On Reaching for Yield and the Coexistence of Bubbles and Negative Bubbles[1]

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Abstract

We develop a model of financial intermediation wherein bank managers "reach for yield" – by overinvesting in risky assets and underinvesting in safer assets – provided they do not face much cost from liquidity shortfalls. The managers follow a pecking order in which their first preference is to invest in risky assets; their second preference is to hoard liquid assets; and their last preference is to invest in safer assets. This behavior is conducive to the formation of bubbles and "negative" bubbles in the market for risky and safer assets, respectively. Monetary loosening, by reducing the cost of liquidity shortfalls, induces further reach for yield and amplifies the bubbles.

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1 Introduction

There is growing concern that banks may have perverse incentives to "reach for yield" especially in a low interest rate environment (e.g., Rajan, 2006; Stein, 2013; Yellen, 2011). Reaching for yield can heuristically be defined as the propensity to invest in riskier assets to achieve higher yields. It has been argued that such behavior is usually a by-product of the loose monetary policies adopted by the central banks and can distort asset prices (e.g., Rajan, 2013). Borio and Zhu (2012) concede that a *fuller understanding (of such a risk-taking channel) calls for an exploration to its link to "liquidity."*

In this paper, we develop a model to study the incentives of banks to reach for yield when they have access to abundant liquidity and analyze its implications for asset prices. Similar to Acharya and Naqvi (2012), we define liquidity as the total investment funds available to the bank. This is because cash reserves in our model are endogenous and determined by the amount of investment funds available to the bank. Hence, instead of referring to the endogenous outcome (i.e., cash reserves) as liquidity, we refer to its driver (i.e., investment funds) as liquidity.

More specifically, we study how banks allocate credit to risky loans versus safer loans. The concern is that in periods when financial conditions are less restrictive, the abundance of liquidity might incentivize banks to misallocate credit by reaching for yield. Indeed, the International Monetary Fund's Global Financial Stability Report (2018) states that the riskiness of credit allocation (i.e. the extent to which riskier firms receive credit relative to less risky ones) increased globally in the years preceding the global financial crisis of 2008 and peaked shortly before its onset. It declined sharply during the crisis but rebounded to its historical average in 2016 (the latest available year for globally comparable data). The country-level data for advanced and emerging economies (e.g., United States, United Kingdom, Korea, and India) exhibit similar patterns, albeit for some countries the rise in riskiness has been more pronounced. Although withdrawal of monetary stimulus has begun in several advanced economies, financial conditions still remain loose and spreads remain compressed by historical standards.

To better understand the portfolio allocation decision of banks, we build a model based on an agency problem inside banks. As argued by Stein (2002), the basic incentive problem stems from the fact that loan officers are tasked with allocating the bank's capital based on private information and risk-assessments that are not verifiable by the bank. The U.S. Office of Comptroller of Currency (1988) found that many of the difficulties experienced by banks resulted from the imprudent loan policies of managers. In our model, we solve for the managerial compensation contract offered to the manager. We show that managerial compensation is based on lending volume and that managers receive larger bonuses for processing riskier loans since the effort cost related to screening and monitoring is higher than for safer loans.[1] Nevertheless, if the principal conducts a (costly) audit and verifies that the manager misallocated credit, then the principal can impose a penalty on the manager. Since audits are costly, they are only conducted if the bank suffers from significant liquidity shortfalls.

We then show that managers have an incentive to reach for yield by overinvesting in risky assets and underinvesting in safer assets as long as the bank has access to sufficient liquidity. Intuitively, the presence of abundant liquidity acts like an insurance against the possibility of liquidity shortfalls. Thus, when a bank is flush with liquidity, a manager has an incentive to reach for yield since he realizes that ex post a principal will have no incentive to conduct a costly audit unless there are significant liquidity shortfalls.

We show that the manager's investment preferences follow a certain pecking order: his first preference is to invest in risky assets (as they potentially yield higher bonuses); his second preference is to hold cash or cash equivalents (so as to provide a buffer against liquidity shortfalls or "runs"); and his last preference is to invest in safer assets (since such assets yield lower or zero bonuses and are not as good a hedge against runs as cash or cash equivalents). It follows that in the presence of an agency problem, the manager invests the minimum possible amount in the safer

[1] Risky assets/loans can be interpreted as loans to non-investment grade firms while loans to investment grade firms can be considered as safer assets. However, the safest assets are liquid assets like cash or cash equivalents (e.g., Treasury bills).

asset. Intuitively, overinvestment in the risky asset crowds out investment in the safer asset.

When considering the asset-pricing implications of our model, we show that when a bank is flush with liquidity, the reaching-for-yield behavior of the manager is conducive to the formation of bubbles in the market for risky assets, along with the formation of a "negative bubble" in asset prices in the market for safer assets. In other words, risky assets tend to be overpriced while safer assets are underpriced when banks have access to abundant liquidity. We thus show that bubbles and negative bubbles can coexist in different markets due to the underlying agency problems in financial intermediaries.

We also analyze the role of monetary policy in influencing the investment decisions of bank managers. We show that a loose monetary policy encourages reaching for yield in two ways. First, a monetary loosening by increasing the pool of liquidity available to the bank lowers the likelihood of liquidity shortfalls, which in turn lowers the probability that the principal will have to conduct a costly audit for any given audit policy. Second, in our model the audit policy itself is endogenous and is a function of monetary policy. A loose monetary policy lowers the likelihood of liquidity shortfalls and induces the principal to adopt a lax audit policy. These effects reinforce each other and incentivize the manger to reach for yield. Hence, by linking the strictness or leniency of the audit policy to the monetary policy, our model provides another mechanism for the risk-taking channel of monetary policy.[2]

2 The Model

2.1 The setup

We consider a model of a bank with three periods. At $t = 0$, risk-neutral investors deposit an endowment of 1 unit each in the bank. There are a total of I investors,

[2] Our model is thus consistent with why lax monetary policy by the Scandinavian Central Banks in 1980's, Bank of Japan during 1986-1987, and the U.S. Federal Reserve during the latter phase of the Greenspan era coincided with housing and real estate bubbles in these countries.

and thus the bank receives I units of investment funds in the initial period. For the purpose of the model, we interpret I as the "liquidity" available to the bank at $t = 0$. As in Kashyap and Stein (1995), the investment funds are a function of monetary policy such that bank liquidity increases under a loose monetary policy but decreases under a tight monetary policy. Let ρ_C denote a measure for monetary policy set by the central bank at $t = 0$, where ρ_C can be interpreted as the yield on Treasury bills. Hence a monetary tightening increases ρ_C while a monetary loosening decreases ρ_C. It follows that $I'(\rho_C) < 0$.

Each investor has a reservation utility of $\bar{u}$. Hence, the bank needs to ensure that the rate of return earned by investors or the promised yield, ρ_I, is such that investors earn an expected profit of at least $\bar{u}$. We assume that investors are rational and when offered a contract, they can determine whether ρ_I is high enough to satisfy their reservation utility.[3]

After receiving investment funds, the bank makes investments in projects while setting aside a fraction of the funds received in the form of cash or cash equivalents, C. We assume that the cash reserves are invested in Treasuries and earn a rate of return, ρ_C, which is realized at $t = 2$. Alternatively, we can consider the case where a fraction of reserves are invested in Treasuries and the rest are held as cash. Our results remain the same under both the cases.

The bank can invest in two types of projects: "risky" projects or "safe" projects. Throughout the model, for consistency with most of the literature, we classify projects into "risky" and "safe". However, it should be noted that the "safe" project is not completely risk-free and it is safe only relative to the risky project. Investment in risky projects can be interpreted as loans to non-investment grade firms while investment in safe projects can be interpreted as loans to investment grade firms.

Both project types either succeed or fail at $t = 2$. The bank is hit by a macroeconomic shock with probability $1 - \theta$, in which case both types of projects fail and the bank is insolvent. For simplicity, we assume that the bank is solvent and hence able to pay back the promised return to its investors (with probability θ) as long as

[3] Alternatively, we can assume that the required risk premium (that satisfies investor rationality), $\kappa = \rho_I - \bar{u}$, is public information.

it is not hit by a macroeconomic shock.

If the bank is solvent, then the risky projects succeed with probability p but fail with probability $1-p$. In the case of failure, the risky projects yield a liquidation value of y as long as the bank is not hit by a macroeconomic shock. More precisely, the probability distribution of the returns of the risky projects is given as follows:

$$\tilde{\rho}_R = \begin{cases} \rho_R & \text{with probability } \theta p \\ y & \text{with probability } \theta(1-p) \\ 0 & \text{with probability } 1-\theta \end{cases}, \tag{1}$$

where ρ_R is the (gross) rate of return from the risky projects charged by the bank. The probability distribution of the returns of the safe projects is given by:

$$\tilde{\rho}_S = \begin{cases} \rho_S & \text{with probability } \theta \\ 0 & \text{with probability } 1-\theta \end{cases}, \tag{2}$$

where ρ_S is the (gross) rate of return from the safe projects charged by the bank. Since $p < 1$, the safe projects have a higher probability of success.

After receiving the investment funds, I, the bank observes θ and p and chooses the lending rates, ρ_i for $i = R, S$, which is the (gross) rate of return on the risky and safe projects, respectively. When setting the lending rates, the bank takes into account the demand function for loans, which is given by $L(\rho_i)$, where $L'(\rho_i) < 0$. The cash holdings of the bank are the residual after it makes all of its investments in the risky and safe projects:

$$C = I - L_R - L_S, \tag{3}$$

where for brevity $L_R = L(\rho_R)$ is the loan demand for the risky assets and $L_S = L(\rho_S)$ is the loan demand for safe assets.

2.2 Liquidity shortfalls

Similar to Diamond and Dybvig (1983), a fraction of the investors, given by $\tilde{x} \in [0,1]$, experience liquidity shocks and withdraw early at $t=1$. The cumulative distribution function of $\tilde{x}$ is given by $F(x)$ while the probability density function is given by $f(x)$. Each investor who withdraws early receives 1 unit of his endowment back at $t=1$. It follows that the total withdrawals at $t=1$ are given by $\tilde{x}I$. If the total withdrawals exceed the amount of cash holdings, C, then the bank suffers a penalty cost, which can be interpreted as a cost of premature liquidation of assets in order to service withdrawals. The penalty cost suffered by the bank in the event of a liquidity shortfall is given by:

$$\Psi = \begin{cases} \rho_S^p (xI - C) & \text{if } C < xI \leq C + L_S \\ \rho_S^p L_S + \rho_R^p (xI - C - L_S) & \text{if } xI > C + L_S \end{cases}, \tag{4}$$

where $\rho_R^p > \rho_R > \rho_C > 1$, $\rho_S^p > \rho_S > \rho_C > 1$, and $\rho_R^p > \rho_S^p > \rho_C > 1$. The interpretation of the above formulation is as follows: when the total withdrawals, xI, are greater than the bank's cash holdings, C, but less than the sum of cash holdings and the amount invested in safe assets, $C + L_S$, then the bank does not need to liquidate the risky assets (which have a higher liquidation cost) and there will be partial or total liquidation of the safe assets in order to service withdrawals. The per unit cost of liquidating the safe asset is ρ_S^p, hence the penalty cost suffered by the bank will be $\rho_S^p (xI - C)$. However, if the total withdrawals, xI, exceed the sum of cash holdings and the amount invested in the safe assets, $C + L_S$, then the bank would need to completely liquidate the safe assets and it would also need to resort to partial or total liquidation of the risky assets, in order to meet the liquidity demands of its investors. The per unit liquidation cost of risky assets is given by ρ_R^p, thus the total penalty cost suffered by the bank in this case would be given by $\rho_S^p L_S + \rho_R^p (xI - C - L_S)$.

In other words, the above formulation implies that the risky assets have a higher default risk as well as a higher liquidity risk since the cost of prematurely liquidating the risky assets is higher than for safe assets. Hence if the bank suffers a liquidity shortfall, then it initially prefers to cover the shortfall by liquidating the safe assets. However, if the number of withdrawals is large enough, the bank will need to liquidate its risky assets. The implication is that the penalty cost of liquidity shortfalls increases with the amount of withdrawals.

2.3 Bank manager

Let us suppose that the bank's lending decisions are made by a manager or a loan officer. The manager needs to exert effort to provide loans and make investments. As discussed by Heider and Inderst (2012), the job of the modern day loan officer is threefold: the loan officer not only does "screening" and "monitoring" but increasingly spends a lot of time in prospecting or "marketing" for new loans. In this context, a higher marketing effort leads to an increased demand for loans. A higher loan demand means that the loan officer has to spend more screening effort to process the loans. Arguably, the marketing effort for both risky and safe loans generates a similar amount of new loans. However, since the screening effort is significantly higher for risky loans, the overall effort cost of making risky loans exceeds that of making safe loans. Once the loans are processed, the manager must monitor the loans and the monitoring effort is also significantly higher for risky loans than for safe loans.

Let e_R and e_S denote the overall effort cost of making risky loans and safe loans respectively. It follows that $e_R > e_S$. Without loss of generality, we normalize $e_S = 0$.[4] Since $e_S = 0$, we simplify our notation and write $e_R = e$, thereby suppressing the subscript R. Henceforth, e refers to the effort cost of making risky investments. We assume that the choice of effort is binary, whereby $e \in \{e^H, e^L\}$. In other words, the manager can either exert high effort, e^H, or low effort, e^L, where $e^H > e^L$.

There is asymmetric information between the principal and the manager such that the effort level of the manager is unobservable. We assume that, although the risky loans are affected by effort, they are not fully determined by it. This

[4] This simplifies the analysis. Nevertheless, all of our qualitative results are unchanged as long as $e_R > e_S$.

stochastic relation is necessary to ensure that effort level remains unobservable. More formally, we assume that the distribution of risky loan demand $L(\rho_R)$ conditional on e^H first-order stochastically dominates the distribution conditional on e^L. In other words, for a given lending rate, the manager on average makes a higher volume of risky loans when he exerts high effort relative to when he exerts low effort, i.e., $E[L(\rho_R)|e_H] > E[L(\rho_R)|e_L]$.[5] We assume that it is in the interest of the principal to implement high effort.[6]

The manager earns an income, b, where $b = b_R + b_S$. The managerial income b can be interpreted as bonuses, where b_R is the bonus earned from processing risky loans while b_S is the bonus earned from processing safe loans. The manager faces a penalty cost, ψ, if the principal conducts an audit and it is revealed that the manager had mispriced the loans by either setting the lending rates too high or too low relative to the case that maximizes the owner's expected profits. Then in the context of an agency problem, a manager is said to be reaching for yield when he takes excessive risk relative to the level that maximizes the expected profits of the bank. Hence, subsequent to an audit, if it is revealed that the manager had reached for yield, then he is imposed a penalty cost, ψ. The managerial penalty is some fraction, γ, of the penalty cost incurred by the bank due to liquidity shortfalls. The manager has limited liability and thus the maximum penalty that can be imposed on the manager is given by $\bar{\psi}$. It follows that the managerial penalty is given by $\psi = \min\left(\bar{\psi}, \gamma\Psi\right)$, where $\gamma \in (0, 1]$. Thus, the net wage earned by the manager is given by $w = b_R + b_S - \psi$. The manager's utility function is given by $u(w, e) = v(w) - e$, where $v'(w) > 0$, $v''(w) < 0$ and his reservation utility is denoted by u^o.

Audits are costly and the cost of an audit is given by z. The probability that

[5] Stated differently for the same price and quality, a manager can sell more units on average if he exerts high effort. This implies that the demand function for risky loans shifts outwards when the manager exerts a high level of effort.

[6] The case where the principal wants to implement low effort is uninteresting because it is simple to show that once we consider asymmetric information, this can be implemented by simply offering a fixed wage to the manager. This is optimal only if the gains from the lower wage costs of inducing low effort outweigh the costs associated with lower profits. In practice, managers' wages are not fixed and they are often given an incentive to exert high effort. Henceforth, we only consider the interesting case where the principal finds in its interest to implement high effort.

the principal will conduct an audit is denoted by ϕ. The audit policy needs to be time-consistent. In other words, even though the principal would like to commit to a tough audit policy but because conducting audits is costly, it does so ex post only if it is desirable at that time. This inherent conflict between ex ante incentives and ex post actions is referred to by Tirole (2006) as the "topsy-turvy principle."

The manager can observe the quality of the projects, θ and p, as well as the specific level of investment funds available to the bank, I, at the time of setting the loan rate. However, this information is unavailable to the principal at the time of setting the contract. Hence, the principal cannot infer whether or not the manager has set the appropriate lending rates, which maximize expected profits (unless the principal conducts an audit at $t = 1$). We assume that the principal can observe the distribution of investment funds (instead of its exact level) conditional on the monetary policy stance, ρ_C, which is given by $J(I|\rho_C)$ and that the liquidity of a bank is non-verifiable ex post. This is plausible given that in practice managers have a lot of leeway regarding where to "park" their funds. For instance, some of the liquidity can be lent to other banks while at the same time the liquidity of other banks can also make its way to the bank in question. Moreover, during the past two decades, financial institutions have sharply expanded their off-balance sheet activities due to the pace of financial innovation. Such off-balance sheet items are particularly difficult to verify.[7] Examples of off-balance sheet liquidity include financing commitments, repurchase agreements, guarantees, foreign currency accruals and receivables, and exposure to special purpose vehicles, among others.

2.4 Timeline

The timeline of events is summarized in Figure 1. The chronology of events at $t = 0$ is as follows. The principal offers a contract to the manager such that high effort levels are chosen; the manager chooses effort levels; the manager receives investments, I, and observes the riskiness of the projects, θ and p; and subsequently the manager

[7] Buljevich and Park (1999) report that by the end of 1991, the top ten U.S. commercial banks carried off-balance sheet related liabilities almost seven times that of their total combined assets.

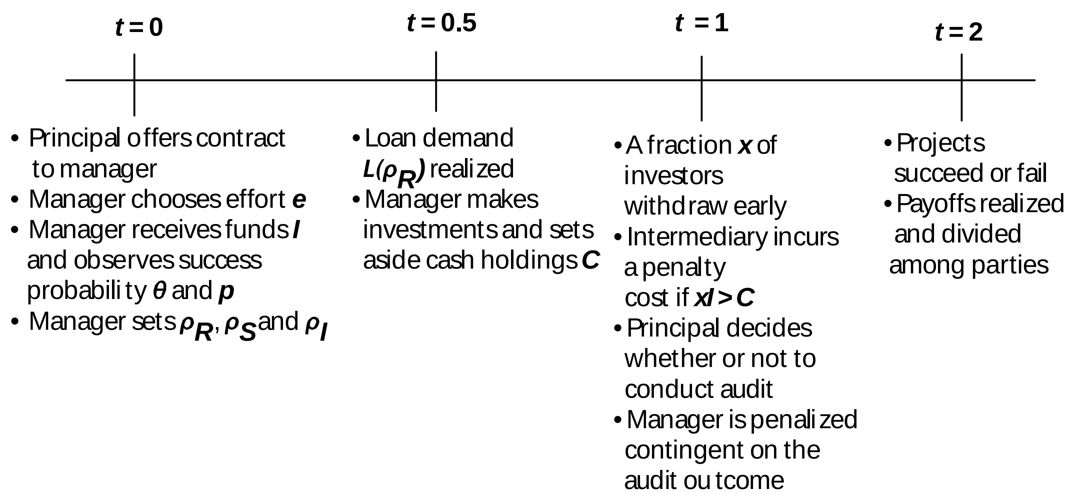

Figure 1: Timeline of events under asymmetric information.

sets the loan rates, ρ_S and ρ_R, as well as the rate of return on investments, ρ_I. At $t = 0.5$, for a given level of ρ_R, the loan volume $L(\rho_R)$ is realized, and cash holdings are set aside. At $t = 1$, the bank could experience early withdrawals and in case of a liquidity shortfall, the bank incurs a penalty cost. The principal then decides whether or not to conduct an audit. If an audit is conducted, the manager may or may not be penalized depending on the outcome of the audit. Finally, at $t = 2$, the project payoffs are realized and divided amongst the parties given the contractual terms.

At the time of contracting, the manager has not yet received investment funds and he sets the lending rate only after funds have been received and after observing the project's risk. This implies that when setting the lending rate, the manager takes into account the level of the bank's liquidity, I, macroeconomic risk, θ, and specific risk of the risky projects, p. However, this information is not available to the principal at the time of contracting, hence the principal cannot enforce the optimal lending rates via an incentive compatible condition.

2.5 Optimal managerial compensation

The contract that the principal offers the manager specifies the manager's compensation in the form of bonuses, b_i for $i = R, S$, penalties, ψ, as well as the audit policy, ϕ. The audit policy is the likelihood with which the principal audits at $t = 1$ contingent on the different scenarios. Because an audit is costly, we consider time-consistent policies only. Moreover, when computing the optimal compensation scheme, the principal anticipates outcomes over different realizations of liquidity levels, I.

Let Π denote the expected profit of the bank gross of the managerial compensation and audit costs conditional on high effort exerted by the manager. Then,

$$\Pi = \pi - E\left[\Psi | e = e^H\right], \tag{5}$$

where $E(\cdot)$ is the expectations operator over the range of values of x, L_R, and I and π is given by:

$$\begin{aligned} \pi \quad = \quad & \theta\{\rho_S L(\rho_S) + [p\rho_R + (1-p)y] E\left[L(\rho_R) | e = e^H\right] \\ & -\rho_I I(1 - E(\tilde{x})) + \rho_C E\left[\max(C - \tilde{x}I, 0) | e = e^H\right]\}. \end{aligned} \tag{6}$$

Equation (6) represents the expected operational profit of the bank. With probability $(1 - \theta)$, profits are zero since the bank is insolvent. With probability θ, the bank is solvent, in which case the safe project gives the promised return of $\rho_S L(\rho_S)$ while the risky project gives a rate of return of ρ_R in case of success but yields the liquidation value y per unit in the case of failure. With a probability of $E(\tilde{x})$, an investor withdraws his funds early and he receives a payoff of 1. Thus the expected number of investors who do not withdraw early is given by $I(1 - E(\tilde{x}))$ and $\rho_I I(1 - E(\tilde{x}))$ represents the cost of servicing these investors as long as the bank is solvent. The last term in Equation (6) is the expected value of the net cash holdings, if any, at time $t = 2$. Thus, in the case of solvency the bank's expected operational profit is given by the expected return from the projects minus the expected cost of investments $(\rho_I I[1 - E(\tilde{x})])$ plus the expected value of net cash holdings at the end of the period. It follows that Equation (5) represents the expected operational profit of the bank net of the expected penalty cost.

To determine the optimal managerial compensation scheme, the principal needs to solve the following program:

$$\max_{b_R, b_S, \psi, \phi} \Pi - E\left(b_R + b_S - \psi\right) - E\left(z\right), \tag{7}$$

subject to

$$E\left[v\left(b_R + b_S - \psi\right)\right] - e \geq u^o, \tag{8}$$

$$E\left[u|e^H\right] > E\left[u|e^L\right], \tag{9}$$

$$\psi \leq \min\left(\bar{\psi}, \gamma\Psi\right), \tag{10}$$

and

$$\phi \in [0, 1]. \tag{11}$$

In the above program the principal chooses a compensation schedule so as to maximize its expected profits minus the expected compensation of the manager and the expected audit costs subject to a number of constraints. Constraint (8) is the participation constraint, which states that the manager's expected utility must be at least equal to his reservation utility. Constraint (9) is the incentive compatibility constraint for inducing high effort. Constraint (10) is the limited liability constraint and states that the managerial penalty cannot exceed $\bar{\psi}$. By definition this constraint holds with equality.[8] Finally, constraint (11) imposes the condition that the audit probability lies between zero and one.

Let $\ell = \max\left(xI - C, 0\right)$ represent the liquidity shortfall of the bank, if any. We can then prove Proposition 1.

Proposition 1 *The managerial compensation contract is such that bonuses for processing riskier loans, b_R, are increasing in the loan volume of risky loans, L_R. However, the bonuses for processing safe loans, b_S, are constant and thus do not vary with the*

[8] An upper bound on managerial penalty is plausible given that if the penalty were extremely large it would not only violate the limited liability of the manager but also an extremely large penalty would fail to satisfy the participation constraint of a risk-averse manager.

loan volume of safe loans, L_S. Moreover, the principal conducts an audit at $t = 1$, if and only if, the liquidity shortfall, ℓ, incurred by the bank exceeds some threshold ℓ^*.[9] *In other words, the optimal audit policy contingent on the realization of liquidity shortfall, ℓ, is given by:*[10]

$$\phi|\ell = \begin{cases} 1 \text{ if } \ell > \ell^* \\ 0 \text{ otherwise} \end{cases} . \tag{12}$$

The intuition is as follows. Managerial bonuses are increasing in risky investments because the manager needs to be incentivized for exerting effort. On the other hand, since the manager does not need to exert effort to make safe investments, he receives a fixed compensation for investing in safe assets irrespective of the loan volume of such assets.[11] By verifying whether or not the manager had reached for yield when liquidity shortfalls are substantial ($\ell > \ell^*$) and punishing him with the maximum penalty if it is inferred that he had misallocated resources, the principal discourages the agent from setting suboptimal loan rates. Importantly, if there are no liquidity shortfalls or liquidity shortfalls are sufficiently low ($\ell < \ell^*$), then that sends a signal to the principal that the manager was less likely to have reached for yield and to have reserved sufficient liquidity. Thus, in the absence of liquidity shortfalls, the expected 'return' to the principal from incurring the cost of an audit is inadequate. This implies that there is no incentive ex post to conduct an audit unless liquidity shortfalls are sufficiently large.

More generally, the rationale behind the above contract is as follows. The realized profit of the bank is a function of many random variables, including the realization of bank liquidity, macroeconomic risk, the proportion of depositors who run, and the

[9] More generally, as shown in the proof of proposition 1 in the Online Appendix, an audit will take place if the cost incurred of covering total liquidity shortfalls is high enough (which will be the case if the liquidity shortfall, ℓ, is high enough).

[10] One can interpret $\phi|\ell$ as the ex post audit probability, i.e., contingent on the realization of ℓ the audit probability is equal to one if $\ell > \ell^*$ and zero otherwise. Thus the ex ante audit probability at $t = 0$ is given by $\Pr(\ell > \ell^*)$.

[11] In the case where the manager had to exert effort to make safe investments, his bonuses for investing in safe assets would also be increasing in the loan volume of safe loans. Nevertheless, his bonuses for making safe investments would be lower vis-à-vis his bonuses for investing in risky assets as long as risky investments required more effort. This is likely to be the case given that making risky investments entails higher screening and monitoring costs.

loan volume. However, the manager's actions only directly influence the loan volumes (and the resulting liquidity shortfalls if any) since the other variables are not in the manager's control. Thus a contract that conditions the manager's compensation on a variable other than loan volume and liquidity shortfalls (e.g., profitability) will be inefficient due to the unnecessary risk that will be passed to a risk-averse manager, resulting in a high contractual cost. Thus, similar to Hölmstrom (1979), the optimal contract trades off the risk-sharing benefits with the provision of managerial incentives.

The presence of a potential penalty upon audit creates a trade-off for the manager. The manager can increase his payoffs by making more risky investments. An increase in the volume of risky investments will crowd out the volume of safe investments. Since the manager receives a fixed compensation from making safe investments, he has an incentive to reduce the volume of safe investments but increase the volume of risky investments so as to increase his total compensation. However, an increase in the volume of risky investments can trigger a liquidity shortfall and subsequently the manager faces the risk of being audited and penalized.

2.6 Benchmark case with no agency problem

In the presence of asymmetric information, if the manager does not reach for yield and acts in the interest of the principal, then he solves the following problem for a given realization of I:

$$\max_{\rho_R,\rho_S,C,\rho_I} \pi - \hat{E}\left[\Psi | e = e^H\right] - \hat{E}\left[b + z | e = e^H\right], \tag{13}$$

subject to the participation constraint:

$$\hat{E}\left(\tilde{x}\right) + \left(1 - \hat{E}\left(\tilde{x}\right)\right)\left[\theta\rho_I + (1-\theta)\frac{\rho_C \hat{E}\left[\max\left(C - \tilde{x}I, 0\right) | e = e^H\right]}{\left(1 - \hat{E}\left(\tilde{x}\right)\right) I}\right] \geq \bar{u} \tag{14}$$

and the budget constraint:

$$L(\rho_R) + L(\rho_S) + C = I, \tag{15}$$

where $\hat{E}$ represents the expectation operator over the range of values of x and L_R and π is given by Equation (6).

With a probability of $\hat{E}(\tilde{x})$, an investor withdraws his funds early, in which case he receives a payoff of 1.[12] With a probability of $\left(1 - \hat{E}(\tilde{x})\right)$, the investor does not experience a liquidity shock, in which case he receives a promised payment of ρ_I if the bank is solvent. If the bank is insolvent (which happens with probability $1 - \theta$), the return on any surplus cash holdings is divided amongst the patient investors. Hence expression (14) states that the investors must on average receive at least their reservation utility. Equation (15) is a budget constraint of the bank, which states that the total assets of the bank (i.e., sum of project loans and cash holdings) must equal the total investment funds.

In other words, a manager acting in the interest of the principal chooses loan rates, level of cash holdings, and rate of return on investments so as to maximize the gross profit of the bank net of the expected penalty costs associated with liquidity shortfalls, net of the expected wage and audit costs faced by the principal, and subject to the investors' participation constraint and the bank's budget constraint. As long as the manager is not taking excessive risk, he does not incur any penalty costs subsequent to an audit and, thus, the expected managerial penalty cost is zero conditional on the manager not reaching for yield. Let ρ_S^*, ρ_R^*, C^*, and ρ_I^* denote the solution to the above problem, the closed form expressions of which can be found in the Online Appendix.

2.7 Managerial agency problem

There will be a managerial agency problem if the manager maximizes his own expected utility instead of maximizing the principal's expected profits. In this case,

[12] Note that since x and L_R are independent, $\hat{E}(x) = E(x)$. Hence, for the consistency of notation we write the entire problem in terms of $\hat{E}(\cdot)$.

the manager will have a tendency to engage in reaching-for-yield behavior. More specifically we define reaching-for-yield as follows.

Definition 1 *A manager is said to be reaching for yield when he sets a lending rate such that* $\rho_R < \rho_R^*$ *and* $\rho_S > \rho_S^*$*, where* ρ_i^* *is the optimal loan rate that maximizes the principal's expected profits in the presence of asymmetric information. In other words, the manager reaches for yield when he underprices the risky loan rate and overprices the safe loan rate.*

Definition 1 implies that if a manager reaches for yield he will be overinvesting in risky assets but underinvesting in safe assets. In order to ascertain whether or not the manager will reach for yield, we solve for the manager's optimization problem, which is given by the following program:

$$\max_{\rho_R,\, \rho_S,\, C} \hat{E}\left[v\left(b_R + b_S - \psi\right)|e = e^H\right] - e^H \tag{16}$$

subject to:

$$L_R + L_S + C = I, \tag{17}$$

$$L_S \geq \underline{L}_S^k \ \forall \theta^k, \tag{18}$$

where:

$$\psi = \begin{cases} \min\left(\bar{\psi},\, \gamma\Psi\right) & \text{if } \ell > \ell^* \text{ and } \rho_i \neq \rho_i^* \\ 0 & \text{otherwise} \end{cases}. \tag{19}$$

In the above program the manager chooses his investment portfolio so as to maximize his expected utility conditional on high effort (16), subject to the budget constraint (17). Condition (18) states that a minimum investment amount needs to be allocated to the safe asset for any given level of risk.[13] This condition is not

[13] For example, given a risk level of $1 - \theta^k$, the manager needs to invest at least $\underline{L}_S^k$ in the safe asset, where $\underline{L}_S^k$ is decreasing in the risk of failure of the safe project. Such constraints satisfy internal risk management requirements, as well as external regulatory requirements. Alternatively, we can simply replace this more general condition with a non-negativity constraint, $L_S \geq 0$, without affecting our results. This is effectively a short selling constraint. In the absence of such a constraint, the manager will have an incentive to short sell the safe assets and reallocate the proceeds between the risky assets and cash holdings.

necessary for any of the qualitative results and as discussed in footnote 13 in the absence of this condition the results would be even stronger. Condition (19) states that if the principal conducts an audit (which happens when $\ell > \ell^*$), then the manager is imposed a penalty (which is a fraction γ of the bank's penalty cost Ψ but cannot exceed $\bar{\psi}$ given limited liability) if it is inferred that the manager has not maximized the expected profits of the bank (which is the case when the manager sets loan rates that do not correspond to the rates that maximize the bank's expected profits under asymmetric information, i.e., $\rho_i \neq \rho_i^*$).

After solving the above problem, we can prove Proposition 2.

Proposition 2 *The manager will reach for yield if the liquidity, I, of the bank is sufficiently high. Furthermore, if the manager reaches for yield, he will make the minimum possible investment in the safe asset and will overinvest in the risky asset.*

According to Proposition 2, when liquidity is high enough, the manager has an incentive to overinvest in risky assets while underinvesting in safe assets. In other words, the agency problem only comes into play if the liquidity (I) of the bank is high enough. The intuition behind the above result is as follows. In the presence of excessive liquidity, the probability that the bank will incur a liquidity shortfall is low, thus an audit is unlikely. A rational manager understands this and thus when he observes that the bank is flush with liquidity he has an incentive to overinvest in the risky assets so as to increase his bonuses. In other words, high liquidity is tantamount to insurance since it provides a buffer to the manager. In contrast, when liquidity is low, an audit is more likely, thus the manager refrains from reaching for yield.

Due to the limited liability of the manager, an upper bound exists on the penalty that can be imposed. Of course, in the absence of limited liability, the principal could avoid an agency problem by imposing an arbitrarily large penalty if it was inferred that the manager had reached for yield. However, limited liability on the part of the manager implies that such extreme punishments cannot plausibly be implemented, thus agency problems will arise for high enough levels of the bank's liquidity.

According to Proposition 2, not only does the manager overinvest in the risky asset, but he also underinvests in the safe asset. Intuitively, overinvestment in the risky asset crowds out investment in the safe asset, which is conducive to underinvestment in the safe asset. Note that the manager has no incentive to invest in the safe asset. This is because he gets higher bonuses from investing the same amount in the risky asset while he gets lower or no bonuses from investment in the safe asset. In fact, the manager is better off by retaining funds in the form of cash holdings rather than investing those funds in the safe asset. This is because cash holdings provide a buffer against runs and lower the expected penalty cost that the manager will suffer. On the other hand, investments in the safe asset yield no bonuses and at the same time have a higher liquidation cost vis-à-vis cash. Thus the manager will only invest the minimum amount necessary in the safe asset.

We then have the following corollary to Proposition 2.

Corollary 1 *If the manager reaches for yield, he follows a hierarchical pecking order when making portfolio allocations: The first preference is to invest in risky assets; the second preference is to invest in cash or cash equivalents; and finally the least desirable investment allocation is in safe assets, which are safer than risky assets but are riskier than cash or cash equivalents.*

3 Bubbles and "Negative Bubbles"

Next we consider the asset pricing implications of our results. We define the fundamental asset price as the price that would prevail in the absence of any agency problems. A "bubble" would then arise if the actual asset price exceeds the fundamental price. Conversely, a "negative bubble" would be created if the actual asset price is lower than the fundamental price. To facilitate this comparison, we model the asset demand by agents who borrow from banks and invest the sum in risky or safe projects.

We assume that there exists a continuum of risk-neutral borrowers who have access to either risky or safe projects. These agents have no wealth and, hence, need to borrow from banks to make investments in projects. We analyze the behavior of a representative borrower who has access to a project of risk type i, where $i = R, S$ denotes that the project is either a risky or a safe project. Analysis of a representative borrower implies that the equilibrium is symmetric and all borrowers of type i will choose the same portfolio. This also implies that the bank cannot discriminate between borrowers of the same type by conditioning the terms of the loan on the amount borrowed. Consequently, borrowers can borrow as much as they like at the going rate of interest.

Asset i returns a cash flow (or cash flow equivalent of consumption) of X_i per unit with a probability of ω_i, where as defined in Subsection 2.1, the success probability of the risky project is given by $\omega_R = \theta p$ while the success probability of the safe project is given by $\omega_S = \theta$, where $\omega_S > \omega_R$ since $p < 1$. We make the usual assumption that the cash flow, X_i, is sufficiently high so that the borrower earns a positive payoff net of any investment costs contingent on the success of the project. Let P_i denote the per unit price of the asset. Let Y_i^d denote the number of units of asset i demanded by the representative borrower and $\tilde{Y}_i^s(P_i)$ denote the total supply of the asset. The supply of asset i, $\tilde{Y}_i^s(P_i)$, is stochastic, where $\tilde{Y}_i^{s\prime}(P_i) > 0$ for any realization of $Y_i^s(P_i)$. In other words, if asset prices are high, then the supply of the asset increases. As in Allen and Gale (2000), we assume that the borrower faces a non-pecuniary cost of investing in projects $t_i\left(Y_i^d\right)$, which satisfies the usual neoclassical properties: $t_i(0) = t_i'(0) = 0$, $t_i'\left(Y_i^d\right) > 0$, and $t_i''\left(Y^d\right) > 0$ for all $Y_i^d > 0$. This serves to restrict the size of the individual portfolios and ensures the concavity of the borrower's objective function. Alternatively, we can assume that the borrower is risk averse, which would lead to similar results.

The problem faced by the representative borrower is to choose the amount of borrowing so as to maximize his expected profits:

$$\max_{Y_i^d} \omega_i \left[X_i Y_i^d - \rho_i P_i Y_i^d\right] - t_i\left(Y_i^d\right), \tag{20}$$

subject to the market-clearing condition:

$$Y_i^d = Y_i^s. \tag{21}$$

Expression (20) represents the expected profit of the representative borrower. In the event of success (with probability ω_i), the borrower receives a return of $X_i Y_i^d$ on the units invested but needs to pay interest of ρ_i on his borrowings $(P_i Y_i^d)$ and also suffers the investment cost $t_i\left(Y_i^d\right)$. Thus, the borrower chooses how much to invest in his project so as to maximize his expected profit given the market clearing condition that aggregate demand equals supply.

The first-order condition of problem (20) is:

$$\omega_i\left[X_i - \rho_i P_i\right] - t_i'\left(Y_i^d\right) = 0. \tag{22}$$

Solving for P_i, we get:

$$P_i = \frac{\omega_i X_i - t_i'\left(Y_i^d\right)}{\omega_i \rho_i}. \tag{23}$$

Finally, substituting $Y_i^d = Y_i^s$ and letting $\tau_i\left(Y_i^d\right) = t_i'\left(Y_i^d\right)$ denote the marginal investment cost, the equilibrium unit asset price is given by the following fixed-point condition:

$$P_i^* = \frac{\omega_i X_i - \tau_i\left(Y_i^s\left(P_i^*\right)\right)}{\omega_i \rho_i}. \tag{24}$$

In Equation (24) the equilibrium asset price is the (risk-adjusted) discounted value of the expected cash flows net of the investment cost. Substituting $i = R$ and $\omega_R = \theta p$, the equilibrium asset price of the risky asset is given by:

$$P_R^* = \frac{\theta p X_R - \tau_R\left(Y_i^s\left(P_R^*\right)\right)}{\theta p \rho_R}, \tag{25}$$

and substituting $i = S$ and $\omega_S = \theta$, we get the equilibrium asset price of the safe asset, which is given by:

$$P_S^* = \frac{\theta X_S - \tau_S\left(Y_i^s\left(P_S^*\right)\right)}{\theta \rho_S}. \tag{26}$$

It can then be shown that there exists a one-to-one mapping from the lending rate, ρ_i, to the asset price, P_i. Taking the derivative of the equilibrium asset price with respect to the loan rate we get:

$$\frac{dP_i^*}{d\rho_i} = -\frac{X_i}{\rho_i^2} + \frac{\tau_i\left(Y^s\left(P_i^*\right)\right)}{\omega_i\rho_i^2} - \frac{\tau_i'\left(Y^s\left(P_i^*\right)\right)Y_i^{s\prime}\left(P_i\right)}{\omega_i\rho_i}\frac{dP_i^*}{d\rho_i}. \tag{27}$$

Rearranging and simplifying Equation (27) we get:

$$\frac{dP_i^*}{d\rho_i}\left[1 + \frac{\tau_i'\left(Y^s\left(P_i^*\right)\right)Y_i^{s\prime}\left(P_i\right)}{\omega_i\rho_i}\right] = -\frac{P_i^*}{\rho_i}. \tag{28}$$

Since $\tau_i'(\cdot) = t_i''(\cdot) > 0$, $Y_i^{s\prime}(\cdot) > 0$, and $P_i^* \geq 0$, it follows that $\frac{dP_i^*}{d\rho_i} < 0$. This implies that $\frac{dY_i^s\left(P_i^*\right)}{d\rho_i} < 0$. Thus, in equilibrium given the market-clearing condition (i.e., $Y_i^d = Y_i^s\left(P_i^*\left(\rho_i\right)\right)$), the asset demand, Y_i^d, is decreasing in ρ_i.

Let ρ_i^* denote the fundamental (gross) lending rate, which is the rate obtained in the absence of any agency problems, given by the solution to the problem in Subsection 2.6. Then the fundamental asset price is given by the following fixed-point condition:

$$\bar{P}_i^* = \frac{\omega_i X_i - \tau_i\left(Y_i^s\left(\bar{P}_i^*\right)\right)}{\omega_i\rho_i^*}. \tag{29}$$

Thus the fundamental asset price of the safe project is given by:

$$\bar{P}_S^* = \frac{\theta X_S - \tau_S\left(Y_S^s\left(\bar{P}_S^*\right)\right)}{\theta\rho_S^*}, \tag{30}$$

while the fundamental asset price of the risky asset is given by:

$$\bar{P}_R^* = \frac{\theta p X_R - \tau_R\left(Y_R^s\left(\bar{P}_R^*\right)\right)}{\theta p\rho_R^*}. \tag{31}$$

Having derived fundamental asset prices, we can now formally define bubbles and negative bubbles as follows:

Definition 2 *An asset price bubble is formed whenever* $P_i^* > \bar{P}_i^*$.

Definition 3 *An asset price negative bubble is formed whenever $P_i^* < \bar{P}_i^*$.*

Comparing the equilibrium asset price, P_i^*, given by Equation (24) with the fundamental asset price, $\bar{P}_i^*$, given by Equation (29), it can be noted that $P_i^* > \bar{P}_i^*$ as long as $\rho_i < \rho_i^*$. Conversely, $P_i^* < \bar{P}_i^*$ as long as $\rho_i > \rho_i^*$. In other words, a lending rate lower than the fundamental rate creates a high demand for the asset, which leads to an increase in asset prices over and above the fundamental values. However, a lending rate higher than the fundamental rate reduces the demand for the asset, which leads to asset prices being suppressed below their fundamental values.

From Proposition 2, we know that for high enough liquidity ($I > I^*$), the manager reaches for yield by overinvesting in the risky asset (by setting $\rho_R < \rho_R^*$) but underinvesting in the safe asset (by setting $\rho_S > \rho_S^*$). It follows that for a high enough liquidity, $P_R^* > \bar{P}_R^*$, but $P_S^* < \bar{P}_S^*$. We thus have the following corollary to Proposition 2.

Corollary 2 *If the liquidity, I, of the bank is sufficiently high, then an asset price bubble is created in the market for the risky asset but concurrently an asset price "negative bubble" is created in the market for the safe asset.*

Interestingly, a negative bubble is likely to arise in the market for the safe assets rather than cash equivalents like Treasury bills. As discussed earlier, this effect arises due to the manager following his pecking order of first investing in the risky assets and then hoarding cash and cash equivalents to avoid the likelihood of liquidity shortfalls. Such a portfolio choice effectively dampens the demand for safe assets when the bank is flush with liquidity. Consequently, negative bubbles are more likely to arise in the market for safe assets whose liquidity risk is not as low as cash equivalents and at the same time offer lower returns to the manager relative to the higher bonuses received when investment is made in risky assets.

4 Monetary Policy

Next, we analyze the role of monetary policy in influencing the investment decisions of money managers by doing comparative statics of our model with respect to ρ_C, where ρ_C denotes the return on liquid reserves (e.g., Treasuries) held by banks. The yield on liquid reserves, ρ_C, is directly affected by the open market operations of central banks. For instance, a central bank's decision to sell Treasuries (i.e., monetary tightening) lowers the price of liquid assets, thereby increasing the yield, ρ_C, of liquid assets. On the other hand, a decision to buy Treasuries (i.e., monetary loosening) increases the price of liquid assets, thereby reducing the yield, ρ_C, of liquid assets.

Since the principal can observe the distribution of investment funds conditional on the monetary policy stance, ρ_C, it can also observe that following a monetary loosening the distribution shifts to the right and hence on average the bank has access to a bigger pool of liquidity. Conversely, following a monetary tightening, the principal can observe that the bank on average has access to a smaller pool of liquidity. By doing comparative statics of our model with respect to ρ_C, we can then prove Proposition 3.

Proposition 3 *A monetary loosening increases the liquidity shortfall threshold, ℓ^*, above which an audit is conducted by the principal. Conversely, a monetary tightening decreases the liquidity shortfall threshold, ℓ^*, above which an audit is conducted. More formally, $d\ell^*/d\rho_C < 0$.*

According to Proposition 3, an audit is less likely to occur following a loosening of monetary policy. Intuitively, a monetary loosening increases the pool of investment funds available to the bank. The increase in liquidity in turn lowers the probability of liquidity shortfalls, thus the bank is less likely to incur costs associated with premature liquidations. Since the expected cost of incurring premature liquidations decreases, the principal has less incentive to conduct a costly audit. Conversely, a monetary tightening increases the expected cost of incurring premature liquidations, which incentivizes the principal to conduct a stricter audit policy by lowering the threshold above which an audit is conducted.

We next examine how a change in monetary policy affects the manager's propensity to reach for yield. We can prove the following proposition.

Proposition 4 *The liquidity threshold, I^*, above which a manager reaches for yield increases with monetary tightening but decreases with monetary loosening. More formally, $dI^*/d\rho_C > 0$.*

According to Proposition 4 if the central bank conducts monetary tightening (loosening) then the liquidity threshold above which an agency problem is actuated increases (decreases) and the manager is less (more) likely to reach for yield. In other words, the inside agency problem in banks is more likely to be triggered when monetary policy is loose.

The intuition is as follows. A monetary loosening has two effects both of which reinforce each other. First, a monetary loosening by increasing the pool of liquidity lowers the probability that the bank will suffer a liquidity shortfall for any given ℓ^*. Second, as discussed in Proposition 3, a monetary loosening (by increasing ℓ^*) encourages a lax audit policy on the part of the principal. Both of these effects reinforce each other and imply that an audit is less likely. Hence the manager in anticipation of a lower likelihood of an audit is more likely to reach for yield by overinvesting in risky assets and underinvesting in safe assets. Conversely, a monetary tightening increases the likelihood of an audit, which dissuades the manager from reaching for yield.

Note that the principal can anticipate that the manager is more likely to reach for yield subsequent to a monetary loosening and hence may want to adopt a stricter audit policy during loose monetary times and a more lenient audit policy in a tight monetary regime. However, such an audit policy is not credible ex post. This is because in a loose monetary regime the expected cost of liquidity shortfalls are lower. The reason the manager is more likely to reach for yield in loose monetary environments is due to the influx of liquidity the bank is less likely to incur a liquidity shortfall (even after reaching for yield). Given that conducting audits is costly any threat of a stricter audit policy during periods with loose monetary conditions is not time-consistent.

We next examine the impact of a change in monetary policy on asset prices. We have the following corollary to Proposition 4.

Corollary 3 *Under a loose monetary policy regime, asset price bubbles in the market for risky assets accompanied by negative bubbles in the market for safe assets are more likely to be formed.*

Intuitively, when monetary policy is loose, managers are more likely to reach for yield since the expected cost of covering liquidity shortfalls is relatively low. This in turn encourages managers to overinvest in risky assets, which drives up the prices of risky assets above their fundamental values. At the same time, investment in safe assets is crowded out, which drives down their prices, and results in negative bubbles.

Allen and Gale in their book "*Understanding Financial Crises*" document the following: "In Finland an expansionary budget in 1987 resulted in massive credit expansion. The ratio of bank loans to nominal GDP increased from 55 percent in 1984 to 90 percent in 1990. Housing prices rose by a total of 68 percent in 1987 and 1988... In Sweden a steady credit expansion through the late 1980's led to a property boom." These observations are perfectly in line with our model. Loose monetary policies can potentially lower the expected cost of liquidity shortfalls, which in turn encourages banks to underprice the underlying risk, thereby increasing the volume of credit in the economy. This in turn creates an asset price bubble in the market for risky assets.

5 Related Literature

5.1 Theoretical literature

The paper that comes closest to this work is the one by Acharya and Naqvi (2012), who show that access to abundant liquidity exacerbates the risk-taking incentives of bank managers by encouraging them to extend excessive loans. However, there are a number of significant differences. We consider a model characterized by heterogeneity on the asset side of the bank, unlike the one by Acharya and Naqvi (2012). In their model banks can only invest in risky assets, whereas in our model banks can invest in both risky and safer projects. This heterogeneity on the asset side enables us to establish the pecking order of the manager's investment preferences. More specifically, we show the coexistence of bubbles (in the market for risky assets) and negative bubbles (in the market for safe assets). On the other hand, in the paper by Acharya and Naqvi (2012), negative bubbles cannot arise since there is only one type of (risky) asset in which the bank can invest.

More importantly, we also analyze the role of monetary policy unlike Acharya and Naqvi (2012). As we discussed in Subsection 5.2, a number of empirical papers have documented a link between loose monetary policy and risk-taking. We provide a theoretical foundation underlying these empirical findings and show how loose monetary policy by triggering an inside agency problem can encourage risk-taking by banks. To the best of our knowledge, we are the first to study how monetary policy can influence the internal audit policy of financial intermediaries.

Furthermore, we also show how loose monetary policy is conducive to the formation of both bubbles and negative bubbles. While bubble formation is discussed widely in the extant literature, little attention is paid to the formation of negative bubbles. We show that overinvestment in risky assets crowds-out investment in safer assets, which leads to the concurrent formation of bubbles and negative bubbles. Hence, by modeling monetary policy, we are able to study the portfolio choice of asset managers under different monetary policy regimes. This in turn provides an insight as to why bubbles and negative bubbles are more likely to arise in loose monetary policy regimes.

In the aftermath of the Global Financial Crisis, a number of researchers found a significant link between monetary policy and risk-taking, pointing to a different dimension of the monetary transmission mechanism, the so-called "risk-taking channel" (e.g., Adrian and Shin, 2010; Borio and Zhu, 2012; Gambacorta, 2009). Borio and Zhu (2012) argue that this channel operates in two ways.

First, loose monetary policy by lowering the returns on investments (such as risk-free securities offered by the government) may encourage banks, asset managers, and insurance companies to take on more risk for contractual or institutional reasons. For instance, Rajan (2006) argues that when interest rates are low, financial institutions search for yield to avoid a default on their contractual obligations. Alternatively, a similar mechanism could be in place whenever private investors use short-term returns to gauge manager competence and withdraw funds after poor performance (Shleifer and Vishny, 1997). Similarly, when interest rates are low, yield-chasing managers may want to invest in riskier securities in an attempt to outperform their peers (Feroli et al., 2014).

Second, a reduction in interest rates boosts asset and collateral values, which can reduce banks' estimates of default probabilities, thereby encouraging bank risk-taking. Adrian and Shin (2010), for instance, argue that a lowering of interest rates induces an increase in asset prices, steepens the yield curve, and lowers the estimates of asset price volatilities. This in turn encourages risk-taking on the part of banks.

Our model provides a third avenue for the operation of the risk-taking channel. Loose monetary policy by increasing the liquidity available to the bank reduces the likelihood of liquidity shortfalls, thereby reducing the probability of an audit. This encourages the bank manager to reach for yield. Furthermore, loose monetary policy induces a lax audit policy on the part of the principal, which accentuates the agency problem inside banks. This provides us with a further insight as to why banks increase risk-taking during periods of low interest rates.

Allen and Gale (2000) consider a model where there is an agency problem between the bank and bank borrowers. Bank borrowers exploit their limited liability by overinvesting in the risky asset. If the risky asset is in fixed supply, then such overinvestment drives up the asset price of risky assets creating an asset price bubble.

Baker (1992) shows that when the principal's objective function contains significant random variation outside the agent's control the principal is forced to use another performance measure to "guide the agent." However, since such a performance measure does not always give the agent accurate incentives, the agent can "game" the performance measure to maximize his own payouts. In our setup, such "gaming" is akin to the bank manager's reaching-for-yield behavior.

5.2 Empirical support

Our result that bank managers' compensation is increasing in loan volume is consistent with the observation of the U.S. Department of Labor (2009), who finds that most loan officers are paid a commission on the number of loans they originate. Agarwal and Ben-David (2018) observe that loan officers' bonuses are higher for loans that have a larger loan size. They also find that conditional on approval, the riskiness of a loan is higher for loans of a larger size. Thus, to the extent that loan size proxies for the riskiness of a loan, a riskier loan can generate higher bonuses for loan officers. More generally, many studies find a positive correlation between bank managers' compensation and risk-taking (e.g., Acharya et al., 2014; Cheng et al., 2015; Chesney et al., 2018; and Efing et al., 2015). In particular, Agarwal and Ben-David (2018) find that the introduction of volume-based pay for loan officers is associated with higher default rates. In parallel work, Cole, Kanz, and Klapper (2015) find that loan officers who are incentivized on lending volume originate more loans of lower quality. In the United Kingdom a parliamentary committee investigating the role of banks in the 2008 crisis found that "bonus-driven remuneration structures encouraged reckless and excessive risk-taking" (United Kingdom House of Commons, 2009).

Another empirical implication of our model is that banks are more likely to reach for yield during a period when there is a loose monetary policy. Hanson and Stein (2015) find that when the U.S. Federal Reserve lowers the short-rate commercial banks rebalance their securities portfolios toward longer-term bonds, thereby significantly increasing the duration of their securities holdings. They argue that their empirical evidence is consistent with the hypothesis that investors react to a loose monetary policy by reaching for yield. Dell'Ariccia, Laeven, and Suarez (2017) find that ex ante risk-taking by banks is negatively associated with increases in short-term policy rates. Furthermore, Jiménez et al. (2014) find that loose monetary policy induces banks to grant more loans to ex ante risky firms. Paligorova and Santos (2017) find that in a loose monetary policy regime, banks charge riskier borrowers lower loan spreads relative to safer borrowers. Ioannidou, Ongena, and Peydró (2015) find that following a loose monetary policy, bank credit risk increases and this effect is more pronounced for banks with more liquid assets and for banks with more acute agency problems. All of these findings are consistent with our results.

6 Conclusion

We develop a model of financial intermediation characterized by an inside agency problem whereby bank managers have an incentive to reach for yield when the bank is flush with liquidity. More specifically, when the bank has access to high enough liquidity, the managers reach for yield by overinvesting in risky assets and under-investing in safer assets. Managerial portfolio selection is characterized by the following hierarchical investment order: (1) risky assets to maximize their bonuses; (2) hoard cash and cash equivalents since liquid assets are a good hedge against liquidity shocks; (3) safer assets since they are not a perfect hedge against liquidity shocks and their yields on average are lower than that of risky assets. We show that such a portfolio allocation choice leads to a bubble in the market for risky assets, as well as a negative bubble in the market for safe assets when the bank has access to high enough liquidity. A loose monetary policy environment only aggravates this agency problem by providing easy access to liquidity at relatively cheaper rates. This is conducive to a lax audit policy and an increased incentive to reach for yield.

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