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

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January 13, 2016

[1]Part of this paper was written while Hassan Naqvi was a Visiting Scholar at MIT Sloan School of Management, whose hospitality is warmly acknowledged. We would like to thank Nittai Bergman for his invaluable comments. To economize on space we have relegated all the proofs to an online Appendix.

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Abstract

We develop a model of financial intermediation characterized by an inside agency problem such that asset managers, when they have access to high enough liquidity, “reach for yield” by overinvesting in risky assets and concurrently underinvesting in safer or medium-risk assets . The managers follow a pecking order whereby their first preference is to invest in risky assets; their second preference is to hoard liquid assets so as to provide a buffer against runs; and their last preference is to invest in medium-risk assets. This reaching-for-yield behavior of managers is conducive to the formation of bubbles in the market for risky assets and concurrently “negative bubbles” in the market for medium-risk assets. We show that loose monetary policy by reducing the cost of liquidity shortfalls suffered by financial intermediaries induces further “reach for yield” and amplifies the magnitude of bubbles and negative bubbles.

JEL Classifications: D82, E32, E52, G21, G28

Keywords: Bubbles, monetary policy, moral hazard, negative bubbles, reaching for yield

1 Introduction

There has been growing concern that financial intermediaries such as asset managers may have perverse incentives to "reach for yield" especially in an environment characterized by low interest rates, (see, for instance, Rajan (2006) and Yellen (2011)). "Reaching for yield" can heuristically be defined as the investors' propensity to buy riskier assets in order to achieve higher yields. It has been argued that such reaching-for-yield behavior is usually a by-product of the loose monetary policies adopted by the central banks and that such behavior can distort asset prices (See, for example, 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"*.

Shin (2013) argues that it is useful to distinguish between two recent phases of "global liquidity".[1] The first phase lasted from 2003-2008 and in this phase global banks were at the center transmitting loose financial conditions across borders via banking capital flows. The second phase of global liquidity started in 2010 and is very much relevant today. In this phase global banks (which have been weighed down by regulation) have paved way to asset managers who are investing heavily in emerging market debt securities. The transmission of financial conditions from developed countries to emerging economies is now done largely via asset managers who are intrinsically reaching for yield. Consequently, there has been a large increase in the issuance of international debt securities to satisfy the corresponding demand. Since the collapse of Lehman Brothers, according to the Bank for International Settlements (BIS), emerging market firms (other than banks) have issued more than $690 billion in international bonds.

IMF's Global Financial Stability report (2015) also highlights the concerns about potential financial stability risks posed by the asset management industry. The report documents that in recent times the prolonged period

[1] CGFS (2011) defines global liquidity in broad terms as global financing conditions or "ease of financing".

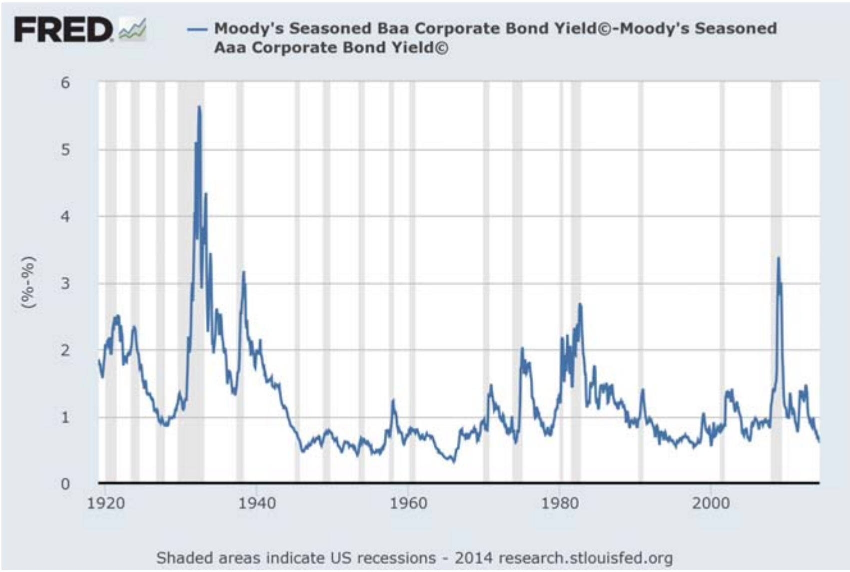

Figure 1: The spread between Moody's Seasoned Baa Corporate Bond Yield and Moody's Seasoned Aaa Corporate Bond Yield. Source: St. Louis Federal Reserve

of low interest rates in advanced economies has resulted in a search for yield and consequently funds have been increasingly investing in less liquid assets such as high-yield corporate bonds and emerging market assets. The report finds that the delegation of day-to-day portfolio management introduces incentive problems between end investors and portfolio managers, which can encourage destabilizing behavior.

Furthermore, easy redemption options create the risk of runs. The empirical evidence in the report finds evidence of these risk-creating mechanisms and finds that mutual fund investments appear to affect asset price dynamics, especially in less liquid markets. These concerns are already being reflected in the very low spread between non-investment grade and investment grade yields. Using Federal Reserve Economic Data (FRED) in Fig. 1 we see that the spread between Moody's seasonal Baa Corporate yield and Aaa corporate yield has plummeted since the peak of the 2008 financial crisis.

In this paper we build a model that captures the reaching-for-yield behavior of asset managers and study how abundant liquidity can encourage such behavior.[2] Subsequently we study the ramifications of reaching-for-yield behavior on the coexistence of bubbles and negative bubbles in asset prices. Our model shows that when an intermediary is flush with liquidity the managers have an incentive to overinvest in the risky asset and concurrently underinvest in the medium-risk asset.[3] Moreover, we are able to 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 finally his last preference is to invest in medium-risk assets (since such assets yield lower or zero bonuses and at the same time 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 medium-risk asset. Intuitively, overinvestment in the risky asset crowds out investment in the medium-risk asset.

When considering the asset-pricing implications of our model, we are able to show that when an intermediary 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 but concurrently a "negative bubble" in asset prices is formed in the market for medium-risk assets. In other words, risky assets tend to be overpriced whilst medium-risk assets are underpriced when intermediaries have access to abundant liquidity. We thus show that bubbles

[2] Our model is applicable to both the pre-2008 crisis period, when global banks were the major players, as well as the post-2008 crisis, where asset managers are the dominant players. Thus, in order to keep our model generic, we use the term 'financial intermediary' or 'intermediary' for short to refer to both banks and asset managers.

[3] In the paper we use the terms "medium-risk assets" to refer to assets that are safer than risky assets but riskier than the safest assets. For example, medium-risk assets (e.g. AAA securities) are safer than risky assets (e.g. non-investment grade securities). However, the safest assets are cash or cash equivalents (e.g. Treasury bills).

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 managers of financial intermediaries. Our results indicate that by lowering the expected cost associated with liquidity shortfalls, loose monetary policy encourages managers to reach for yield. On the contrary, tight monetary policy by absorbing some of the excess liquidity from financial intermediaries dissuades managerial risk-taking.[4]

We argue that the reaching-for-yield behavior of asset managers in recent data is consistent with the findings of our model. The central banks of advanced countries have followed loose monetary policies since the 2008 financial crisis. The loose financial conditions have culminated in an increase in liquidity of financial intermediaries. Our model predicts that an influx of liquidity triggers an agency problem whereby managers of intermediaries search for yield and consequently overinvest in risky assets (e.g. high yield bonds and emerging market debt securities) and underinvest in medium-risk securities (e.g., investment grade debt securities of developed countries). The overinvestment in risky securities eventually leads to inflated prices of risky assets (translating into low yields for emerging market debt securities and other risky securities) and concurrently deflated prices for medium-risk assets.[5] This is evident from the very low spread between non-investment grade and investment grade yields as depicted in Figure 1.

[4]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 Federal Reserve in the United States during the latter phase of the Greenspan era coincided with housing and real estate bubbles in these countries.

[5]It is noteworthy that the yield on Spanish 10-year bond in 2014 was the lowest since 1789. Perhaps, more suprisingly, Greece managed to sell 3 billion Euros worth of 5-year bonds at a yield of only 4.95% in April 2014. The yields on Greek bonds only went up recently given the uncertainties related to its bail-out package.

1.1 Outline of the paper

The rest of the paper is organized as follows. The model is outlined in Section 2. In Subsection 2.1 we construct a base model of a financial intermediary in the presence of symmetric information. The intermediary receives investment funds from investors and then allocates these funds to projects after setting aside some of the funds in the form of cash or cash equivalents. The intermediary can invest in risky projects as well as medium-risk projects. The risky projects give higher returns in case of success but are characterized by a higher default risk as well as higher liquidity risk. Furthermore, the cost of prematurely liquidating the risky projects is higher as compared to the medium-risk projects. The intermediary suffers from early withdrawals whereby a fraction of investors withdraw their funds earlier in an interim period.[6] If the cash holdings of the intermediary are insufficient to cater for the liquidity needs of the investors who withdraw early then the intermediary is forced to prematurely liquidate its projects. It prefers to liquidate the medium-risk projects first given that these projects have a lower cost of premature liquidation.

In Subsection 2.2 we introduce asymmetric information between the manager of the intermediary and the principal. The manager needs to exert higher effort when investing in risky projects vis-a-vis medium-risk projects. This is because risky projects entail higher (ex ante) screening costs as well as higher (ex post) monitoring costs. Since such effort is unobservable we show that the manager needs to be given higher bonuses for investing in risky assets relative to medium-risk assets. However, such a contract encourages the manager to reach for yield by overinvesting in risky assets and underinvesting in medium-risk assets. To mitigate such behavior we allow for an audit which is conducted by the principal ex post to verify whether or not the

[6]Chen, Goldstein, and Jiang (2010) provide evidence that redemptions from mutual funds holding illiquid assets create run-like incentives similar to depositors in a bank run, as in Diamond and Dybvig (1983). Hence, as mentioned earlier our model is relevant for intermediaries in general (including banks and funds).

manager had reached for yield. We show that since such audits are costly the principal will conduct an audit if and only if the liquidity shortfall suffered by the intermediary is sufficiently high. Intuitively, a high enough liquidity shortfall sends a signal to the principal that the manager is more likely to have reached for yield.

Thus the manager of the intermediary faces a trade-off: if he reaches for yield he can potentially earn higher bonuses but in the event of a high enough liquidity shortfall the manager will be penalized. We then show that the manager will reach for yield by overinvesting in the risky asset and underinvesting in the medium-risk asset if and only if the liquidity (or the available investment funds) of the intermediary is sufficiently high. Intuitively, if the intermediary is awash with liquidity then the manager realizes that the likelihood of the intermediary suffering a liquidity shortfall in the interim period is significantly low. Consequently there is a high probability that the manager would be able to evade any penalties and earn high bonuses if the intermediary has access to abundant liquidity.

We then show that if the manager reaches for yield his first preference would be to invest in risky assets; the second preference would be to invest in liquid assets like cash or cash equivalents; and finally he would invest the minimum possible amount in the medium risk assets. Intuitively, by investing in risky assets the manager is able to earn high bonuses as long as no audit is conducted. Investment in liquid assets like cash and cash equivalents enables the manager to reduce the liquidity risk of his portfolio since such liquid assets are a good hedge against potential runs by investors. Thus retaining some investment funds in liquid assets effectively reduces the likelihood of an audit by reducing the probability of liquidity shortfalls. Finally, the manager will invest the minimum possible amount in the medium-risk assets since such assets give low returns to the manager (in the form of lower bonuses) and also the liquidity risk of such assets is higher than that of liquid assets.

In Section 3 we consider the asset-pricing implications of our model. We define "fundamental" asset prices as those that arise in the absence of any agency frictions within the intermediary. An asset price "bubble" is said to exist when asset prices are above their fundamental values whilst an asset price "negative bubble" is said to exist when asset prices are below their fundamental values. We construct the optimal demand function of agents who borrow from the intermediary to invest in either risky or medium-risk projects. Finally, we solve for asset prices using the market clearing condition that the aggregate demand for assets should equal their supply. We then show that if the liquidity of the intermediary is sufficiently high then an asset price bubble is formed in the market for the risky asset and concurrently an asset price negative bubble is formed in the market for the medium-risk asset. Intuitively, when the intermediary has access to abundant liquidity an agency problem is triggered which encourages the manager to overinvest in risky assets and underinvest in medium-risk assets. Overinvestment in risky assets creates a bubble in the asset prices of risky assets whilst underinvestment in medium-risk assets leads to a negative bubble being created in the market for medium-risk assets. In other words, we show that bubbles and negative bubbles coexist in different markets due to agency problems within intermediaries.

In Section 4 we study the role of monetary policy in influencing the portfolio allocation decisions of managers. We show that under a loose monetary policy regime funding is more readily available at lower rates to intermediaries in the interim period to cover any potential liquidity shortfalls and thus the expected cost of liquidity shortfalls is relatively low. This encourages managers to overinvest in risky assets and underinvest in medium-risk assets. Conversely, a tight monetary policy regime increases the expected cost of liquidity shortfalls which discourages managers from reaching for yield. Thus central banks can use tight monetary policy as a disciplining device to dampen the risk taking appetite of managers.

Section 5 surveys the theoretical and empirical literature related to our work.

Section 6 concludes.

2 The Model

2.1 The base model with symmetric information

We consider a model of a financial intermediary with three periods. At $t = 0$, risk-neutral investors invest an endowment of 1 unit each in the financial intermediary. There are a total of I investors and thus the intermediary receives I units of investment funds in the initial period.[7] Each investor has a reservation utility of $\bar{u}$. Hence, the intermediary 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 ascertain whether ρ_I is high enough to satisfy their reservation utility.[8]

After receiving investment funds, the intermediary 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 earn a rate of return, ρ_C, which is realized at $t = 2$, where ρ_C is determined by monetary policy set by the central bank.

The intermediary can invest in two types of projects: "risky" projects or "medium-risk" projects. Both projects either succeed or fail at $t = 2$. The intermediary is hit by a macroeconomic shock with probability $1 - \theta$, in which case all of the projects (including the medium-risk projects) fail and

[7] Similar to Acharya and Naqvi (2012), we interpret I as the liquidity available to the intermediary at $t = 0$, or more simply the liquidity of the intermediary. This is because the cash reserves in the model are endogenous and are determined by the amount of investment funds, I, available to the intermediary at $t = 0$. 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.

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

the intermediary is insolvent. For simplicity, we assume that the intermediary is solvent and hence able to pay back the promised return to its investors (with probability θ) as long as it is not hit by the macroeconomic shock.

If the intermediary is solvent then the risky projects succeed with probability p but fail with probability $1-p$. In case of failure, the risky projects yield a liquidation value of y as long as the intermediary is not hit by the 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 intermediary. The probability distribution of the returns of the medium-risk projects is given by

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

where ρ_M is the (gross) rate of return from the medium-risk projects charged by the intermediary. Since $p < 1$ the medium-risk projects have a higher probability of success.

After receiving the investment funds, I, the intermediary observes θ and p and chooses the lending rates, ρ_i for $i = R, M$, which is the (gross) rate of return on the risky and medium-risk projects. When setting the lending rates, the intermediary takes into account the demand function for loans, which is given by $L(\rho_i)$, where $L'(\rho_i) < 0$.[9] The cash holdings of the intermediary are

[9] For the purpose of the model, the choice variable of the intermediaries is the lending rate (or rate of return) which in turn determines loan or investment volume. Alternatively, we could have assumed that intermediaries take the 'rate of return' schedule as given and then choose the volume of investments in the risky and safer assets. We acknowledge that for some intermediaries setting the 'price' might be more relevant whilst for others

the residual after it makes all of its investments in the risky and medium-risk projects:

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

where for brevity $L_R = L(\rho_R)$ is the loan demand for the risky asset and $L_M = L(\rho_M)$ is the loan demand for medium-risk assets.

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 $t = 1$.[10] 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 $t = 1$.[11] 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 intermediary suffers a penalty cost which can be interpreted as a cost of premature liquidation of assets in order to service withdrawals.[12] The penalty cost suffered by the intermediary in the event of

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'quantity' or volume might be a more apt choice variable. Nevertheless, since there is a direct relationship between lending rates and investment volumes as given by the demand function, $L(\rho_i)$, both approaches yield the same results. Henceforth, the manager in our model will choose the 'lending rate' or 'loan rate' which in turn will determine the portfolio allocations of the intermediary.

[10] As in Allen and Gale (1998) or Goldstein and Pauzner (2005), we could have assumed that $\tilde{x}$ is correlated with asset quality news in the sense that investors receive a noisy signal of the intermediary fundamentals on the basis of which they decide whether or not to run. While this is more realistic, it blurs the focus of the paper by complicating the analysis while not changing our qualitative results. Hence, similar to Diamond and Dybvig (1983) and the ensuing literature, we assume for tractability that $\tilde{x}$ is random.

[11] More generally, we can assume that an impatient investor receives ρ^1 if he withdraws early since our results are not dependent on ρ^1 being equal to 1. However, for tractability we do not endogenize ρ^1. It could be thought of as being pinned down to a certain level due to regulatory restrictions or being matched to government saving schemes rates.

[12] As noted by Stein (2013), the short-term claims of investors "need not (necessarily) be debt claims. If relatively illiquid junk bonds or leveraged loans are held by open-end investment vehicles such as mutual funds or by exchange-traded funds (ETFs) ... then this demandable equity will have the same fire-sale-generating properties as short-term debt." Indeed, the classic treatment of fire sales by Shleifer and Vishny (1997) is based not on a leverage mechanism, but on outflows from open-end funds. Coval and Stafford (2007) provide empirical evidence of the presence of fire sales in the mutual fund industry.

a liquidity shortfall is given by:

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

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

In other words, the above formulation implies that the risky assets not only have a higher default risk but also a higher liquidity risk since the cost of prematurely liquidating the risky assets is higher as compared to that of the medium-risk assets. Hence if the intermediary suffers a liquidity shortfall then it initially prefers to cover the shortfall by liquidating the medium-risk assets. However, if the number of withdrawals is large enough then the intermediary will eventually need to liquidate its risky assets.[13] The

[13] The model setup is consistent with IMF's Global Financial Stability Report (2015) which notes that asset managers use cash buffers and sell relatively more liquid assets first in the face of large redemptions.

implication is that the penalty cost of liquidity shortfalls increases with the amount of withdrawals.

We assume that as long as the intermediary is solvent it is able to repay the patient investors the promised rate of return at $t = 2$.

Let us suppose that the intermediary is run by a "money manager" who decides how to allocate the intermediary's investment resources across assets. The manager needs to exert effort in order to provide loans and make investments. We assume that the effort cost of making risky loans, e_R, is higher than the effort cost of making medium-risk loans, e_M, i.e. $e_R > e_M$. This is plausible because risky projects have a higher screening cost as well as a higher monitoring cost. Without loss of generality we normalize $e_M = 0$.[14] Since $e_M = 0$, 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 $e \in \left\{e^H, e^L\right\}$. In other words, the manager can either exert high effort, e^H, or low effort, e^L, where $e^H > e^L$. We assume that it is in the interest of the principal to implement high effort.[15] If the manager exerts high effort then he is able to make more investments, i.e. $\left[L\left(\rho_R\right)|e = e^H\right] > \left[L\left(\rho_R\right)|e = e^L\right]$.[16]

The sequence of events is summarized in the time line depicted in Fig. 2.Given this setup, in the case of symmetric information a money manager

[14] This simplifies the analysis. Nevertheless all our qualitative results are unchanged as long as $e_R > e_M$.

[15] 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.

[16] More specifically, if the manager exerts high effort, then for the same level of lending rate (and the same risk) he is able to make more loans. Stated differently for the same price and quality a manager can sell more units if he exerts high effort. This implies that the demand function for risky loans shifts outwards when high effort is exerted.

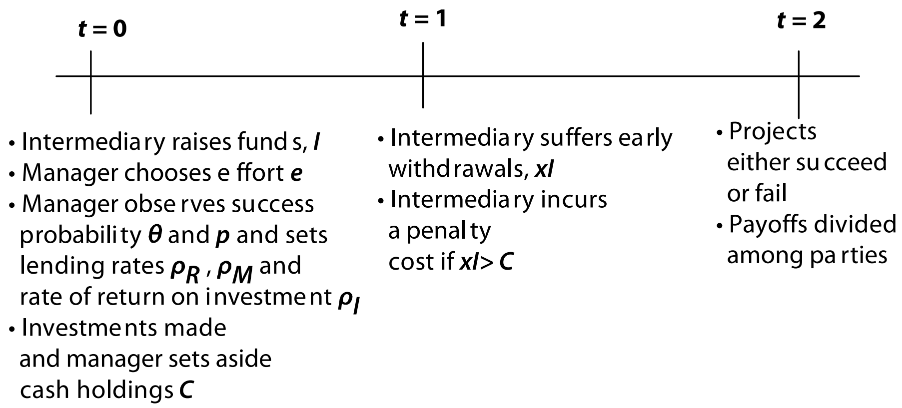

Figure 2: Base model: timeline of events

acting in the interest of the intermediary would solve the following problem:

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

subject to

$$E\left(\tilde{x}\right) + \left(1 - E\left(\tilde{x}\right)\right)\left[\theta\rho_I + (1-\theta)\frac{\rho_C E\left[\max\left(C - \tilde{x}I, 0\right)|e = e^H\right]}{\left(1 - E\left(\tilde{x}\right)\right)I}\right] \geq \bar{u} \tag{6}$$

and

$$L\left(\rho_R\right) + L\left(\rho_M\right) + C = I, \tag{7}$$

where $E\left(\cdot\right)$ is the expectations operator over $\tilde{x}$ and π is given by

$$\begin{aligned} \pi &= \theta\{\rho_M L\left(\rho_M\right) + p\rho_R\left[L\left(\rho_R\right)|e = e^H\right] + (1-p)\,y \\ &\quad -\rho_I I\left(1 - E\left(\tilde{x}\right)\right) + \rho_C E\left[\max\left(C - \tilde{x}I, 0\right)|e = e^H\right]\}. \end{aligned} \tag{8}$$

The above program says that a manager acting in the interest of the intermediary exerts high effort and chooses project lending rates, returns on investments and the level of cash holdings so as to maximize the expected profits of the intermediary, π, net of any penalty incurred in case of liquidity shortages and subject to participation constraint of the investors given by expression (6) and the budget constraint given by Eq. (7). With a probability of $E(\tilde{x})$ an investor withdraws his funds early in which case he receives a payoff of 1. With a probability of $(1 - E(\tilde{x}))$ the investor does not experience a liquidity shock in which case he receives a promised payment of ρ_I if the intermediary is solvent. In case of insolvency of the intermediary (which happens with probability $1 - \theta$), the return on any surplus cash holdings is divided amongst the patient investors. Hence expression (6) states that the investors must on average receive at least their reservation utility. Eq. (7) is a budget constraint of the intermediary which says that the total assets of the intermediary (i.e. sum of project loans and cash holdings) must equal the total investment funds. Eq. (8) represents the expected profit of the intermediary excluding the penalty costs. With probability $(1 - \theta)$ profits are zero since the intermediary is insolvent. With probability θ the intermediary is solvent in which case the medium-risk project gives the promised return of $\rho_M L(\rho_M)$ while the risky project pays $\rho_R L(\rho_R)$ (conditional on high effort) in case of success but yields the liquidation value y in case of failure. Thus in the case of solvency the intermediary's expected 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 (which is given by the last term of Eq. (8)).

We solve the above optimization problem and derive the first-best project lending rates, rate of return on investments, and level of cash holdings. The results are summarized in Proposition 1.

Proposition 1 *The optimal gross lending rate for the medium-risk project is given by*

$$\rho_M^* = \frac{\rho_C \Pr\left[(\tilde{x}I \leq C^*) \,|e = e^H\right] + \rho_M^p \Pr\left[(\tilde{x}I > C^*) \,|e = e^H\right]}{\theta\left(1 - \frac{1}{\eta_M}\right)} \tag{9}$$

where $\eta_M = -\rho_M L'(\rho_M)/L_M > 0$ *is the elasticity of the demand for medium-risk loans. The optimal gross lending rate for the risky project is given by*

$$\rho_R^* = \frac{\rho_C \Pr\left[(\tilde{x}I \leq C^*)\,|e = e^H\right]}{\theta p\left(1 - \frac{1}{\eta_R}\right)} + \frac{\rho_M^p \Pr\left[(C^* < \tilde{x}I \leq C^* + L_M)\,|e = e^H\right]}{\theta p\left(1 - \frac{1}{\eta_R}\right)}$$

$$+\frac{\rho_R^p \Pr\left[(\tilde{x}I > C^* + L_M)\,|e = e^H\right]}{\theta p\left(1 - \frac{1}{\eta_R}\right)} \tag{10}$$

where $\eta_R = -\rho_R\left[L'(\rho_R)\,|e = e^H\right]/\left[L_R|e = e^H\right] > 0$ *is the elasticity of the demand for risky loans. The optimal gross rate of return on investments is given by*

$$\rho_I^* = \frac{(\bar{u} - E(\tilde{x}))\,I - (1-\theta)\,\rho_C E\left[\max(C^* - \tilde{x}I, 0)\,|e = e^H\right]}{\theta(1 - E(\tilde{x}))\,I}. \tag{11}$$

And, the optimal level of cash holdings is given by

$$C^* = I - L(\rho_M^*) - \left[L(\rho_R^*)\,|e = e^H\right]. \tag{12}$$

The lending rates in Proposition 1 are a (probability) weighted average of the per unit cost of liquidating the intermediary's assets scaled by default risk and adjusted for the elasticity of loan demand. As expected, the project lending rates increase as the per unit liquidation costs increases. Furthermore, the lending rates increase as the elasticity of loan demand decreases.

Taking the partial derivatives of the lending rates with respect to project risk and with respect to liquidity we get the following corollary to Proposition 1.

Corollary 1 *(Risk effect)* $\frac{\partial \rho_i^*}{\partial \theta} < 0$ *for* $i = R, M$*, i.e., an increase in macroeconomic risk* $(1-\theta)$*, ceteris paribus, increases the equilibrium lending rate for both project types;* $\frac{\partial \rho_R^*}{\partial p} < 0$*, i.e., an increase in specific risk of the risky project* $(1-p)$*, ceteris paribus, increases the equilibrium lending rate for the* *risky project. (Liquidity effect)* $\frac{\partial \rho_i^*}{\partial I} < 0$ *for* $i = R, M$*, i.e., an increase in the liquidity of the intermediary, ceteris paribus, decreases the equilibrium lending rate for both project types.*

The results of Corollary 1 are very intuitive. The first part of the corollary implies that the project loan rates are increasing in default risk. The last part of the corollary implies that as the intermediary's liquidity (defined by its total investment funds) increases the expected penalty cost of liquidity shortage decreases and thus the intermediary passes some of this benefit to the borrowers in the form of a lower lending rate.

2.2 The model with asymmetric information

Now let us consider the case where 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 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 level of lending rate, the manager on average makes a higher volume of risky loans when he exerts high effort relative to the case in which he exerts low effort, i.e. $E[L(\rho_R)|e_H] > E[L(\rho_R)|e_L]$. As before, we consider the case where it is in the interest of the principal to implement high effort.

The manager earns an income, b, where $b = b_R + b_M$. The managerial income b can be interpreted as bonuses where b_R is the bonus earned from processing risky loans while b_M is the bonus earned from processing medium-risk 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 which 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 expected profits of the intermediary.[17] 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 intermediary 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 $w = b_R + b_M - \psi$.

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

The manager's utility function is represented by $u(w, e)$, where $u_w(w, e) > 0$, $u_{ww}(w, e) < 0$, and $u_e(w, e) < 0$ (where the subscripts denote the partial derivatives). This implies that the manager prefers more wealth to less, he is risk averse, and he dislikes high effort. More specifically we assume that the utility function is given by $u(w, e) = v(w) - e$, where $v'(w) > 0$, $v''(w) < 0$. The manager's reservation utility is denoted by u^o.

The manager can observe the quality of the projects, θ and p, as well as the specific level of investment funds available to the intermediary, 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 had set the appropriate lending rates which maximize expected profits (unless the principal conducts an audit at $t = 1$).

[17] A more formal definition of 'reaching for yield' is provided in Section 2.2.2. Note that there may be other scenarios whereby a manager takes excessive risk which may not be induced by a principal-agent problem. Nevertheless, in this paper our focus is on reaching-for-yield behavior which is an outcome of an inside agency problem.

We assume that the principal can observe the distribution of investment funds (instead of its exact level) which is given by $J(I)$ and that the liquidity of an intermediary 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 out to other intermediaries while at the same time the liquidity of other intermediaries can also make its way to the intermediary 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.[18] Examples of off-balance sheet liquidity include financing commitments, repurchase agreements, guarantees, foreign currency accruals and receivables, and exposure to special purpose vehicles amongst others.

The time line of events is summarized in Fig. 3. The chronology of events at $t = 0$ is as follows. Principal offers contract to manager such that the high effort levels are chosen; manager chooses effort levels; manager receives investments, I, and observes the riskiness of the projects, θ and p; and subsequently the manager sets the loan rates, ρ_M 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 intermediary could experience early withdrawals and in case of a liquidity shortfall the intermediary suffers 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 contingent 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

[18] 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.

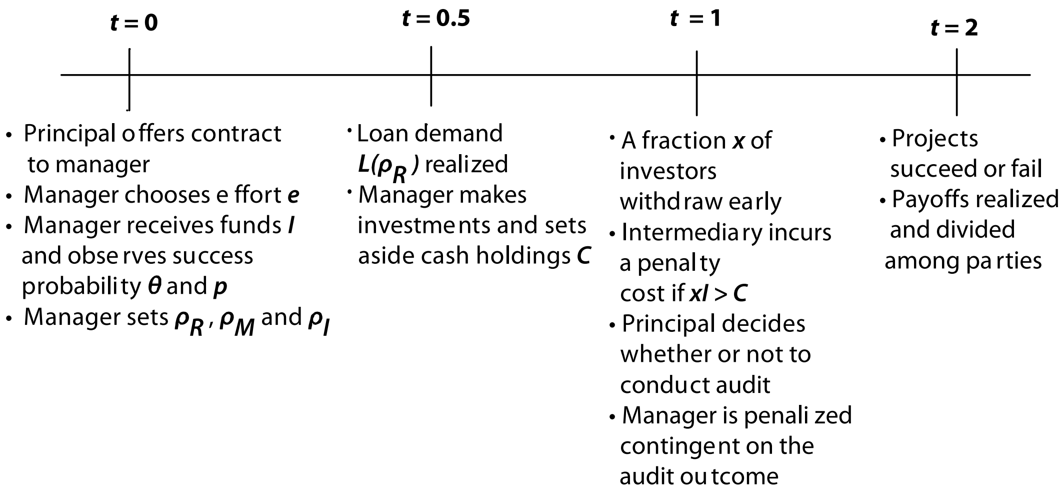

Figure 3: Timeline of events under asymmetric information.

after observing projects' risk. This implies that when setting the lending rate, the manager takes into account the level of financial intermediary'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 and, hence the principal cannot enforce the optimal lending rates via an incentive compatible condition.

In this asymmetric information setting, the contract that the principal offers the manager specifies the compensation of the manager in the form of bonuses, b_i for $i = R, M$, 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 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.

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

$$\max_{b_R, b_M, \psi, \phi} \Pi - \bar{E}\left(b_R + b_M - \psi\right) - \bar{E}\left(z\right) \tag{13}$$

subject to

$$\bar{E}\left[v\left(b_R + b_M - \psi\right)\right] - e \geq u^o, \tag{14}$$

$$\bar{E}\left[u|e^H\right] > \bar{E}\left[u|e^L\right], \tag{15}$$

$$\psi \leq \min\left(\bar{\psi}, \gamma\Psi\right), \tag{16}$$

and

$$\phi \in [0,1]. \tag{17}$$

where $\bar{E}$ represents the expectations operator over the range of values of x, L_R, and I.

The above program says that the principal chooses a compensation schedule so as to maximize its expected profits minus the expected compensation of the manager and minus the expected audit costs subject to a number of constraints. Constraint (14) is the participation constraint which says that the manager's expected utility must be at least equal to his reservation utility. Constraint (15) is the incentive compatibility constraint for inducing high effort. Constraint (16) is the limited liability constraint and says that the managerial penalty cannot exceed $\bar{\psi}$. In fact by definition this constraint holds with equality.[19] Finally, constraint (17) 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 intermediary, if any. We can then prove the following proposition.

Proposition 2 *The managerial compensation contract is such that bonuses*

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

for processing riskier loans, b_R, are increasing in the loan volume of risky loans, L_R. However, the bonuses for processing medium-risk loans, b_M, are constant and thus do not vary with the loan volume of medium-risk loans, L_M. Moreover, the principal conducts an audit at $t = 1$, if and only if, the liquidity shortfall, ℓ, suffered by the intermediary exceeds some threshold ℓ^*.[20] *In other words, the optimal audit policy contingent on the realization of liquidity shortfall, ℓ, is given by*

$$\phi|\ell = \begin{cases} 1 \text{ } if \text{ } \ell > \ell^* \\ 0 \text{ } otherwise \end{cases} .^{21} \tag{18}$$

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 medium-risk investments he receives a fixed compensation for investing in medium-risk assets irrespective of the loan volume of such assets.[22] 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

[20] More generally, as shown in the proof of proposition 2 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).

[21] 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 $\Pr(\ell > \ell^*)$.

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

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.

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 medium-risk investments. Since the manager gets a fixed wage from making medium-risk investments he has an incentive to reduce the volume of medium-risk 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.

2.2.1 Optimal loan rates under asymmetric information

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

$$\max_{\rho_R,\rho_M,C,\rho_I} \pi - \hat{E}\left[\Psi|e = e^H\right] - \hat{E}\left[b + z|e = e^H\right], \tag{19}$$

subject to the participation constraint

$$\hat{E}(\tilde{x}) + \left(1 - \hat{E}(\tilde{x})\right)\left[\theta\rho_I + (1-\theta)\frac{\rho_C\hat{E}\left[\max\left(C - \tilde{x}I, 0\right)|e = e^H\right]}{\left(1 - \hat{E}(\tilde{x})\right)I}\right] \geq \bar{u} \tag{20}$$

and the budget constraint

$$L(\rho_R) + L(\rho_M) + C = I, \tag{21}$$

where $\hat{E}$ represents the expectation operator over the range of values of x and L_R and π is given by Eq. (8). 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 intermediary 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 intermediary'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.

Proposition 3 *In the presence of asymmetric information, if the manager does not reach for yield and, hence, there is no agency problem, then (for a given I) the lending rates chosen by the manager are given by:*

$$\rho_M^{na} = \rho_M^* + \frac{\frac{\partial \hat{E}\left[b+z|e=e^H\right]}{\partial \rho_M}}{\theta L'(\rho_M)}, \tag{22}$$

and

$$\rho_R^{na} = \rho_R^* + \frac{\frac{\partial \hat{E}\left[b+z|e=e^H\right]}{\partial \rho_R}}{\theta \frac{\partial \hat{E}[L|e=e^H]}{\partial \rho_R}}, \tag{23}$$

where ρ_i^*, for $i = R, M$, are the first-best rates given by Eqs. (9) and (10). It follows that $\rho_M^{na} > \rho_M^*$ and $\rho_R^{na} > \rho_R^*$.

The lending rates set by the manager in the presence of asymmetric information but in the absence of any agency problems are higher than the first-best. The intuition is as follows. In the case of risky loans, an increase in the lending rate for risky loans lowers the loan volume of risky loans and thus reduces the associated bonuses which the principal has to pay to the manager given that managerial bonuses for risky loans are increasing in the loan volume of risky loans. Furthermore, expected audit costs are decreasing in the loan rate of both risky and medium-risk loans. This is because an increase in lending rates reduces loan volume which in turn lowers the probability of liquidity shortfalls and thus decreases the expected audit costs. Consequently, a manager acting in the interest of the principal sets lending rates which are higher than the first-best. In short, in the presence of asymmetric information, the optimal loan rates that maximize the principal's expected profits are given by the second-best rates in Eqs. (22) and (23), which are both higher than the corresponding first-best rates.

2.2.2 Managerial agency problem

We will encounter a managerial agency problem if the manager maximizes his own expected utility instead of maximizing the principal's expected profits. In this case it can be shown that 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 $\rho_R < \rho_R^{na}$ and $\rho_M > \rho_M^{na}$, where ρ_i^{na} 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 medium-risk loan rate.*

The above definition implies that if a manager reaches for yield he will be overinvesting in risky assets but underinvesting in medium-risk 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:

$$\max_{\rho_R,\, \rho_M,\, C} E\left[v\left(b_R + b_M - \psi\right)|e = e^H\right] - e^H \tag{24}$$

subject to

$$L_R + L_M + C = I, \tag{25}$$

$$L_M \geq \underline{L}_M^k \; \forall \theta^k, \tag{26}$$

where

$$\psi = \begin{cases} \min\left(\bar{\psi}, \gamma\Psi\right) & \text{if } \ell > \ell^* \text{ and } \rho_i \neq \rho_i^{na} \\ 0 & \text{otherwise} \end{cases}. \tag{27}$$

The above program says that the manager chooses his investment portfolio so as to maximize his expected utility conditional on high effort (24), subject to the budget constraint (25). Condition (26) states that a minimum investment amount needs to be allocated to the medium-risk asset for any given level of risk.[23] Condition (27) 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 intermediary's penalty cost Ψ but cannot exceed $\bar{\psi}$ given limited liability) if it is inferred that the manager had not maximized the expected profits of the intermediary (which is the case when the manager sets loan rates which do not correspond to the rates that maximize the intermediary's expected profits under asymmetric information, i.e. $\rho_i \neq \rho_i^{na}$).

After solving the above problem we can prove the following proposition.

Proposition 4 *The manager will reach for yield if the liquidity, I, of the intermediary is sufficiently high. Furthermore, if the manager reaches for yield he will make the minimum possible investment in the medium-risk asset and will overinvest in the risky asset.*

The proposition says that for high enough liquidity the manager has an incentive to overinvest in risky assets while underinvesting in medium-risk

[23]For example, given a risk level of $1 - \theta^k$ the manager needs to invest at least $\underline{L}_M^k$ in the medium-risk asset, where $\underline{L}_M^k$ is decreasing in the risk of the failure of the medium-risk project. Such constraints exist in practice to 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 $L_M \geq 0$ without affecting any of our results. This is effectively a short selling constraint and in the absence of such a constraint the manager will have an incentive to short sell the medium-risk invest and reallocate the proceeds between the risky asset and cash holdings.

assets. In other words, the agency problem only comes into play if the liquidity (I) of the intermediary is high enough. The intuition behind the above result is as follows. In the presence of excessive liquidity the probability that the intermediary will suffer a liquidity shortfall is very low and hence it is unlikely that the manager will be audited. A rational manager understands this and thus when he observes that the intermediary 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, for low enough liquidity an audit is more likely and 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 on the manager. 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 and consequently, agency problems will arise for high enough levels of intermediary's liquidity.

The above proposition says that not only does the manager overinvest in the risky asset, but he also underinvests in the medium-risk asset. Intuitively, overinvestment in the risky asset crowds out investment in the medium-risk asset, which is conducive to underinvestment in the medium-risk asset. It is interesting to note that the manager has no incentive whatsoever to invest in the medium-risk 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 medium-risk asset given that investments in medium-risk assets entail lower screening and monitoring costs. In fact, the manager is better off by retaining funds in the form of cash holdings rather than investing those funds in the medium-risk 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 medium-risk 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 medium-risk asset.[24]

We then have the following corollary to Proposition 4.

Corollary 2 *If the manager reaches for yield he follows the following pecking order when making portfolio allocations: The first preference is to invest in risky assets; the second preference is to invest in the safest asset like cash or cash equivalents; and finally the least desirable investment allocation is in "medium-risk 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 financial intermediaries and subsequently invest the borrowed sum in risky or medium-risk projects.

We assume that there exists a continuum of risk-neutral borrowers who have access to either risky or medium-risk projects. These agents have no wealth and, hence, need to borrow from financial intermediaries to make investments in projects. We analyze the behavior of a representative borrower who has access to a project of risk type i, where $i = R, M$ denotes that the project is either a risky project or a medium-risk project. Analysis of a

[24]In fact, as noted in footnote 23, in the absence of the short-sale constraint (26) the manager will short sell the medium-risk asset as much as is possible and reallocate the proceeds between the risky asset and cash.

representative borrower implies that the equilibrium is symmetric and all borrowers of type i will choose the same portfolio. This also implies that the intermediary 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 medium-risk project is given by $\omega_M = \theta$, where $\omega_M > \omega_R$ since $p < 1$.[25] 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 Acharya and Naqvi (2012) and Allen and Gale (2000), we assume that the borrowers face a non-pecuniary cost of investing in projects $t_i\left(Y_i^d\right)$, which satisfies the usual neoclassical properties 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 borrowers are 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:

$$\max_{Y_i^d} \omega_i \left[X_i Y_i^d - \rho_i P_i Y_i^d\right] - t_i\left(Y_i^d\right) \tag{28}$$

[25] In case of failure, the risky project yields y but this return accrues to the intermediary owing to default and thus the borrower gets zero in the event of failure.

subject to the market-clearing condition

$$Y_i^d = Y_i^s. \tag{29}$$

Expression (28) 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 (28) is

$$\omega_i \left[X_i - \rho_i P_i\right] - t_i' \left(Y_i^d\right) = 0. \tag{30}$$

Solving for P_i we get

$$P_i = \frac{\omega_i X_i - t_i' \left(Y_i^d\right)}{\omega_i \rho_i}. \tag{31}$$

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

$$P_i^* = \frac{\omega_i X_i - \tau_i \left(Y_i^s \left(P_i^*\right)\right)}{\omega_i \rho_i}. \tag{32}$$

The above expressions says that 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

$$P_R^* = \frac{\theta p X_R - \tau_R \left(Y_i^s \left(P_R^*\right)\right)}{\theta p \rho_R}, \tag{33}$$

and substituting $i = M$ and $\omega_M = \theta$ we get the equilibrium asset price of the medium-risk asset which is given by

$$P_M^* = \frac{\theta X_M - \tau_M \left(Y_i^s \left(P_M^*\right)\right)}{\theta \rho_M}. \tag{34}$$

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:

$$\frac{dP_i^*}{d\rho_i} = -\frac{X_i}{\rho_i^2} + \frac{\tau_i \left(Y^s \left(P_i^*\right)\right)}{\omega_i \rho_i^2} - \frac{\tau_i' \left(Y^s \left(P_i^*\right)\right) Y_i^{s\prime} \left(P_i\right)}{\omega_i \rho_i} \frac{dP_i^*}{d\rho_i}. \tag{35}$$

Rearranging and simplifying Eq. (35) we get

$$\frac{dP_i^*}{d\rho_i} \left[1 + \frac{\tau_i' \left(Y^s \left(P_i^*\right)\right) Y_i^{s\prime} \left(P_i\right)}{\omega_i \rho_i}\right] = -\frac{P_i^*}{\rho_i}. \tag{36}$$

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^{na} denote the fundamental (gross) lending rate which is the rate obtained in the absence of any agency problems, where ρ_M^{na} is given by Eq. (22) and ρ_R^{na} is given by Eq. (23). Then the fundamental asset price is given by the following fixed-point condition

$$\bar{P}_i^* = \frac{\omega_i X_i - \tau_i \left(Y_i^s \left(\bar{P}_i^*\right)\right)}{\omega_i \rho_i^{na}}. \tag{37}$$

Thus the fundamental asset price of the medium-risk project is given by

$$\bar{P}_M^* = \frac{\theta X_M - \tau_M \left(Y_M^s \left(\bar{P}_M^*\right)\right)}{\theta \rho_M^{na}}, \tag{38}$$

whilst the fundamental asset price of the risky asset is given by

$$\bar{P}_R^* = \frac{\theta p X_R - \tau_R \left(Y_R^s \left(\bar{P}_R^* \right) \right)}{\theta p \rho_R^{na}}. \tag{39}$$

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 Eq. (32) with the fundamental asset price, $\bar{P}_i^*$, given by Eq. (37), it can be noted that $P_i^* > \bar{P}_i^*$ as long as $\rho_i < \rho_i^{na}$. Conversely, $P_i^* < \bar{P}_i^*$ as long as $\rho_i > \rho_i^{na}$. In 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 the fundamental values.

From Proposition 4 we know that for high enough liquidity of the intermediary ($I > I^*$), the manager reaches for yield by overinvesting in the risky asset (by setting $\rho_R < \rho_R^{na}$) but underinvesting in the medium-risk asset (by setting $\rho_M > \rho_M^{na}$). It follows that for a high enough liquidity level of the intermediary, $P_R^* > \bar{P}_R^*$, but $P_M^* < \bar{P}_M^*$. We thus have the following corollary to Proposition 4.

Corollary 3 *If the liquidity, I, of the intermediary 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 medium-risk asset.*

The formation of a bubble and negative bubble can also be illustrated by way of a four-quadrant diagram. In Fig. 4 we depict the mechanics behind the formation of a negative bubble. Quadrant I shows the relation between the risk of the medium-risk project, $1-\theta$, and the loan rate for the medium-risk project, ρ_M as measured by line AA. Note that, in general, the higher the risk, the higher would be the equilibrium loan rate. The lending rate in turn determines the demand for loans and the volume of credit in the economy. The lower the loan rate, the higher is the amount of investment in the asset as is captured by line NN in Quadrant II. Quadrant III illustrates the positive relation between investment and asset prices as captured by line BB. In general, an increase in investment pushes up asset demand, which in turn increases asset prices. Conversely, a reduction in investment reduces asset prices. Finally, Quadrant IV depicts the relation between asset price and risk. The equilibrium relation between asset price and risk is derived by tracing the effects of risk on lending rate, which in turn influences investment, which subsequently affects the asset price. As expected, there is an inverse relation between asset price and risk as is captured by line ZZ, i.e. an increase in risk lowers the asset price and vice versa.

For example, if the risk of the medium-risk project is given by $1-\theta^o$, then as shown in Quadrant I, the manager will set a loan rate of ρ_M^o as long as there are no agency problems. The amount of investment corresponding to a loan rate of ρ_M^o is given by N^o in Quadrant II. Given an investment of N^o the equilibrium asset price is given by P^o in Quadrant III. Tracing the relation between varying levels of risk and the corresponding asset price via loan rates and investment volumes, we can derive line ZZ in Quadrant IV which summarizes the negative relation between risk and asset price.

Let the line AA represent the fundamental relation between risk and loan rates, i.e. the relation that would prevail in the absence of any agency problems. Then, for any given level of risk, the fundamental asset price would be determined by the line ZZ. However, as discussed in Proposition 4, if the liquidity of the intermediary is sufficiently high then an agency problem is actuated whereby the manager crowds out investment in the medium-risk asset so as to overinvest in the risky asset. In other words, for sufficiently

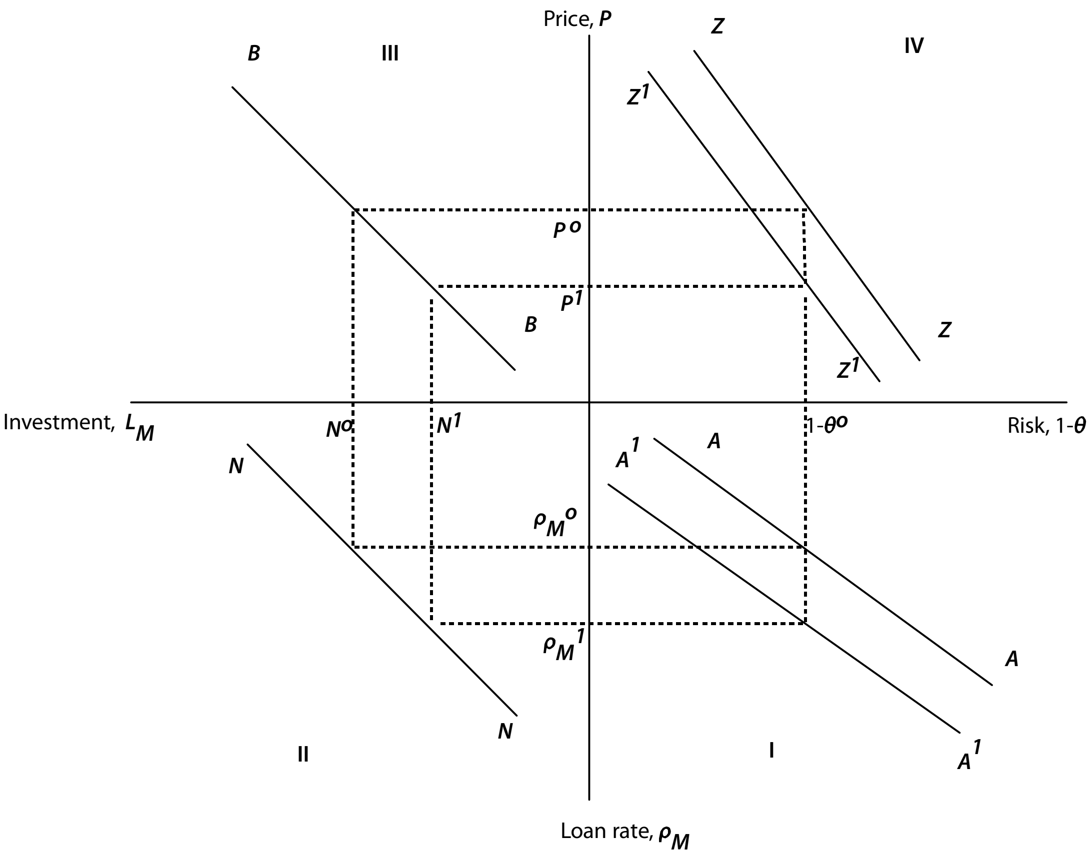

Figure 4: The mechanics of the formation of “negative bubbles”.

high liquidity levels, the manager increases the loan rate for the medium-risk asset for the same level of risk. This shifts the line AA to A^1A^1 in Quadrant I and thus for the same level of risk the loan rate increases to ρ^1_M. An increase in the loan rate crowds out investment from N^o to N^1 as shown in Quadrant II. The dampening of investment demand in turn reduces the asset price from P^o to P^1 as can be seen in Quadrant III. Finally, Quadrant IV depicts that an increase in liquidity reduces the asset price from P^o to P^1 for the same level of risk implying that the line ZZ shifts to the left to Z^1Z^1.

In short, once the agency problem is actuated, an asset price negative bubble is formed in the market for the medium-risk asset. Using similar dynamics, we can show that the opposite happens in the market for the risky asset, whereby an increase in the liquidity of the intermediary inflates the asset price of the risky asset thereby forming an asset price bubble in the market for the risky asset.

Our analysis implies that a bubble in the market for an asset is accompanied by a negative bubble in the market for another asset. More specifically, a bubble in the market for the risky asset exists concurrently with a negative bubble in the market for the medium-risk asset. Intuitively, overinvestment in one market crowds out investment in another market causing bubbles and negative bubbles to arise simultaneously.

Interestingly, the negative bubble is likely to arise in the market for the 'medium-risk' assets rather than the 'safest' assets (for instance, 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 on to cash and cash equivalents so as to avoid the likelihood of liquidity shortfalls. Such a portfolio choice effectively dampens out the demand for the medium-risk asset when the intermediary is flush with liquidity. Consequently, negative bubbles are more likely to arise in the market for medium-risk 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. First, we will study the direct effects of open market operations via changes in the yield of liquid assets (e.g. treasuries) on the behavior of managers.[26] We will then study the effects of open market operations via changes in the interbank rate on managerial behavior.

As mentioned in Section 2.1, ρ_C denotes the return on liquid reserves (e.g. treasuries) held by financial intermediaries. The yield on liquid reserves, ρ_C, is directly affected by 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 and hence increases 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 and thus reduces the yield, ρ_C, of liquid assets.

Hence, in order to analyze the direct effects of open market operations on the investment decisions of managers, we do comparative statics with respect to ρ_C, holding all other things constants. We can then prove the following proposition.

Proposition 5 *As the return on liquid reserves, ρ_C, increases, ceteris paribus, managers set aside higher liquid reserves, C, and reduce the volume of investments made in risky and medium-risk assets as long as there is no agency problem inside intermediaries. Conversely, as ρ_C decreases, ceteris paribus, managers set aside lower liquid reserves, C, and increase the volume of investments made in risky and medium-risk assets in the absence of any agency*

[26] We use the terms 'cash reserves', 'liquid reserves', and 'liquid assets' interchangeably to refer to the (highly liquid) reserves, C, retained by the intermediary after making investments in risky and medium-risk assets.

problems inside intermediaries.

However, in the presence of an agency problem (whereby the manager reaches for yield), any changes in ρ_C, ceteris paribus, do not affect the investment allocation decision of managers. Furthermore, the likelihood that the manager reaches for yield is not affected by changes in ρ_C, all other things being equal.

The intuition behind the above proposition is as follows. As the return on holding liquid assets (e.g. treasuries) increases (following a monetary tightening) then in the absence of any agency problems, there is a substitution effect whereby managers maximizing the expected profits of the intermediary increase their holdings of liquid assets and at the same time reduce the volume of investments made in risky and medium-risk assets. Conversely, as the return on holding liquid assets decreases (following a monetary loosening) then in the absence of any agency problems, managers reduce their holdings of liquid assets and subsequently increase their investments made in risky and medium-risk assets. This result is purely a substitution effect whereby managers who are maximizing the expected profit of intermediaries hold liquid assets up to the point where the marginal benefit of holding an additional unit of a liquid asset just equals the corresponding marginal cost.

The second part of Proposition 5 says that if managers are maximizing their expected utility by reaching for yield (rather than maximizing the expected profit of the intermediary) then any change in the return on holding liquid assets, ρ_C, *ceteris paribus*, does not affect the investment decision of managers. More precisely, the portfolio allocation between risky assets, medium-risk assets, and liquid assets is independent of ρ_C, ceteris paribus, if the manager is reaching for yield. Intuitively, managers who are reaching for yield prefer investing in risky assets so as to increase their bonuses while the motivation behind investing in liquid assets is to provide them with a buffer against shocks and runs rather than to earn the (lower) return from holding liquid reserves. Thus any change in the return on liquid assets does not change the portfolio allocation problem of such managers since the return on risky assets (in the form of higher bonuses) always dominates the lower return from holding liquid reserves.[27] Hence, conditional on the actuation of an agency problem, *other things being equal*, any change in the return on holding liquid reserves, ρ_C, will not *directly* affect the portfolio choice of the manager.

Nevertheless, in practice, 'other things are not equal', in the sense that open market operations do not only directly affect Treasury yields but also target the interbank rate and hence the opportunity cost of borrowing. We show that this will directly have an impact on the amount of liquidity available to financial intermediaries. More precisely, we will show that loose monetary policy decreases the expected cost of liquidity shortfalls. It is possible to show this relationship in a number of ways. However, we will show this more formally by studying a stylized model of impatient investors and later we will discuss simpler ways that lead us to the same result.

As before, a fraction $\tilde{x}$ of the investors experience a liquidity shock at $t = 1$. However, now we make the more realistic assumption that these impatient investors can finance their liquidity shock in either of two ways. First, as before the impatient investors can run on the intermediary and withdraw their endowment of 1 unit prematurely at $t = 1$. Alternatively, the impatient investors can borrow from other institutions who have ample liquid funds and are willing to lend funds at a rate commensurate with the risk level of the borrowers. For example, investors who have invested their endowments with a fund can either run and liquidate their investments (and lose out on the long term return from the fund) or they can borrow from a bank to cover their liquidity shock.[28]

[27] Managers do not get higher bonuses from investing in liquid assets because as shown earlier bonuses are increasing in the investment volume of risky assets but the bonuses from other forms of investment are lower or flat. This is because managers need to put in more effort (screening, monitoring, etc.) when they make investments in risky assets.

[28] The assumption that investors borrow from another financial institution is just for simplicity and ensures that in a three period model the level of liquid reserves of the inter-

The borrowing rate, at which an impatient investor, j, can obtain funding is given by

$$\rho_B^j = \rho_B^j \left(r^j, \rho_C \right) \tag{40}$$

where ρ_B^j denotes the borrowing rate for investor j, r^j denotes the risk level of investor j, and as before ρ_C is a function of monetary policy whereby a monetary tightening increases ρ_C while a monetary loosening reduces ρ_C.[29] In the above formulation, $\partial \rho_B^j / \partial r^j > 0$, i.e. for any given monetary policy an increase in the riskiness of the borrower increases the borrowing rate for that borrower. Also, $\partial \rho_B^j / \partial \rho_C > 0$, i.e. a monetary tightening increases the borrowing rate while a monetary loosening decreases the borrowing rate. This is plausible given that monetary policy targets the interbank rate and the borrowing rates are often indexed to the interbank rate.

Given this setup, an investor j who experiences a liquidity shock will run on the intermediary if and only if the expected utility of running exceeds the expected utility of borrowing to finance the liquidity shock. If the investor runs then he can liquidate his position in the intermediary to cover his liquidity shock and avoid any costs related to borrowing. On the other hand, if the investor borrows to finance his liquidity shock, then he does not need to liquidate his investment in the intermediary and can consume the payoffs from this investment at $t = 2$. However, in the latter case, the investor needs to incur the costs related to borrowing. It can then be shown that for a low

mediary at the end of the interim period are not neutral to the decision of the impatient investors. In a more dynamic model for instance we can have a setup where investors make periodic investments every period. If in any period, an investor experiences a liquidity shock then instead of liquidating his entire portfolio the investor can borrow from the same institution (against the value of his portfolio) to cover his liquidity needs for that period. In this case, the intermediary would prefer that the investor borrow (rather than liquidate his position) since the relative effect on the level of intermediary's liquid reserves is positive with borrowing vis-à-vis liquidating.

[29] We can easily assume that all investors have the same risk profile. However, that simplified assumption would give us a corner solution such that either all impatient investors will run or all of them will borrow since they are all identical. Hence, we consider the more realistic case where investors are heterogenous with differing risk profiles.

enough borrowing rate, investors are encouraged to borrow rather than run since the cost of borrowing is low and they can then consume their payoffs from their investment rather than having to liquidate.

Thus, when monetary policy is loose, the borrowing costs are lower and consequently many investors choose not to run. On the other hand, under a tight monetary policy regime borrowing costs are higher and subsequently more investors run to finance their liquidity shocks. We can reinstate this result in the following proposition, a formal proof of which is provided in the online Appendix.

Proposition 6 *A monetary loosening reduces the expected number of investors who run in the interim period. Conversely, a monetary tightening increases the expected number of investors who run.*

Other than reducing the incentives of investors to run, loose monetary policy can also reduce the intermediaries cost of covering liquidity shortfalls in primarily two ways. First, in a loose monetary policy regime the interbank rate is low and thus intermediaries can borrow from the interbank market at low rates to cover any liquidity shortfalls. Second, intermediaries can also borrow funds from the central bank discount window at the discount rate (which is usually higher than the interbank rate). In a loose monetary policy regime, the central bank's discount rate is also low which again implies that liquid funds are more readily available to intermediaries at relatively lower rates to cover any liquidity shortfalls.[30]

In summary, under a loose monetary policy regime not only there are fewer runs on average (as show in Proposition 6) but also the cost of covering any liquidity shortfalls is relatively cheaper. Conversely, under a tight monetary policy regime, there are more runs on average and the cost of covering liquidity shortfalls is relatively more expensive due to the higher interbank and discount rates.

[30]Formally, in terms of our model monetary policy not only affects the yield of liquid assets, ρ_C, but also affects the expected penalty cost of liquidity shortfalls.

Let I_{LM}^* denote the liquidity threshold at $t = 0$ above which an agency problem is actuated (whereby a manager reaches for yield) under a loose monetary policy regime and I_{TM}^* denote the liquidity threshold at $t = 0$ above which an agency problem is actuated under a tight monetary policy regime. We can then prove the following proposition.

Proposition 7 *Under a loose monetary policy regime, managers are more likely to reach for yield by overinvesting in risky assets and underinvesting in medium-risk assets. Conversely, under a tight monetary policy regime, managers are less likely to reach for yield. More formally,* $I_{LM}^* < I_{TM}^*$.

The intuition behind Proposition 7 is straightforward. Under a loose monetary policy regime, rational managers realize that the expected cost associated with liquidity shortfalls is relatively low. Thus managers realize that when monetary policy is loose an audit is less likely to take place which in turn increases their risk appetite.[31] In other words, under a loose monetary policy regime, the ex ante liquidity threshold (at $t = 0$) above which managers reach for yield is relatively low (as compared to the analogous liquidity threshold in a tight monetary policy regime) and thus managers are more likely to reach for yield by overinvesting in risky assets and underinvesting in medium-risk assets.[32]

Conversely, under a tight monetary policy regime the cost of covering any liquidity shortfalls is also higher. Hence, ex ante the probability of an audit is higher. Subsequently, the ex ante liquidity threshold (at $t = 0$) above which an agency problem is actuated is higher as compared to that in

[31] Recall from Proposition 2 that an audit takes place when the cost incurred due to a liquidity shortfall is high enough or equivalently when the liquidity shortfall is high enough.

[32] This is consistent with Stein's (2013) observation that "a prolonged period of low interest rates, of the sort we are experiencing today, can create incentives for agents to take on greater duration or credit risks ... in an effort to "reach for yield."" Similarly, Rajan (2006) also notes that in an environment of low interest rates the incentive of agents to "search for yield" goes up.

a loose monetary policy regime. Thus, under a tight monetary policy regime managers are less likely to reach for yield. In other words, tight monetary policy by increasing the cost of liquidity shortfalls acts as a disciplining device to mitigate the risk taking appetite of managers.

We then have the following corollary to Proposition 7.

Corollary 4 *Under a loose monetary policy regime, asset price bubbles in the market for risky assets accompanied by negative bubbles in the market for medium-risk 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 medium-risk assets is crowded out which drives down the prices of medium-risk assets resulting in negative bubbles in the prices of medium-risk assets.

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 intermediaries to underprice the underlying risk and thereby increase the volume of credit in the economy. This in turn creates an asset price bubble in the market for risky assets.[33]

[33] Indeed Kindleberger (2005) in his study on the history of financial crises notes that: "Speculative manias gather speed through expansion of money and credit."

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 give out excessive loans. However, there are a number of significant differences. This work generalizes the model of Acharya and Naqvi (2012) by introducing heterogeneity on the asset side of the intermediary. In the model of Acharya and Naqvi (2012) banks can only invest in risky assets, whereas in this paper intermediaries can invest in risky projects as well as medium-risk projects. This heterogeneity on the asset side enables us to establish the pecking order of manager's investment preferences as discussed in the paper. The generalization also enables us to show the coexistence of bubbles (in the market for risky assets) and negative bubbles (in the market for medium-risk 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. Furthermore, this paper also analyzes the role of monetary policy unlike the one by Acharya and Naqvi (2012).

Feroli, Kashyap, Schoenholtz, and Shin (2014) study market "tantrums" whereby risk premiums fluctuate widely. They show that tantrums may arise if asset managers are motivated by their relative performance ranking given that ultimate investors may redeem their investments similar to bank runs. The paper shows that flows in an investment opportunity creates momentum in returns driving up asset prices. These flows arise as a result of yield chasing managers motivated by a drive to outperform their peers. However, changes in the stance of monetary policy can trigger sharp reversals.

Allen and Gale (2000) consider a model whereby 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 thereby fostering an asset price bubble. Barlevy (2014) extends the idea of Allen and Gale (2000) in a dynamic context whereby borrowers with limited liability have an incentive to invest in the risky assets for speculative motives and creditors cannot distinguish between the speculators and nonspeculators. Such behavior of speculators with limited liability leads to the formation of a bubble.

Dow and Han (2015) study a general equilibrium model where some intermediaries have bad management who raise extra debt for empire-building motives rather than maximizing equity value. Since levered intermediaries are protected from downside risk by limited liability the bad management have an incentive to engage in asset substitution by taking excessive risk and consequently bidding up the price of the risky asset. They show that in this context limited liability alone does not cause bubbles as long as the contractual incompleteness in the economy is not too severe. However, more severe contractual incompleteness prevents financial securities from being fairly priced and enables the bad management to exploit limited liability by taking excessive risk thereby causing a bubble in the market for risky assets.

5.2 Empirical support

Our result that overinvestment in the risky market crowds out investment in the market for the medium-risk asset is consistent with the empirical findings of Chakraborty, Goldstein, and MacKinlay (2013). Using U.S. data from 1988 through 2006 they find evidence that banks which increase their investment in the housing market simultaneously cut down on commercial lending. They find that an increase in housing prices is accompanied by a decrease in commercial lending. Coincidentally their sample period is also the period during which the intermediaries had abundant liquidity.

Becker and Ivashina (2014) find empirical evidence that insurance companies, which are the largest institutional holders of corporate bonds, reach for yield when choosing their investment portfolio. Since lower rated bonds bear higher capital requirements, insurance companies prefer to hold high rated bonds. However, conditional on credit ratings, the paper finds that insurance portfolios are systematically biased toward higher yield, higher CDS bonds. Consistent with the results of our model they find that this behavior is related to the business cycle and is most pronounced during economic expansions when investors are flush with ample liquidity.

In parallel work, Choi and Kronlund (2015) find evidence of reaching for yield behavior in U.S. corporate bond mutual funds. They find that reaching for yield was prevalent from 2002 to 2005 and then from 2009 onwards. In both of these periods interest rates were low and mutual funds had ample access to liquidity. Furthermore, they find that the main vehicle for reaching for yield is non-AAA corporate bonds. However, during the 2008 financial crisis funds hoarded on to extremely safe AAA bonds in a sign of the reversal of the reaching-for-yield behavior. These findings are in confirmation with the empirical implications of our model.

Hanson and Stein (2015) find that when the 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. Similarly, Di Maggio and Kacperczyk (2014) provide empirical evidence that money market funds reach for yield by investing in riskier asset classes and holding less diversified portfolios when the fed fund rate is low. In a similar vein, Aramonte, Lee, and Stebunovs (2014) find evidence that investment banks and funds search for yield in response to a decline in spot and forward ten-year U.S. Treasury rates. Dell'Ariccia, Laeven, and Suarez (2013) find evidence that ex-ante risk taking by banks is negatively associated with increases in short-term policy rates. Furthermore, Jiménez, Ongena, Peydró, and Saurina (2014) find that loose monetary policy induces banks to grant more loans to ex ante risky firms. Paligorova and Santos (2013) find evidence that in a loose monetary policy regime banks charge riskier borrowers lower loan spreads relative to safer borrowers. Ioannidou, Ongena, and Peydró (2014) also find that following a loose monetary policy bank credit risk increases and that this effect is more pronounced for banks with more liquid assets and for banks with more acute agency problems.

On a similar note, Maddaloni and Peydró (2011) find evidence that low monetary policy rates have resulted in a softening of the lending standards in Europe and USA and that these results are stronger when banking supervision is weak and when bank moral hazard problems are high. Amato (2005) finds evidence that the monetary policy stance has an impact on the pricing of credit risk as estimated from CDS spreads. Cappiello et al. (2010) and Altunbas et al. (2015) also document a link between monetary policy and risk-taking. All these findings are consistent with the results of our paper.

6 Conclusion

We develop a model of financial intermediation characterized by an inside agency problem whereby managers have an incentive to reach for yield when the intermediary is flush with liquidity. More specifically, when the intermediary has access to high enough liquidity the managers reach for yield by overinvesting in risky assets but underinvesting in medium-risk assets. Managerial portfolio selection is characterized by the following pecking order: their first preference is to invest in risky assets so as to maximize their bonuses; the second preference is to hoard on to cash and cash equivalents since such liquid assets are a good hedge against liquidity shocks that might hit an intermediary; finally the least attractive investment choice is that of medium-risk assets since these assets are not a perfect hedge against liquidity shocks and furthermore their yields on average are lower than that of risky assets. We show that such portfolio allocation choice leads to a bubble in the market for risky assets but a negative bubble in the market for medium-risk assets when the intermediary has access to high enough liquidity. Loose monetary policy only aggravates this agency problem by providing easy access to liquidity at relatively cheaper rates.

References

[1] Acharya, Viral V., and Hassan Naqvi, 2012, The seeds of a crisis: A theory of bank liquidity and risk-taking over the business cycle, *Journal of Financial Economics* 106, 349-366.

[2] Allen, Franklin, and Douglas Gale, 1998, Optimal Financial Crises, *Journal of Finance 53(4)*, 1245-1284.

[3] Allen, Franklin, and Douglas Gale, 2000, Bubbles and crises, *The Economic Journal* 110, 236-255.

[4] Allen, Franklin, and Douglas Gale, 2007, *Understanding financial crises*, New York: Oxford University Press.

[5] Altunbas, Yener, Leonardo Gambacorta, and David Marqués-Ibanez, 2015, Does monetary policy affect bank risk-taking?, forthcoming *The International Journal of Central Banking*.

[6] Amato, Jeffery D., 2005, Risk aversion and risk premia in the CDS market. *BIS Quarterly Review* (December), 55–68.

[7] Aramonte Sirio, Seung Jung Lee, and Viktors Stebunovs, 2014, Risk taking and low longer-term interest rates: Evidence from the U.S. syndicated loan market, Working Paper, Federal Reserve Board.

[8] Barlevy, Gadi, 2014, A leverage-based model of speculative bubbles, *Journal of Economic Theory* 153, 459–505.

[9] Becker, Bo, and Victoria Ivashina, Reaching for yield in the bond market, forthcoming *Journal of Finance*.

[10] Borio, Claudio, and Haibin Zhu, 2012, Capital regulation, risk-taking and monetary policy: A missing link in the transmission mechanism?, *Journal of Financial Stability* 8(4), 236-251.

[11] Buljevich, Esteban C., and Yoon S. Park, 1999, *Project Financing and the International Financial Markets*, New York: Springer.

[12] Cappiello, Lorenzo, Arjan Kadareja, Christoffer K. Sorensen, and Marco Protopapa, 2010, Do bank loans and credit standards have an effect on output? A panel approach for the Euro Area, ECB Working Paper 1150.

[13] CGFS, 2011, Global liquidity - concepts, measurement and policy implications, CGFS Paper, 45.

[14] Chakraborty, Indraneel, Itay Goldstein, and Andrew MacKinlay, 2013, Do asset price bubbles have negative real effects?, Working Paper, University of Pennsylvania.

[15] Chen, Qi, Itay Goldstein, and Wei Jiang, 2010, Payoff complementarities and financial fragility: Evidence from mutual fund outflows, *Journal of Financial Economics* 97(2), 239-62.

[16] Choi, Jaewon, and Mathias Kronlund, 2015, Reaching for yield or playing it safe? Risk taking by bond mutual funds, Working Paper, University of Illinois at Urbana-Champaign.

[17] Coval, Joshua, and Erik Stafford, 2007, Asset fire sales (and purchases) in equity markets, *Journal of Financial Economics* 86, 479-512.

[18] Dell'Ariccia Giovanni, Luc Laeven, and Gustavo Suarez, 2013, Bank leverage and monetary policy's risk-taking channel: Evidence from the United States, IMF Working Paper.

[19] Di Maggio, Marco, and Marcin Kacperczyk, 2014, The unintended consequences of the zero lower bound policy, Working Paper, Columbia University.

[20] Diamond, D., Dybvig, P., 1983, Bank runs, deposit insurance, and liquidity, *Journal of Political Economy* 91, 401–419.

[21] Dow, James, and Jungsuk Han, 2015, Contractual incompleteness, limited liability and asset price bubbles, *Journal of Financial Economics*, 116(2), 383-409.

[22] Feroli, Michael, Anil K. Kashyap, Kermir L. Schoenholtz, and Hyun Song Shin, 2014, Market tantrums and monetary policy, Paper for the U.S. Monetary Policy Forum, New York.

[23] Goldstein, Itay, and Ady Pauzner, 2005, Demand deposit contracts and the probability of bank runs, *Journal of Finance* 60, 1293-1328.

[24] Hanson, Samuel G., and Jeremy C. Stein, 2015, Monetary policy and long-term real rates, *Journal of Financial Economics* 115(3), 429–448.

[25] International Monetary Fund, 2015, *Global Financial Stability Report - Navigating Monetary Policy Challenges and Managing Risks*, Washington.

[26] Ioannidou, Vasso, Steven Ongena, and José-Luis Peydró, 2014, Monetary policy, risk-taking and pricing: Evidence from a quasi-natural experiment, forthcoming *Review of Finance.*

[27] Jimenéz, Gabriel, Steven Ongena, José-Luis Peydró, and Jesús Saurina, 2014, Hazardous times for monetary policy: What do twenty-three million bank loans say about the effects of monetary policy on credit risk-taking?, *Econometrica* 82, 463–505.

[28] Kindleberger, Charles P., 2005, *Manias, panics, and crashes: A history of financial crises*, New Jersey: Wiley.

[29] Maddaloni, Angela, and José-Luis Peydró, 2011, Bank risk-taking, securitization, supervision, and low interest rates: Evidence from the Euro area and U.S. lending standards, *Review of Financial Studies* 24, 2121-65.

[30] Paligorova, Teodora, and João A. C. Santos, 2013, Monetary policy and bank risk-taking: Evidence from the corporate loan market, Working paper, Federal Reserve Bank of New York.

[31] Rajan, Raghuram G., 2006, Has Finance Made the World Riskier?, *European Financial Management* 12, 499-533.

[32] Rajan, Raghuram G., 2013, A step in the dark: Unconventional monetary policy after the crisis, Andrew Crockett Memorial Lecture, Bank for International Settlements.

[33] Shin, Hyun S., 2013, The second phase of global liquidity and its impact on emerging economies, Proceedings of the *Asia Economic Policy Conference*, Federal Reserve Bank of San Francisco.

[34] Shleifer, Andrei, and Robert W. Vishny, 1997, The limits of arbitrage, *Journal of Finance* 52, 35-55.

[35] Stein, Jeremy C., 2013, Overheating in credit markets: Origins, measurement, and policy responses, Speech at the "Restoring Household Financial Stability after the Great Recession: Why Household Balance Sheets Matter" research symposium sponsored by the Federal Reserve Bank of St. Louis, St. Louis, Missouri.

[36] Yellen, Janet, 2011, Assessing Potential Financial Imbalances in an Era of Accommodative Monetary Policy, Remarks at the "International Con-

ference: Real and Financial Linkage and Monetary Policy", Bank of Japan.