned backed by the Treasury. If many of the mortgages underlying the MBS held by the Federal Reserve had defaulted, the consolidated Treasury-Federal Reserve balance sheet would have faced losses, as in our model, because of the Treasury guarantee.

Under deposit insurance, insured and uninsured debt coexist in the equilibrium of the model, resembling the coexistence, in practice, of insured commercial bank deposits and uninsured liabilities of shadow banking institutions. This coexistence arises endogenously. Intermediaries are ex-ante identical, and those that invest in risky projects endogenously decide whether to operate under the deposit insurance scheme or in the unregulated shadow banking system.

5.5 Regulation of intermediaries' investments

We now turn our attention to a policy that restricts the type of investments of private intermediaries and, in particular, forces them to invest only in riskless projects. As a result, all intermediaries issue safe assets without the need of the government to provide deposit insurance.

Forcing all intermediaries to invest in riskless projects reduces welfare. We first state the analysis in the context of our simple model. We then claim that a similar result can be obtained in a more general model in which banks issue not only debt but also equity, and regulation forces intermediaries to be safe by imposing large capital requirements.

Restricting intermediaries' investments is fundamentally different from the policies studied in Sections 5.1-5.4. Government provision of liquidity and deposit insurance require an adequate fiscal backing in the low state, even if the government buys assets through the balance sheet of the central bank. These policies primarily work

by complementing the insufficient private backing of liquidity with public backing. In contrast, the regulation of financial intermediaries' investments affects directly the private backing of securities issued by intermediaries, without requiring any fiscal capacity.

To understand why this policy reduces welfare, recall the result of the unregulated equilibrium. Some intermediaries invest in the the risky technology to economize on the monitoring cost, and thus they issue pseudo-safe debt that defaults in the low state. The argument is similar to that in Geanakoplos (1997, 2003), in which default is desirable to economize on scarce collateral. As a result, forcing all intermediaries to invest in safe projects eliminates liquidity crises but requires intermediaries to waste a large amount of resources to pay monitoring costs.

Proposition 8 *Assume that financial intermediaries face a monitoring cost $\tau > 0$, and T_h, $T_l < 1$. If the government forces all intermediaries to invest in safe projects, welfare is lower in comparison to the laissez-faire equilibrium.*

We now discuss two possible interpretations of this policy. The policy can be interpreted literally as a restriction on the type of assets held in the balance sheet of financial intermediaries, in line with the recommendation of the real bills doctrine. In addition, and stepping outside our simple model, the policy can be reinterpreted more generally as an extreme form of capital requirements. In a previous working paper version of this paper (Benigno and Robatto, 2017) we study a model in which banks are financed not only with debt but also with equity. If there are costs associated with issuing equity (as documented for banks by Calomiris and Wilson, 2004, and more generally for non-financial firms by Altınkılıç and Hansen, 2000), extreme forms of capital requirements like those suggested by Admati and Hellwig (2013) and Kashkari (2016) make banks very safe but forces banks to incur the equity issuance costs. The equity issuance cost can be mapped into the monitoring cost in the simpler model studied here, and thus the logic of the result is identical. That is, capital requirements that force all banks to issue large amount of costly equity decrease welfare as well.

6 Conclusion

We have presented a framework to study private money creation in a model in which both public and private liquidity play a role for transactions. If creating private, safe assets is relatively cheap, the efficient level of liquidity is supplied without any need for government regulation. Rather, if producing safe assets is costly, the demand for

liquidity is satiated only in good times, whereas in times of economic distress the economy is subject to liquidity shortages and crises.

Within this framework, we have explored several policies to improve welfare. The main message is that policies in which public and private liquidity complement each other, such as a government guarantee of private debt or a large supply of public liquidity backed by a portfolio of private risky securities, are desirable. In contrast, forcing intermediaries to take costly action to reduce their default probability affects welfare negatively.

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