Liquidity, Collective Moral Hazard, and Government Bailouts

Ashley Wumian Zhao
Purdue University

May 25, 2022

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Abstract

The paper develops a general equilibrium model of assets market integrating a theory of liquidity risk in a New Monetarist framework. Collective moral hazard arises from the interaction between banks' maturity transformation and government intervention. With the anticipation and implmentation of government bailouts during a crisis, collective moral hazard creates current and deferred social costs. However, under the "correct" monetary policy, the costs are justified by the improvement of liquidity condition as a result of higher provision of public and private liquidity.

Keywords: bailouts; moral hazard; maturity transformation; New Monetarism

1 Introduction

One of the striking features of the 2008 financial crisis is the extreme exposure to liquidity needs and market conditions. The center of the problem is that wide-scale maturity mismatch gives rise to systematic liquidity risk. A maturity mismatch is a situation in which assets and liabilities held by a financial institution are not aligned in terms of maturity time. Commercial banks traditionally engage in transformation, and had increased their sensitivity to market conditions. Prior to the financial crisis, large banks and conduits hold substantial asset backed commercial papers relative to equity retail deposits to liabilities ratio decreased substantially banks counted on securitization for new cash.

This paper shows recapitalization of distressed financial institutions by the government creates moral hazard, and gives rise to strategic complementarities between government bailout policy and private leverage choices.
This gives rise to multiple equilibria in a crisis: 1) there is no risky behavior by the banks, and there is no need for bailouts by the government; 2) there is some degree of risky behavior by the banks and some bailouts by the government; 3) banks engage in maximum risky behavior, and the government has to employ maximum bailout. The paper also compares the welfare in different equilibria.

So what is maturity mismatch? It is basically a situation in which assets and liabilities held by a financial institution are not aligned in terms of maturity time, or using short-term debts to fund long-term projects. This paper models maturity mismatch as the following. There are three periods. In the first period, an entrepreneur chooses investment scale and amount of short-term debt to fund the investment. In the second period, the entrepreneur experiences an aggregate shock. There is a non-zero probability that the project remains intact (Good), and generates profit in this period; otherwise, the project is distressed (Bad), generates zero profit this period, and requires additional investment in the next period to generate profit. In the third period, in case of Bad state, profits generated by the project depends on the reinvestment scale.

There are tradeoffs between initial investment scale and reinvestment scale for the entrepreneurs, which drive their behaviors. If they choose to devote all their resources to the initial investment, they will get the maximum amount of return in the good state, but in the bad state, they will have no resources left to reinvest and salvage the project. If they choose to devote only part of the resources to initial investment, they will not get as much return in the good state, but in the bad state, they will have resources to reinvest. The balance depends on the cost of refinancing, which will be affected by government's policies.

This mechanism connects the wide-scale maturity mismatch and government's bailout policies during the 2008 crisis. The first problem arises is collective moral hazard. Policymakers would only intervene when a large enough proportion of financial institutions are exposed to risks. It is more like a "too-many-to-fail" problem relative to a "too-big-to-fail" problem. Instead of considering the size, this paper focuses on the quantity of the financial institutions. Financial institutions, anticipating interventions, engage in sub-optimal level of maturity transformation, because interventions are expected to lower the refinancing cost in the bad state. Given the financial institutions' expectation and behavior, when the economy experiences a negative shock, the government has little choice but intervening. More importantly, this serves as an amplification mechanism, thus the herding behavior: if all other financial institutions adopt a risky balance sheet, a financial institution follows suit, because refusing to do so lowers its rate of return.

2 Literature

This paper is related to a body of literature focused on the transmission of monetary policy through the bank lending channel. I will focus on the maturity transformation role of commercial banks, since substantial maturity transformation has been the center of the 2008 banking crisis.[1] Excessive maturity transformation exposes banks to significant liquidity and interest rate risks since short-term debts (e.g. demand deposits) are used to finance long-term investments (e.g. mortgage loans). When there is an economy in which the investments fail to service the debts, it generates huge demand for cheap liquidity. The conventional interest rate policy, therefore, directly affects banks' leverage and investment behavior by changing banks' borrowing costs.

This paper is also related to the literature of the time inconsistency of government bailouts and moral hazard. The idea that government policy and bank regulations may be time inconsistent and may induce moral hazard in the banking sector is first discussed by Bagehot (1873), and is thereafter extensively studied in different contexts. This approach is more related to papers that focus on the "too-many-to-fail" aspect of the time inconsistency as opposed to those on the "too-big-to-fail" aspect, in the sense that even small banks have herding incentives. The too-many-to-fail problem induces banks to herd ex-ante in order to increase the likelihood of being bailed out. Among the many channels of herding, we focus on the banks' collective response to government policy due to strategic complementaries, which was first studied by Diamond (1982). Our model is most closely related to Farhi and Tirole (2012), which discusses the time inconsistency of interest-rate pol-

[1]Acharya and Richardson (2009), Farhi and Tirole (2012)

icy in a broader bailout context.

Finally, this paper is related to the New Monetarist literature of monetary policy and its implications for liquidity and asset returns. The model builds on Williamson (2012) and Williamson and Wright (2010), which concern not only how households finance consumptions but also how entrepreneurs finance investments. These models give explicit and essential roles for banks for supporting these financing needs. Monetary policy impacts households through inflation tax, and banks through lending costs. Our model complements these models by including the maturity transformation to the banking sector, introducing a new bank lending channel of monetary policy. On the banks' side, the policy interest rate affects banks' choices of investment scale, leverage, and most importantly, issuance of private securities. Private liquidity functions as a medium of exchange in the goods market, and therefore can potentially facilitate trade in the goods market and improve households' surplus.

This model contributes to the literature by integrating maturity transformation and the time inconsistency of policy into a New Monetarist framework. Due to the endogenous generation of private liquidity, monetary policy affects both supply and demand sides of each asset, and has a general equilibrium effect on asset returns.

3 Environment

The environment modifies Williamson (2012), incorporating the maturity transformation function of the commercial banks - how private liquidity is generated. Following Farhi and Tirole (2012), we incorporate aggregate shocks to allow for liquidity risks arising from maturity transformation. The new modifications enriches the original model, allowing strategic complementarities to arise from the banking sector, which enables discussions of collective moral hazard caused by government bailouts. Another important modification is to generalize the type of agents and investment project. By including heterogeneous agents and divisible investment project private liquidity now changes on both intensive and extensive margins: who gets a loan and how much loan they get.

Time is infinite and discrete. Each period is divided into two sub-periods - the first is a decentralized market (DM) for the trade of goods, and the second is a centralized market (CM) for settlement. DM is featured by search frictions, lack of commitment, and lack of record keeping. CM is a Walrasian market without search frictions. Five types of agents interact in each period: buyers, sellers, investors, banks, and the government. Two types of goods are produced and consumed. The DM good x is produced and consumed only in DM, and the CM good, or the numeraire, is produced and consumed only in CM. Both CM and DM goods are divisible and non-storable across periods. Three types of assets are generated and have the potential to circulate in the economy – fiat currency and government bonds issued by the government, and private securities generated by private banks. The rest of this section describes the interactions, and the exchange of goods and assets between agents.

Buyers and Sellers

Buyers and sellers are infinitely lived. Each agent has a discount factor of $\beta \in (0,1)$. Buyers and sellers have a linear production technology that allows them to transfer one unit of labor into one unit of CM goods. This technology implies that the real wage is normalized to 1. The DM goods x can only be produced by sellers and can only be consumed by buyers. The CM goods X can be produced and consumed by both buyers and sellers. There is a continuum of buyers with mass one. Each buyer has a lifetime utility given by

$$E_0 \sum_{t=0}^{\infty} \beta^t [-H_t + u(x_t)].$$

H_t denotes the difference between labor supply and consumption in CM, and x_t is the consumption in DM. $u(\cdot)$ satisfies $u' > 0, u'' < 0, u(0) = 0, u'(0) = \infty$, and $u'(\infty) = 0$. Define x^* such that $u'(x^*) = 1$.[2] There is a continuum of sellers, also with mass one, and each seller has preferences

$$E_0 \sum_{t=0}^{\infty} \beta^t [U(X_t) - h_t],$$

where X_t is the CM consumption and h_t is the DM labor supply.

In DM, each buyer is matched at random with a seller. Both agents are anonymous and have limited commitment, which precludes trade credits between the buyer and seller, i.e. all trades must be *quid pro quo* in equilibrium.

[2]Assume that the cost function takes the functional form $c(x) = x$. In general, x^* maximizes the surplus $u(x) - c(x)$ and satisfies $u'(x) = c'(x)$.

The role for a medium of exchange arises from this environment because it allows for trading of future goods for current consumption without credit arrangements. A fraction ρ of the meetings is not monitored by financial intermediaries in the sense that the only liquid asset that can be costlessly verified by the trading parties is the fiat currency issued by the government. We call transactions in this type of meetings *cash* transactions. The currency is perfectly durable, divisible, and not counterfeitable. A fraction $(1 - \rho)$ of the meetings is monitored, meaning that both currency and IOUs issued by banks can be verified at zero cost in this type of meetings. The verification technology is costless available to the intermediaries, and the information is costlessly communicated to the buyer and the seller. IOU holders may redeem IOUs for assets held by banks on demand. The interaction between buyers and sellers in DM is illustrated in Figure 1.

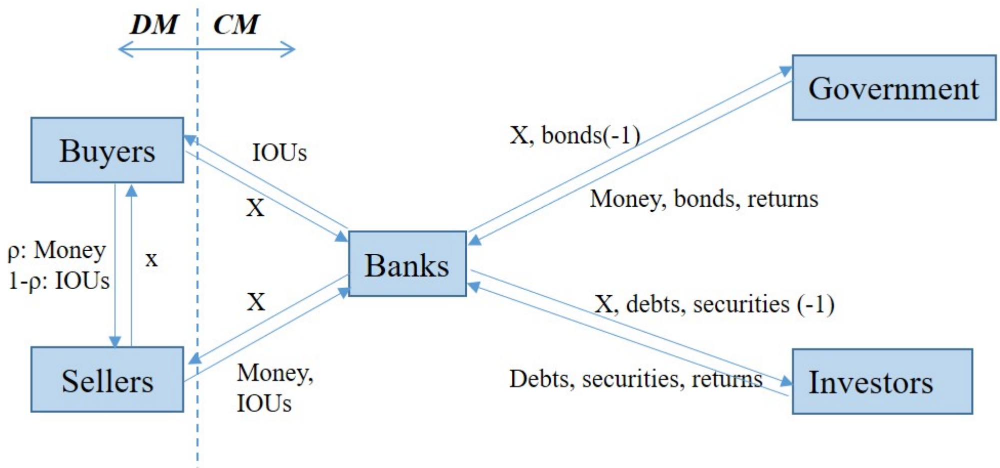

Figure 1: Interactions in a representative period

The Consolidated Government

The consolidated government has the power to levy lump-sum taxes on buyers in CM, where τ_t denotes the taxes in real terms. The government has M_t units of currency outstanding, and issues B_t one-period nominal bond in terms of currency. The consolidated government budget constraints are

$$\begin{aligned} &\phi_t(M_t + B_t) + \tau_t = \phi_t(M_{t-1} + q_t B_{t-1}) + \sigma_t, \\ &\phi_0(M_0 + B_0) + \tau_0 = \sigma_0, \end{aligned} \tag{1}$$

where q_t is the price of the government bond in nominal terms, ϕ_t is the real value of the currency, and σ_t is the fiscal deficit in real terms. Define

$$\delta_t = \frac{M_t}{B_t + M_t}, \quad \mu_{t+1} = \frac{B_{t+1} + M_{t+1}}{B_t + M_t}, \tag{2}$$

where δ_t is the ratio of currency to the stock of nominal government liabilities, and μ_t is the growth rate of the total stock of nominal government liabilities. We refer to (δ_t, μ_t) as the monetary policy, and σ_t as the fiscal policy in period t. Combining (1) and (2), taxes $\{\tau_0, \tau_t\}$ are determined passively given monetary and fiscal policy $(\delta_t, \mu_t, \sigma_t)$.

$$\begin{gathered} \tau_t = -\frac{\phi_t M_t}{\delta_t}(1 - \frac{1}{\mu_t}) + \frac{\phi_t M_{t-1}(1-\delta_t)}{\delta_t}(\mu_t r_{t+1} - 1) + \sigma_t, \\ \tau_0 = -\frac{\phi_0 M_0}{\delta_0}, \end{gathered} \tag{3}$$

where $r_{t+1} = \frac{\phi_{t+1}}{\phi_t} q_{t+1}$ denotes the gross real interest rate on government debt. Tax τ_t is reduced by the proceeds from the net increase in government liabilities - the first term, and is increased by the interests paid on outstanding government liabilities - the second term. The government deficit is taxation increasing since it is funded by issuance of currency and government debt. In the initial period, the government does not have any outstanding liabilities.

Banks and Entrepreneurs

Interactions between banks and entrepreneurs involve three stages. Stages 0 and 1 happen in the CM of each period, and stage 2 happens in the CM of the following period. At stage 0, an entrepreneur has access to a long-term investment project. They take on a short-term debt d and choose their investment scale i.[3] At stage 1, the investment project yields a cash flow wi, that can be used to pay back the short-term debt; $w \sim F(w)$, where $w \in [0, \bar{w}]$.[4] The investment project is exposed to an aggregate shock, which describes the state of the economy. With probability α, the economy is in a *good* (G) state, and the project stays intact. With probability $1-\alpha$, the economy is in a *bad* (B) state - a crisis, in which the project is distressed.

If the project is intact, the investment delivers at stage 1 an additional payoff of $\rho_1 i$, of which $\rho_0 i$ is pledgeable to banks. If the project is distressed,

[3] Terms of debt is described later in this section.

[4] This is different from the safe cash flow πi in Farhi and Tirole (2012). The distribution of cash flow helps pin down the terms of an optimal debt contract.

it yields no additional payoff at stage 1, except for the cash flow wi; it yields a payoff at stage 2 in the next CM if fresh resources j are reinvested. The project can be downsized to any level $j \leq i$,[5] and then delivers a payoff of $\rho_1 j$, of which $\rho_0 j$ is pledgeable to banks. Figure 2 illustrates the chain of events regarding borrowing, investments, and payoffs in different states.

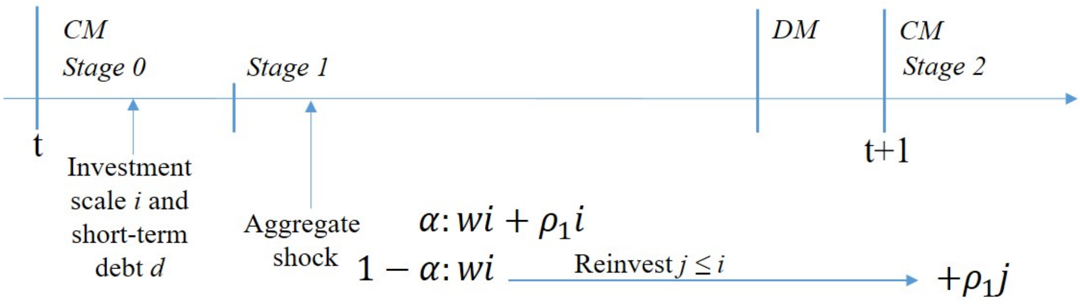

Figure 2: Short-term debt and long-term investment project

At the core of this setup is a maturity mismatch issue, where a long-term project is funded by short-term debts and requires occasional reinvestments. For each investor, the tradeoffs are between the initial investment scale i and reinvestment scale j in the event of a crisis. If an investor exhausts reserves of pledgable income and take on a debt to maximize the initial investment scale i, they receive the maximum returns in a good state, but risk significant downsizing in a crisis. The interest rate, or cost of financing, between stages 1 and 2 is a key determinant of the collateral value of a project, and therefore plays an important role in determining the initial investment scales. The equilibrium interest rate is determined by the supply and demand of funds described in the next section.

We start with the structure of a state contingent short-term debt contract issued by the bank to investors. A continuum of investors with mass k are born at the beginning of each stage 0, and each lives until the end of stage 2. A investor is risk neutral, receives no endowment, and has access to the long-term divisible investment project described above. The return of an investor in stage 1 is private information, and can only be verified by others at a cost $\gamma \sim G(\gamma)$, where $\gamma \in [0, \bar{\gamma}]$ and is specific to investors. We can interpret γ as the bankruptcy cost. A financial intermediary observes the investor's type γ, and offers a loan contract to the investor that specifies a state-contingent

[5] In equilbrium, reinvestment is expensive, and investors would not want to expand the project.

payment d_S, where $S = \{G, B\}$. If for an investor γ, the payoff is lower than the debt payment, they default on the debt; the bank incurs the verification cost γ, and observes and seizes the investor's the payoff.[6] If the payoff is higher than the debt payment, the investor repays the debt.[7] In the *bad* state, the bank's expected return from extending a loan to a type γ investor is

$$\pi^B(\gamma) = \underbrace{\int_0^d wi - \gamma \, dF(w)}_{default} + \underbrace{di\Big(1 - \int_0^d dF(w)\Big)}_{repay}. \tag{4}$$

In the *good* state, the expected return from type γ investor is

$$\pi^G(\gamma) = \underbrace{\int_{\rho_1}^d yi - \gamma \, dF(y)}_{default} + \underbrace{di\Big(1 - \int_{\rho_1}^d dF(y)\Big)}_{repay}, \tag{5}$$

where $y = w + \rho_1$. The first term on the right-hand side is the expected return from defaulting, and the second term is the expected return from full repayment.

Banks and Buyers

IOUs are generated as deposit contracts issued to buyers in CM when banks take in deposits from the buyers in the form of goods. Assuming perfect competition between banks, a bank offers a deposit contract that maximizes the expected utility of its depositors in equilibrium. The bank acquires enough deposits to purchase m units of currency, b units of government bonds, and a units of private securities, all in real terms.

We assume that banks have a technology that allows costless record keeping of financial histories but not trading histories in the goods market. Since record keeping can only be done for financial transactions, trade credit between buyers and sellers is not feasible. Record keeping implies that banks can issue inside money such as IOUs, which are essentially claims on the banks' assets. In a monitored meeting in DM, where there is record keeping

[6] γ can be interpreted as the bankruptcy cost. (see Williamson 2012 pg 28)

[7] Instead of letting investors decide the term of the short-term debt as in Farhi and Tirole (2012), the banks get to decide in a fashion similar to Williamson (2012). Here, banks assume a monitoring role on behalf of the depositors/buyers to economize on monitoring costs.

for financial transactions, the ownership of IOUs can be verified and transfered. IOUs, therefore, can serve as a medium of exchange together with the outside money in the goods market. In a non-monitored meeting, on the other hand, such record keeping does not exist, precluding inside money as a medium of exchange.

4 Monetary Equilibrium

4.1 Monetary policy

The government has control over monetary policy. In a stationary equilibrium,

$$\delta = \frac{M}{B+M}, \text{ and } \mu = \frac{B'+M'}{B+M},$$

where δ is the ratio of currency to the total nominal liabilities, and μ is the growth rate of nominal liabilities. Given $\{\tau_0, \tau\}$, policy (δ, μ) must satisfy two budget constraints,

$$\tau = -\frac{m}{\delta}(1-\frac{1}{\mu}) + m(\frac{1}{\delta}-1)(r_b - \frac{1}{\mu}),$$
$$\tau_0 = -\frac{m}{\delta}.$$

4.2 Buyers' problem

CM Value Function

In CM, an agent chooses H - labor supply less CM consumption, and claims on the amount of currency and interest-bearing assets carried forward to the next period. m and a denote quantities of currency and interest-bearing assets in real terms, respectively. ϕ denotes the real value of currency, and r denotes the real gross return on government bonds. W is the CM value function, and V is the DM value function. An agent maximizes their CM value by solving the following problem,

$$\begin{aligned} W(m,b,a) &= \max_{H,m',b',a'} E[-H + \beta V(m',a')] \\ \text{s.t.} \quad & -H + \frac{\phi}{\phi'}(m'+b'+a') = m + r_b b + r_a a + \tau, \end{aligned} \tag{6}$$

where τ is a lump-sum transfer from the government determined passively by the government budget constraints (3) given the monetary and fiscal policy.

Terms of Trade
After matched with a seller in DM, a buyer learns the type of the meeting and makes a take-it-or-leave-it offer.[8] Let x^c be the quantity of DM goods traded in a cash meeting, and x^n be the quantity in a non-cash meeting. The buyer chooses x^c or x^n to maximize the surplus of the trade, $S(\cdot) \equiv u(\cdot) - c(\cdot)$.

In a cash meeting, only currency is accepted as a medium of exchange since only currency is verifiable costlessly. The total demand for currency is therefore the proportion of non-monitored meeting, ρ, multiplied by the payment to the seller for each trade, $c(x)$. The total payment shall not exceed the total real balances held by the buyers. x^c solves the problem

$$x^c \in \text{argmax } u(x) - c(x) \text{ s.t. } \rho c(x) \leq m.$$

$x^c = x^*$ if $\rho c(x^*) \leq m$, and $x^c = c^{-1}(\frac{m}{\rho})$ otherwise.

In a non-cash meeting, both currency and claims can be verified costlessly, and therefore are both accepted as mediums of exchange. Since buyers can redeem assets with claims any time they want, there is no difference between holding currency and holding claims on banks that acquire the same amount of currency. We assume buyers hold claims, so the claims function as the medium of exchange in monitored meetings. The total demand for claims is the proportion of monitored meeting, $(1 - \rho)$, multiplied by the payment to the seller for each trade, $c(x)$. The total payment shall not exceed the total real balances held by the banks. x^n solves the problem

$$x^m \in \text{argmax } u(x) - c(x) \text{ s.t. } (1 - \rho)c(x) \leq m + b + a.$$

$x^n = x^*$ if $(1 - \rho)c(x^*) \leq m + a$, and $x^n = c^{-1}(\frac{m+b+a}{1-\rho})$ otherwise.

DM Value Function
Banks maximize the depositors' (buyers') utilities, because we assume the banking industry is perfectly competitive. Any banks who do not maximize the buyers' utilities are competed out of the market. The value function of a buyer in DM is

$$V(m, b, a) = \max_{m,b,a} \rho S(x^n) + (1 - \rho)S(x^m) + W(m, b, a), \tag{7}$$

[8] With a TIOLI offer, the buyer has all the bargaining power. Other pricing mechanisms that allow the buyer and seller to share the trade surplus do not change the results qualitatively.

where x^n and x^m are the DM quantities determined by the terms of trade above, and $S(\cdot) \equiv u(\cdot) - c(\cdot)$ represents the total surplus of each meeting.

Buyers' Problem
Substituting $V(m', a')$ into the DM value function yields the depositors' (buyers') maximization problem[9]

$$\begin{aligned} \max_{m',b',a'} \underbrace{(1 - \frac{\phi}{\beta\phi'})}_{-\iota\leq 0} m' + \underbrace{(r'_b - \frac{\phi}{\beta\phi'})}_{\leq 0} b' + \underbrace{(Er'_a - \frac{\phi}{\beta\phi'})}_{\leq 0} a' \\ + [\rho S(\underbrace{x'_c}_{\textit{Currency}}) + (1-\rho) S(\underbrace{x'_n}_{\textit{Non-currency}})], \end{aligned} \tag{8}$$

where (m, b, a) are the real quantities of currency, bonds, and securities. ϕ is the value of currency in terms of CM goods. (r_b, r_a) are gross real interest rates on government bonds and securities.

The terms $1 - \frac{\phi}{\beta\phi'}$ and $r' - \frac{\phi}{\beta\phi'}$ can be interpreted respectively as the returns of holding real balances and interest-bearing assets to the next period. Define $\iota \equiv -(1 - \frac{\phi}{\beta\phi'})$, where ι is interpreted as nominal interest rate, or the cost of holding money. In equilibrium, returns to both assets need to be non-positive for (m', a') to be finite, i.e. holding either assets cannot generate positive returns. If $1 - \frac{\phi}{\beta\phi'} > 0$, for instance, the bank wants to hold an infinite amount of real balances to maximize profit. Solving the banks' problem gives us the demand for interest-bearing assets.

Demand curve

[9]See Appendix - Monetary equilibrium.

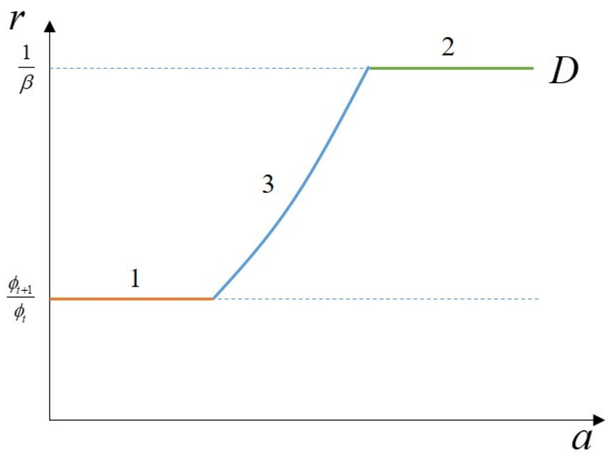

Figure 3: Demand

4.3 Banks' problem

To solve for the optimal debt contract in each state, d_B and d_G, we take first-order conditions of (4) and (5) with respect to d.[10]

$$\begin{aligned} & i[1 - F(d_B)] - \gamma f(d_B) = 0, \\ & i[1 - F(d_G) + F(\rho_1)] - \gamma f(d_G) = 0. \end{aligned} \tag{9}$$

In equilibrium, the expected payoffs to a bank from a loan contract (d_B, d_G, γ) must equal the real gross return on the government bonds, r_b. Let the bank's expected payoffs be

$$E\pi = \alpha\pi^G + (1-\alpha)\pi^B. \tag{10}$$

Given r_b, (d_B, d_G, γ) satisfies

$$r_b = E\pi/i. \tag{11}$$

Combining (9) and (11) yeilds a marginal verification cost in each state, γ_B^* and γ_G^*, such that in the bad (good) state, each investor with $\gamma \leq \gamma_B^*(\gamma_G^*)$ receives a loan in the amount of $d_B(\gamma)i$ ($d_G(\gamma)i$) that satisfies (11).

[10] We assume $-\gamma f'(w) - if(w) < 0$ $\forall w \in [0, \bar{w}]$ and $\forall \gamma \geq 0$ to ensure the strict concavity of π^B and π^G.

4.4 Entrepreneurs' problem

A type γ investor takes the debt contract (γ, d_B, d_G) and the gross return on securities r_a as given, and decide on the initial investment scale i and reinvestment scale j. To economize on notations, d_B, i and j are all functions of γ. In stage 1, in the bad state, the investor can issue new securities against the stage 2 pledgeable income $\rho_0 j$, and so j must satisfy

$$\underbrace{j}_{reinvest} \leq \underbrace{(w - d_B)i}_{excess\,cash} + \underbrace{\frac{\rho_0 j}{r_a}}_{securities}$$

where r_a is the gross return on securities. The reinvestment scale j must not exceed the excess cash after repaying the short-term debt plus funds from issuing private securities. The reinvestment scale j can therefore be expressed in terms of the initial investment scale i,

$$j = \min\left\{\frac{w - d_B}{1 - \rho_0/r_a}, 1\right\} i. \tag{12}$$

From this expression, we can see a lower cost of financing r_a facilitates investment and reinvestment. For each investor type, the investment scale i needs to satisfy the borrowing capacity condition

$$i - A = \alpha d_G i + (1 - \alpha) d_B i, \tag{13}$$

where A is the endowment held by an investor. The amount of securities generated, or the supply of securities given r_a is

$$a^s = k \int_0^{\gamma^*} \frac{\rho_0}{r_a} E_w j(\gamma) dG(\gamma). \tag{14}$$

When the cost of refinancing r_a decreases, the investment scales i, j decline, liquidity hoarding $(w - d_B)i$ declines, and the debt repayment d_B increases.

Definition 1 Given a policy (μ, δ), a stationary equilibrium consists of real quantities of currency m, government bonds b, securities a, taxes τ_0 and τ, and gross real interest rates r_b and r_a, such that when $\frac{\phi_{t+1}}{\phi_t} = \frac{1}{\mu}$,

i) m, b and a solve the buyers' problem 8;
ii) asset markets clear;
iii) the government budget constraints hold.

Four types of equilibria are listed below and illustrated in Figure **??**. Four types of equilibria are listed below and illustrated in Figure **??**.

1. *Liquidity trap*
   In this equilibrium, $\frac{1}{\mu} = r < \frac{1}{\beta}$. Currency and interest-bearing assets are perfect substitutes. $(a+m)$ satisfies
$$u'\left[\frac{\beta}{\mu}(a+m)\right] = \iota + 1. \tag{15}$$
   Transactions in non-monitored and monitored meetings are both inefficient, where $x^n < x^*$ and $x^m < x^*$.

2. *Plentiful interest-bearing assets*:
   In this equilibrium, $\frac{1}{\mu} < r = \frac{1}{\beta}$. Gross return on interest-bearing assets equals the time preference. m satisfies
$$u'\Big(\frac{\beta}{\mu}\frac{m}{\rho}\Big) = \iota + 1, \tag{16}$$
   and $a \geq (1-\rho)x^*$. Transactions are inefficient in non-monitored meetings and efficient in monitored meetings, where $x^n < x^*$ and $x^m = x^*$.

3. *Scarce interest-bearing assets*:
   In this equilibrium, $\frac{1}{\mu} < r < \frac{1}{\beta}$. m and a satisfy (19) and
$$u'\Big(\beta r\frac{a}{1-\rho}\Big) = \frac{1}{\beta r}. \tag{17}$$
   Transactions in non-monitored and monitored meetings are both inefficient, where $x^n < x^*$ and $x^m < x^*$.

4. *Friedman rule*:
   In this equilibrium, $\frac{1}{\mu} = r = \frac{1}{\beta}$. $m \geq \rho x^*$ and $x \geq (1-\rho)x^*$. Transactions in non-monitored and monitored meetings are both efficient, where $x^n = x^m = x^*$.

4.5 Monetary policy

If the central bank increases the growth of nominal liabilities via lump sum taxation, μ increases. First, the nominal interest rate ι increases, and the gross returns on government bonds r_b increases.
$$\frac{\partial \iota}{\partial \mu} > 0, \quad \frac{\partial r_b}{\partial \mu} > 0.$$

Nominal interest rate ι increases because higher inflation causes higher cost of holding money. r_b increases as a result, because of the bank's no-arbitrage condition – the returns on holding government bonds must be high enough to compensate for not holding cash for lending.

Second, the marginal entrepreneur type in both states, γ_B^* and γ_G^*, decreases due to the increase in r_b.

$$\frac{\partial \gamma_B^*}{\partial r_b} < 0, \quad \frac{\partial \gamma_G^*}{\partial r_b} < 0$$

In order to satisfy the no arbitrage condition (11), the bank lower the requirement for loans such that more entrepreneurs are qualified. In other words, some previously qualified entrepreneurs (for short-term loans from the bank because of their bankruptcy costs γ) are now unqualified for loans because of the increased returns on government bonds. The bank is less generous about granting loans, since they can reallocate their resources to investing in government bonds.

Third, the cost of refinancing, r_a, increases, resulting in a decrease in investment scale i:

$$\frac{\partial r_a}{\partial \gamma *} < 0, \quad \frac{\partial i}{\partial \gamma *} > 0.$$

As fewer loans are extended (γ^* decreases), the entrepreneur has no other choice but to issue more private securities, increasing the supply of private liquidity. As a result, the return on private liquidity, or cost of refinancing r_a increases. As discussed before, when the cost of refinancing increases, the entrepreneur chooses a lower initial investment scale i, and hoard more liquidity $w - d$, because being more cautious about investment scale and liquidity on hand is beneficial when liquidity is more expensive.

The other kind of monetary policy is open market operations by the central government. If the central bank conducts open market purchases of government bonds, δ increases – the proportion of currency in total nominal liabilities increases. First, the gross returns on government bonds r_b decreases,

$$\frac{r_b}{\delta} < 0,$$

because when the supply of government bonds decreases, the rate of return decreases.

Second, the marginal entrepreneur type in both states γ_B^* and γ_G^*, increases due to the decrease in r_b:

$$\frac{\gamma_B^*}{r_b} < 0, \quad \frac{\gamma_G^*}{r_b} < 0.$$

As the return on government bonds decreases, banks are less reluctant to extend loans – increase in γ; therefore, some previously unqualified entrepreneurs are now qualified.

Third, the cost of refinancing, r_a, decreases, resulting in an increase in investment scale i, reinvestment scale j, and short-term debt d:

$$\frac{r_a}{\gamma^*} < 0, \quad \frac{i}{\gamma^*} > 0, \quad \frac{j}{\gamma^*} > 0, \quad \frac{d}{\gamma^*} > 0.$$

As banks are more generous with loans – d increases, entrepreneurs want to issue less private securities, thus less supply of private liquidity. As a result, the return on private securities r_a decreases. This translates to lower costs of refinancing, and entrepreneurs choose to increase investment scales.

4.6 Moral hazard

There are three equilibria based on agents' expectation of the government's policy. If agents anticipate central bank to take a soft stance (increase in δ): central bank conducts OMO to lower r_a and support refinancing. They take on larger amount of short-term debt, expand the initial investment scale, and hoard little liquidity. When the economy is in a Bad state, the central bank has no choice but to help out. If Agents expect central bank to take a tough stance. They choose a smaller scale and hoard enough liquidity. In bad state, the central bank does not need to help out banks.

4.7 Strategic complementarities

Strategic complementarities: an amplification mechanism. When some players expose themselves to liquidity risk, strategic complementarities manifest themselves in the increased willingness of other actors to take on more liquidity risk.

5 Conclusion

This paper proposes a new channel through which monetary policy affects returns on securities. Monetary policy affects the design of short-term debt contracts and types of entrepreneurs who get loans. The change in debt affects issuance of securities. Bailouts are associated with higher interest rates. Bailouts are associated with larger investment scale, lower liquidity hoarding, and higher level of short-term debt and securitization.

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6 Appendix

6.1 Monetary Equilibrium

6.1.1 Banks and buyers

Substitute the budget constraint and the DM value function in the CM value function

$$\begin{aligned} W(m,a) &= \max_{m',a'} -H + \beta V(m',a') \\ &= \max_{m',a'} -\frac{\phi}{\phi'}(m'+a') + m + ra + \tau + \beta V(m',a') \\ &= \max_{m',a'} -\frac{\phi}{\phi'}(m'+a') + m + ra + \tau + \beta[\rho S(x^{n\prime}) + (1-\rho)S(x^{m\prime}) + W(m',a')] \end{aligned}$$

Due to the linearity of W, we know that $W(m,a) = m + ra$

$$W(0,0) = \max_{m',a'} -\frac{\phi}{\phi'}(m'+a') + \tau + \beta[\rho S(x^{n\prime}) + (1-\rho)S(x^{m\prime}) + m' + r'a' + W(0,0)]$$

Divide both sides by β and simplify, the banks' problem becomes:

$$\max_{m',a'}(1 - \frac{\phi}{\beta\phi'})m' + (r' - \frac{\phi}{\beta\phi'})a' + [\rho S(x^{n\prime}) + (1-\rho)S(x^{m\prime})]$$

For finite (m', a') to exist, $\frac{\phi'}{\phi}$ and r' must satisfy

$$1 - \frac{\phi}{\beta\phi'} \leq 0 \text{ and } r' - \frac{\phi}{\beta\phi'} \leq 0$$

6.1.2 Banks and entrepreneurs

Expected profit from lending to a type γ entrepreneur is

$$\pi(R,\gamma) = \int_0^R w - \gamma \, dF(w) + R\Big(1 - \int_0^R dF(w)\Big).$$

Take the first-order condition with respect to R,

$$1 - \gamma f(R) - F(R) = 0.$$

The bank must be indifferent between holding government bonds and extending private loans. Given the gross return on government debt r,

$$r = \pi(R,\gamma).$$

Solve the two equations to get the verification cutoff point γ^*. An entrepreneurs γ gets a loan only if $\gamma \leq \gamma^*$. The debt repayment is $R(\gamma) = r$. Given r, the quantity of private loans generated is therefore

$$L(r) = \alpha G(\gamma^*)$$

.

6.1.3 Equilibrium

The market for interest-bearing assets clear

$$a = m(\frac{1}{\delta} - 1) + L(r);$$

In a stationary equilibrium where $\frac{\phi'}{\phi} = \frac{1}{\mu}$ and $r' = r$, the following four types of equilibria satisfy the conditions above.

Four types of equilibria are listed below and illustrated in Figure 3.

1. *Liquidity trap*
   In this equilibrium, $\frac{1}{\mu} = r < \frac{1}{\beta}$. Currency and interest-bearing assets are perfect substitutes. $(a+m)$ satisfies

$$u'\Big[\frac{\beta}{\mu}(a+m)\Big] = \iota + 1. \tag{18}$$

   Transactions in non-monitored and monitored meetings are both inefficient, where $x^n < x^*$ and $x^m < x^*$.

2. *Plentiful interest-bearing assets*:
   In this equilibrium, $\frac{1}{\mu} < r = \frac{1}{\beta}$. Gross return on interest-bearing assets equals the time preference. m satisfies

$$u'\left(\frac{\beta}{\mu}\frac{m}{\rho}\right) = \iota + 1, \tag{19}$$

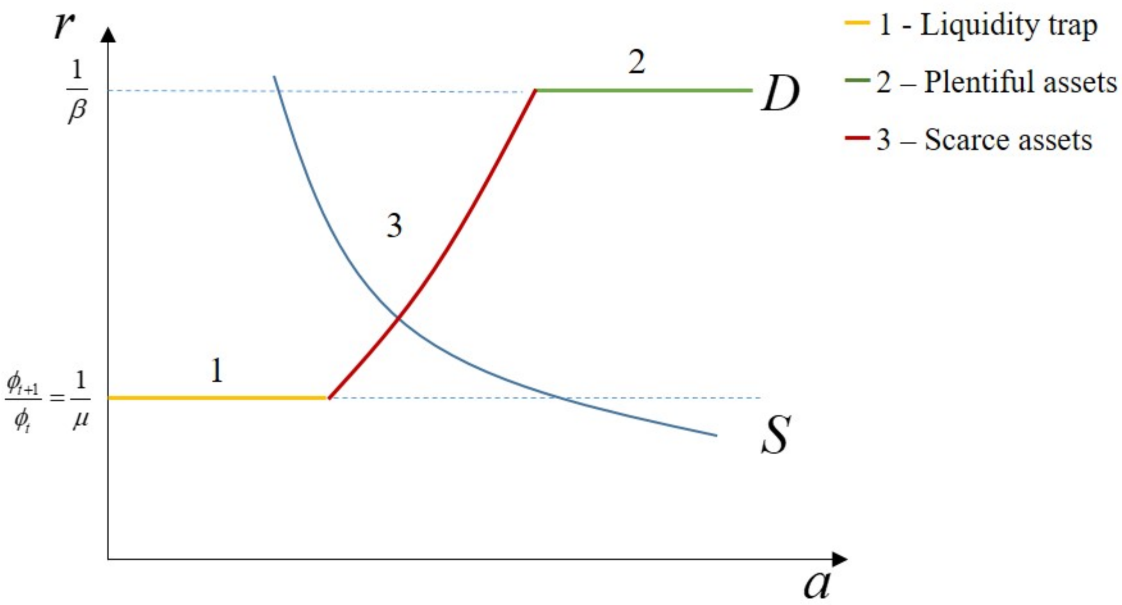
   and $a \geq (1-\rho)x^*$. Transactions are inefficient in non-monitored meetings and efficient in monitored meetings, where $x^n < x^*$ and $x^m = x^*$.

3. *Scarce interest-bearing assets*:
   In this equilibrium, $\frac{1}{\mu} < r < \frac{1}{\beta}$. m and a satisfy (19) and

$$u'\left(\beta r \frac{a}{1-\rho}\right) = \frac{1}{\beta r}. \tag{20}$$

   Transactions in non-monitored and monitored meetings are both inefficient, where $x^n < x^*$ and $x^m < x^*$.

4. *Friedman rule*:
   In this equilibrium, $\frac{1}{\mu} = r = \frac{1}{\beta}$. $m \geq \rho x^*$ and $x \geq (1-\rho)x^*$. Transactions in non-monitored and monitored meetings are both efficient, where $x^n = x^m = x^*$.



6.2 Noncontingent loan contract

Similar to the equilibrium in Williamson (1987), the entrepreneur's expected profit is

$$\pi_e(R,\gamma) = \int_{\underline{\xi}}^{\bar{\xi}} \int_{R-\xi}^{\bar{w}-\xi} w \, dF(w)dH(\xi) - R \int_{\underline{\xi}}^{\bar{\xi}} \int_{R-\xi}^{\bar{w}-\xi} dF(w)dH(\xi). \tag{21}$$

The entrepreneur's expected profit decreases monotonically with R. Therefore, given the same expected profit, the bank will choose the lower R, and therefore, $R < \hat{R}$.

6.3 Marginal entrepreneur

In Figure 4, we can see that the expected return $\pi(R,\gamma)$ decreases in γ. A bank is willing to extend loans to an entrepreneur with verification cost γ as long as the highest expected return from him is not lower than r. γ^*, the verification cost of a marginal entrepreneur, is therefore determined when π is maximized and is equal to r. Entrepreneurs with $\gamma \leq \gamma^*$ receive loans with repayment $R(\gamma)$. The repayment $R(\gamma) < R^*$ is determined for each type $\gamma < \gamma^*$.

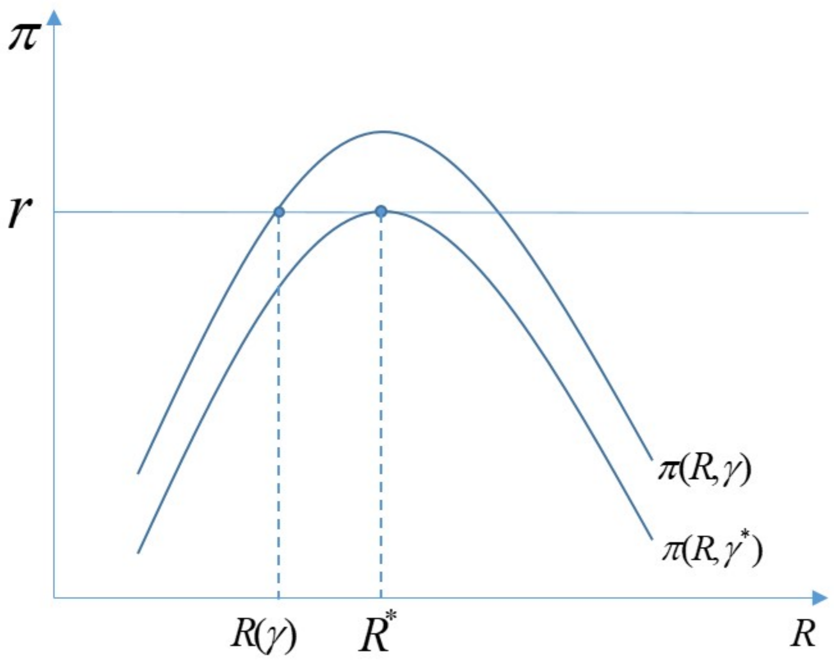


Figure 4: Loan contracts

In equilibrium, the quantity of private loans is

$$L = L(r) = \alpha G(\gamma^*)$$

When r increases from r_1 to r_2, banks lower the cutoff verification cost from $\gamma^*(r_2)$ to $\gamma^*(r_1)$, because they need to make higher expected returns from the entrepreneurs with lower verification costs. Therefore, a smaller amount of entrepreneurs with lower verification costs get loans from the bank.

$$\alpha G(\gamma_1^*) = L(r_1) > L(r_2) = \alpha G(\gamma_2^*) \tag{22}$$

Therefore, $L(r)$ decreases in r.

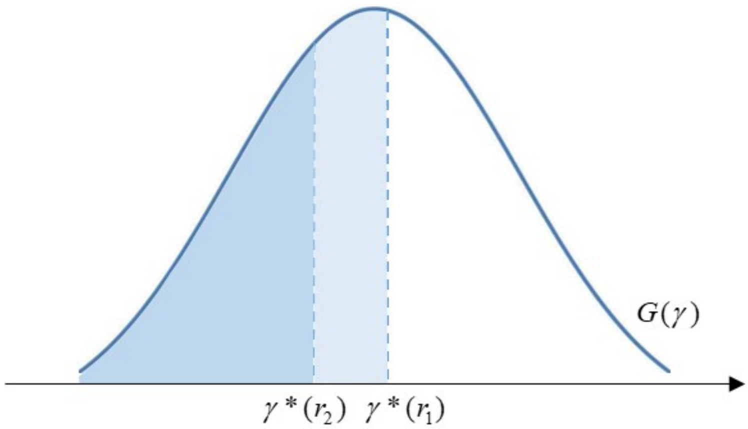


Figure 5: The quantity of private liquidity

6.4 Comparative statics

The following table shows the comparative statics when the government conducts an open-market purchase of government bonds, where δ increases, and when there is an increase in the growth rate of the total nominal liabilities, where μ increases.

	policy	x^n	x^m	r	price
1 - liquidity trap	$\delta\uparrow$	$=$	$=$	$=$	$=$
	$\mu\uparrow$	$\downarrow$	$\downarrow$	$\downarrow$	$\uparrow$
2 - plentiful assets	$\delta\uparrow$	$=$	$=$	$=$	$\uparrow$
	$\mu\uparrow$	$\downarrow$	$=$	$=$	$\uparrow$
3 - scarce assets	$\delta\uparrow$	$\downarrow$	$\downarrow$	$\downarrow$	$\uparrow$
	$\mu\uparrow$	$\downarrow$	$\downarrow$	$\downarrow$	$\uparrow$

6.5 Lower bound

In a stationary equilibrium, σ and b satisfy

$$\sigma \leq \lambda_1 x, \quad b \leq \lambda_2 x.$$

From the definition of δ

$$\frac{m}{m+b} = \delta,$$

we know

$$b = (\frac{1}{\delta} - 1)m \leq \lambda_2 x.$$

Therefore,

$$\delta \geq \frac{m}{\lambda_2 x + m}.$$

From

$$\frac{m}{\delta}(1 - \frac{1}{\mu}) = \sigma \leq \lambda_1 x,$$

we derive

$$\delta \geq \frac{m(1-\frac{1}{\mu})}{\lambda_1 x}$$

$$\delta \geq \min\left\{\frac{m}{\lambda_2 x + m}, \frac{m(1-\frac{1}{\mu})}{\lambda_1 x}\right\}$$