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Monetary Policy, Macroprudential Policy, and Financial Stability

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Abstract

This paper reexamines from a theoretical perspective the role of monetary and macroprudential policies in addressing the build-up of risks in the financial system. We construct a stylized general equilibrium model in which the key friction comes from a moral hazard problem in firms' financing that banks' equity capital serves to ameliorate. Tight monetary policy is introduced by open market sales of government debt, and tight macroprudential policy by an increase in capital requirements. We show that both policies are useful, but macroprudential policy is more effective in terms of financial stability and leads to higher social welfare.

JEL Codes: G21, G28, E44, E52.

Keywords: Bank monitoring, intermediation margin, monetary policy, macroprudential policy, capital requirements, financial stability.

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1 Introduction

The Global Financial Crisis has highlighted the relevance of financial intermediaries' risk-taking behavior. Various channels have been advanced as possible causes of the build-up of risks in the financial sector leading to the crisis, and also multiple policies have been put forward by academics and policy makers to reduce the likelihood and impact of future crises. This paper adds to this literature by reexamining from a theoretical perspective the role of monetary policy and macroprudential policy in addressing the build-up of risks in the financial system. To do this, we construct a stylized general equilibrium model in which the key friction comes from the existence of a moral hazard problem in firms' financing by banks.

Our main building block is the setup of Martinez-Miera and Repullo (2017), in which competitive financial institutions that are funded with uninsured debt can monitor entrepreneurial firms at a cost. Monitoring is costly and unobservable, so there is a moral hazard problem. This setup provides a characterization of the financial industry in which direct market finance and bank finance endogenously arise for different types of firms.[1]

We make three main changes in our previous setup: we introduce the possibility of costly equity financing for banks, we reduce the possible types of entrepreneurs to two, safe and risky, and we analyze the effects on the equilibrium of the model of monetary and macroprudential policies. Allowing for equity financing in a model with unobservable monitoring is relevant since (inside) equity capital will ameliorate the moral hazard problem, so banks will be able to reduce the cost of debt finance and offer lower rates to their borrowers.[2]

The model features four types of agents: entrepreneurs, investors, bankers, and consumers. There is large set of potential entrepreneurs that can be either safe or risky. They require external funding for their investment projects, which is provided by investors and banks. Banks are monitoring institutions set up by bankers to fund risky entrepreneurs.

[1] This is in line with the results of Hölmstrom and Tirole (1997), but focusing on firms' observable risk characteristics instead of on their initial wealth.

[2] Martinez-Miera and Repullo (2018) analyze a related model focusing on the effects of bank capital regulation in the presence of unregulated financial intermediaries (shadow banks).

Investors are characterized by their aggregate initial wealth that is used to fund safe entrepreneurs and provide banks' debt. Bankers are characterized by their aggregate initial wealth that is used to provide banks' equity capital (and possibly also fund safe entrepreneurs). Finally, consumers are characterized by a downward-sloping demand for the output of safe and risky entrepreneurs. We assume that investors and bankers are risk-neutral, and that all agents are price-takers.

The equilibrium is characterized by a rate at which safe entrepreneurs borrow from investors (the safe rate), which defines the return that investors get from their wealth, a rate at which risky entrepreneurs borrow from banks, and a return that bankers get from their wealth. It is also characterized by the capital per unit of loans that banks choose to have, the rate at which they borrow from investors, and the monitoring intensity of the projects that they fund. Finally, the rates at which safe and risky entrepreneurs borrow from investors and banks, respectively, determine their investment and output, via the consumers' inverse demand functions.

There are two possible types of equilibria. In the first one bank capital is scarce, in the sense that bankers get a higher return from their wealth than investors. In the second one bank capital is abundant, and bankers get the same return from their wealth as investors. In a capital scarce equilibrium all bankers' wealth is invested in bank capital, while in a capital abundant equilibrium part of it is also used to fund safe entrepreneurs. We focus our analysis on the capital scarce equilibrium.

We show that in equilibrium banks will choose a positive amount of capital and a positive level of monitoring. Moreover, their monitoring intensity will be increasing in their intermediation margin. Since financial stability is determined by the monitoring of risky entrepreneurs by banks, this result implies that whatever happens to banks' intermediation margin is key to determine its effects on financial stability.

After characterizing the equilibrium of the model, we show that an (exogenous) increase in investors' wealth results in higher investment of safe and risky entrepreneurs, lower returns of debt and equity, lower intermediation margins, and higher leverage and risk-taking by banks. We also show that an (exogenous) increase in bankers' wealth results in higher investment of safe and risky entrepreneurs, lower returns of debt and equity, higher intermediation margins, and lower leverage and risk-taking by banks. Hence, we conclude that not only the aggregate amount of funding but also the relative amounts of investors and bankers' wealth are key determinants of financial stability, as they generate opposite effects on banks' risk-taking incentives.

We next analyze the effect of monetary and macroprudential policies. The latter is modeled by introducing a macroprudential regulator that can set a minimum capital requirement for banks, that is a regulation that requires banks to have a minimum amount of equity capital per unit of loans. The former is modeled by introducing a central bank that can raise the safe interest rate via open market sales of government debt that reduce the funds that investors allocate to safe entrepreneurs and banks.

We show that tighter monetary policy increases the return of debt and equity, reduces investment for both safe and risky entrepreneurs, increases the intermediation margin and reduces risk-taking by banks. We also show that higher capital requirements (if binding) increase the return of equity, decrease the return of debt, shift investment from risky to safe firms, increase the intermediation margin and reduce risk-taking by banks. Although the effect of both policies on risk-taking goes in the same direction, higher capital requirements have a positive effect that is not present with tight monetary policy, namely they shift investment toward safe firms, reducing the safe rate and consequently the cost of bank debt, which leads to a further increase in the intermediation margin. For this reason, we conclude that macroprudential policy appears to be more effective than monetary policy for reducing risk-taking by banks.

Moreover, we consider how these two policies interact, showing that, in contrast with our previous result, in the presence of binding capital requirements a tightening of monetary policy increases risk-taking by banks. The reason for this somewhat surprising result is as follows. With binding capital requirements, investment of risky entrepreneurs, and hence the rate at which they borrow from banks, is determined by the capital requirement. Under these conditions, the higher cost of bank debt due to the tightening of monetary policy is not translated into higher loan rates, so the intermediation margin goes down, increasing banks' risk-taking.[3]

Although both policies can be effective in ameliorating banks' risk-taking incentives, this may be costly in terms of social welfare. Hence, to complete the discussion we undertake a welfare analysis, which requires to derive the objective function of the social planner. Social welfare comprises the return of investors' wealth, the return of bankers' wealth, the consumers' surplus from entrepreneurial output, and the profits or losses of the central bank from open market operations, in the case of active monetary policy, which are assumed to be transferred to or from investors in a lump sum manner.

Armed with this social welfare function we first show that the laissez-faire equilibrium of the model is constrained inefficient, that is, a social planner subject to the same moral hazard problem as the banks could improve upon the equilibrium allocation. The reason is that competition among banks leads to intermediation margins and monitoring intensities that are too low. By moving investment from risky to safe firms, the social planner widens intermediation margins and increases bank monitoring, which leads to higher social welfare.

Finally, we analyze the optimal stand-alone monetary policy, the optimal stand-alone macropudential policy, and the optimal combination of the two policies. Our numerical results show that the optimal combination of both policies is closer in terms of both financial stability and social welfare to the optimal stand-alone macropudential policy, which are in turn higher than those that can be obtained with the optimal stand-alone monetary policy. The increase in welfare delivered by the combination of both policies is achieved by a further increase of capital requirements which is accompanied by a tightening of monetary policy, which dampens the fall in the safe rate.

This paper is related to a large literature that analyzes the so-called "risk-taking channel" of monetary policy, that is the connection between monetary policy rates and financial stability. In particular, a set of recent empirical papers has shown that low interest rates, especially for an extended period of time, are significant factors in the build-up of risks in

[3]It should be noted that our results should be qualified whenever, as noted by Hanson et al. (2011), a tightening of macropudential tools may shift some intermediation away from regulated banks and into the shadow banking system, reducing the effectiveness of such tools.

the banking system. For example, Maddaloni and Peydró (2011) find that low short-term interest rates soften standards for household and corporate loans, Altunbas, Gambacorta and Marques-Ibanez (2014) document that "too low for too long" short-term interest rates lead to increases in risk-taking by banks, Jiménez et al. (2014) show that lower short-term rates induce lowly capitalized banks to grant more loan applications to ex-ante riskier firms, while Dell'Ariccia, Laeven and Suarez (2017) show that short-term interest rates are negatively associated to ex-ante risk-taking by banks, via changes in leverage. Our paper provides a theoretical framework that can account for these empirical results.

The paper is also related to the literature on the connection between financial frictions and macroeconomic fluctuations, starting with Bernanke and Gertler (1989), Bernanke, Gertler and Gilchrist (1996), and Kiyotaki and Moore (1997). This literature has mainly focused on agency problems between firms and their financiers, in which firms' net worth plays a key role. In this setup lower rates increase borrowers' net worth, leading to credit expansions. More recently, this approach has been extended to incorporate similar agency problems between banks and their financiers, in which the focus is on banks' net worth; see, for example, Gertler and Kiyotaki (2010), He and Krishnamurthy (2013), Brunnermeier and Sannikov (2014), and the survey by Brunnermeier, Eisenbach, and Sannikov (2013). While these papers shed light on the mechanisms by which shocks can be amplified, their focus is not on banks' risk-taking decisions, and the way in which they might depend on monetary and macroprudential policies, which is the focus of our work.

Finally, our paper is closely related to the theoretical literature that has analyzed the determinants of banks' risk-taking incentives and the way in which they are affected by competition and regulation; see Holmström and Tirole (1997), Allen and Gale (2000), Hellmann, Murdoch and Stiglitz (2000), and Repullo (2004). Unlike these models, which are essentially partial equilibrium, following Martinez-Miera and Repullo (2017) our approach is to embed the key incentive mechanism into a stylized general equilibrium model. The paper closest to ours is Dell'Ariccia, Laeven and Marquez (2014); see also Dell'Ariccia and Marquez (2013). In their model there is an infinitely elastic supply of investors' wealth at a given safe rate, determined by monetary policy, and infinitely elastic supply of bankers' wealth at a given spread over the safe rate. In contrast, we posit fixed aggregate supplies of investors' and bankers' wealth. Among other things, our setup allows for monetary and macroprudential policies to affect the cost of bank equity capital, which is exogenously fixed in their model.

With regard to the policy implications of our paper, it is useful to recall the main contrasting views described in the survey paper by Smets (2014); see also Adrian and Liang (2018). The first view, which he calls the *modified Jackson Hole consensus*, argues that "the monetary authority should keep its relatively narrow mandate of price stability and stabilizing resource utilization around a sustainable level, whereas macroprudential authorities should pursue financial stability, with each having their own instruments." In Bernanke's (2011) words, "monetary policy is too blunt a tool to be routinely used to address possible financial imbalances; instead, monetary policy should remain focused on macroeconomic objectives, while more-targeted microprudential and macroprudential tools should be used to address developing risks to financial stability."

The second view is the *leaning against the wind* policy, according to which "financial stability concerns should be part of the secondary objectives in the monetary policy strategy." This view is best described by Stein (2013): "Supervisory and regulatory tools remain imperfect in their ability to promptly address many sorts of financial stability concerns. If the underlying economic environment creates a strong incentive for financial institutions to, say, take on more credit risk in a reach for yield, it is unlikely that regulatory tools can completely contain this behavior." He concludes that "monetary policy ... has one important advantage relative to supervision and regulation–namely that it gets in all of the cracks."

Our results provide support for the view that macroprudential policy should be the primary tool for addressing risks to financial stability. It is true that tight monetary policy "gets in all of the cracks," raising all interest rates and reducing investment across all types of firms, but it also implies raising banks' cost of borrowing, which increases their risk-taking incentives. Thus, from the perspective of our model, getting in all of the cracks can in fact be counterproductive.

The structure of the paper is as follows. Section 2 presents the model, characterizes the laissez-faire equilibrium, and shows some useful comparative statics results. Section 3 analyzes the effects on the equilibrium of the model of two possible instruments to control banks' risk-taking, namely monetary and macroprudential policies. Section 4 derives the objective function of the social planner and presents the welfare analysis of the two policies. Section 5 contains our concluding remarks.

2 Model

Consider an economy with two dates ($t = 0, 1$) and three types of risk-neutral agents: entrepreneurs, investors, and bankers.

There is a continuum of two observable types of potential entrepreneurs, safe (type 0) and risky (type 1). Entrepreneurs are penniless and have investment projects that require external finance. The projects of safe entrepreneurs can be funded by investors and bankers, while those of risky entrepreneurs are only funded by monitoring institutions set up by bankers to fund risky projects, called banks.[4]

Safe entrepreneurs have projects that require a unit investment at $t = 0$ and yield a deterministic return A_0 at $t = 1$. *Risky entrepreneurs* have projects that require a unit investment at $t = 0$ and yield a stochastic return $\widetilde{A}_1$ at $t = 1$ given by

$$\widetilde{A}_1 = \begin{cases} A_1, & \text{with probability } 1 - p + m, \\ 0, & \text{with probability } p - m, \end{cases} \tag{1}$$

where p is a parameter in $(0, 1)$ and $m \in [0, p]$ is the monitoring intensity of the lending bank.

The return A_0 of the projects of the safe entrepreneurs is a positive and decreasing function of the aggregate investment x_0 of the safe entrepreneurs. Similarly, the success return A_1 of the projects of the risky entrepreneurs is a positive and decreasing function of the aggregate investment x_1 of the risky entrepreneurs. Moreover, to simplify the presentation we assume that the same function describes the return of the projects of both types of entrepreneurs, so $A_0 = A(x_0)$ and $A_1 = A(x_1)$, with $A'(x) < 0$.

[4]In general, investors could also fund risky entrepreneurs, but since they are not able to monitor them they cannot successfully compete with banks.

We also assume that the outcome of the projects of the risky entrepreneurs is driven by a single aggregate risk factor z that is uniformly distributed in $[0,1]$. A project monitored with intensity m will fail if and only if $z < p - m$. This assumption implies that the return of projects monitored with the same intensity will be perfectly correlated.

There is a continuum of *investors* characterized by their aggregate initial wealth $W > 0$. Investors are only interested in consumption at $t = 1$, so they supply their wealth inelastically to fund safe entrepreneurs and banks.

There is a continuum of *bankers* characterized by their aggregate initial wealth $K > 0$. Bankers are only interested in consumption at $t = 1$, so they supply their wealth inelastically to fund safe entrepreneurs and/or set up banks to fund risky entrepreneurs. Bankers choose the capital structure of the banks they set up, described by the capital per unit of loans k, and the interest rate B at which they borrow from investors. They also choose the monitoring intensity m of each of the risky projects they fund, which entails a non-pecuniary monitoring cost

$$c(m) = \frac{\gamma}{2}m^2, \tag{2}$$

where $\gamma > 0$. A key informational friction is that bank monitoring is not observed by investors, so there is a moral hazard problem.

We assume *free entry of entrepreneurs*, which implies that they will only be able to borrow at an interest rate that leaves them no surplus. Hence, if the rate at which safe entrepreneurs borrow from investors is R_0, then a measure x_0 of these entrepreneurs will enter the market until $A(x_0) = R_0$. Also, if the rate at which risky entrepreneurs borrow from banks is R_1, then a measure x_1 of these entrepreneurs will enter the market until $A(x_1) = R_1$. Thus, $A(x_0)$ and $A(x_1)$ are the *inverse loan demand functions* of safe and risky entrepreneurs.

The initial wealth W of investors is used to either directly fund safe entrepreneurs at the rate $R_{0,}$ or indirectly (via banks) fund risky entrepreneurs, where by arbitrage they will get an expected return equal to R_0.

The initial wealth K of bankers is used to either directly fund safe entrepreneurs at the rate $R_{0,}$ or to set up banks, where they get an expected return R_k. If $R_k > R_0$ they will invest all their wealth in banks, while if $R_k = R_0$ they will also fund safe entrepreneurs (which in equilibrium ensures that R_k never falls below R_0).

Finally, we assume that *funding markets are perfectly competitive* in the sense that investors take the safe rate R_0 as given, and banks take as given the loan rate R_1 as well as the rates R_0 and R_k that determine their cost of debt and equity, respectively.

2.1 Equilibrium

Consider a representative bank lending to risky entrepreneurs. The bank chooses three variables: the capital per unit of loans k provided by bankers, the interest rate B offered to investors (to raise the remaining $1-k$ funds per unit of loans), and the monitoring intensity m of its loans, taking as given the loan rate R_1, and the returns R_0 and R_k required by investors and bankers, respectively.

As shown in the Appendix, perfect competition in the market for risky loans leads to an equilibrium in which the representative bank lends at the minimum feasible rate R_1^*. Hence, an equilibrium is defined by

$$R_1^* = \min_{(k,B,m)} R_1 \tag{3}$$

subject to the bank's incentive compatibility constraint

$$m^* = \arg\max_m \left[(1-p+m)[R_1^* - (1-k^*)B^*] - c(m)\right], \tag{4}$$

the bankers' participation constraint

$$(1-p+m^*)[R_1^* - (1-k^*)B^*] - c(m^*) \geq R_k k^*, \tag{5}$$

and the investors' participation constraint

$$(1-p+m^*)B^* \geq R_0. \tag{6}$$

The incentive compatibility constraint (4) characterizes the bank's choice of monitoring m^* given that it gets R_1^* and pays $(1-k^*)B^*$ with probability $1-p+m$ (and with probability $p-m$ gets zero, by limited liability). The participation constraints (5) and (6) ensure that bankers and investors get the required return on their investments.

It should be noted that the assumption of a single aggregate risk factor implies that the bank's return per unit of loans is identical to the individual project return. It also implies that the loans' probability of default equals the bank's probability of failure.

A *competitive equilibrium* is characterized by a triple (R_0^*, R_1^*, R_k^*) such that if $R_k^* > R_0^*$ (a capital scarce equilibrium) we have

$$W = x_0^* + (1 - k^*)x_1^*, \tag{7}$$

$$K = k^* x_1^*, \tag{8}$$

and if $R_0^* = R_k^*$ (a capital abundant equilibrium) we have

$$W + K = x_1^* + x_0^*, \tag{9}$$

where R_1^* is a solution for $R_0 = R_0^*$ and $R_k = R_k^*$ to the bank's problem (3) subject to constraints (4)-(6), k^* is the capital per unit of loans chosen by the banks in this solution, and x_0^* and x_1^* satisfy $A(x_0^*) = R_0^*$ and $A(x_1^*) = R_1^*$.

According to this definition, there are two possible types of equilibria. In the first one bank capital is scarce, in the sense that bankers get a higher return from their wealth than investors ($R_k^* > R_0^*$). In the second one bank capital is abundant, and bankers get the same return from their wealth as investors ($R_k^* = R_0^*$). In both equilibria, given the free entry assumption, the aggregate investments of safe and risky entrepreneurs, x_0^* and x_1^*, are the ones implied by the loan rates R_0^* and R_1^*.

In a *capital scarce equilibrium*, equation (7) states that the funds allocated by investors to funding safe entrepreneurs plus those allocated to funding banks must be equal to their initial wealth W, while equation (8) states that the funds allocated by bankers to funding banks must be equal to their initial wealth K. In contrast, since the funds of investors and bankers get the same return in a *capital abundant equilibrium*, we only need a single market clearing condition given by equation (9).

In what follows, we focus on a capital scarce equilibrium with $m^* < p$, so the projects of the risky entrepreneurs have a positive probability of failure.[5] To characterize the solution

[5] A sufficiently large value of parameter γ in the monitoring cost function (2) ensures that $m^* < p$.

to the bank's problem (3) subject to constraints (4)-(6), suppose that the equilibrium monitoring intensity m^* satisfies $m^* > 0$. Then, by the convexity of the monitoring cost function $c(m)$, the bank's incentive compatibility constraint (4) reduces to the first-order condition

$$R_1^* - (1 - k^*)B^* = c'(m^*). \tag{10}$$

To show that in this case the investors' participation constraint (6) is binding, note that if it were not we could slightly reduce the borrowing rate B^* and the loan rate R_1^* so that (10) would hold for the same m^*, in which case the bankers' participation constraint (5) would still be satisfied, which contradicts the definition of equilibrium.

To show that the bankers' participation constraint (5) is also binding, note that if it were not we could slightly increase the bank's capital k^* and reduce the loan rate R_1^* so that (10) would hold for the same m^*, in which case the investors' participation constraint (6) would still be satisfied, which contradicts the definition of equilibrium.

Solving for B^* in the investors' participation constraint (6) (written as an equality), substituting it into the first-order condition (10), and rearranging gives

$$R_1^* = \frac{(1 - k^*)R_0}{1 - p + m^*} + c'(m^*). \tag{11}$$

Solving for $R_1^* - (1 - k^*)B^*$ in the bankers' participation constraint (5) (written as an equality), substituting it into the first-order condition (10), and solving for k^* gives

$$k^* = \frac{(1 - p + m^*)c'(m^*) - c(m^*)}{R_k}. \tag{12}$$

By the properties of the monitoring cost function (2) the right-hand-side of (12) is increasing in m^* (since the derivative is $(1-p+m^*)c'(m^*)/R_k > 0$) and equals zero when $m^* = 0$, which implies $m^* > 0$ if and only if $k^* > 0$. In other words, in an interior monitoring equilibrium the bank will always want to have a positive amount of capital.

These results imply that the equilibrium loan rate R_1^* satisfies

$$R_1^* = \min_{m,k} \left[\frac{(1 - k)R_0}{1 - p + m} + c'(m) \right] \tag{13}$$

subject to (12). The first-order condition that characterizes the solution to this problem is

$$\begin{aligned}\frac{dR_1^*}{dm} &= -\frac{(1-k^*)R_0}{(1-p+m^*)^2} + c''(m^*) - \frac{R_0}{1-p+m^*}\frac{dk^*}{dm^*} \\ &= -\frac{(1-k^*)R_0}{(1-p+m^*)^2} + \frac{R_k - R_0}{R_k}c''(m^*) = 0. \end{aligned} \tag{14}$$

Moreover, one can show that under assumption (2) the second-order condition is satisfied. Hence, there will be an equilibrium with $m^* > 0$ if and only if

$$\left.\frac{dR_1^*}{dm}\right|_{m=k=0} = -\frac{R_0}{(1-p)^2} + \frac{R_k - R_0}{R_k}c''(0) < 0. \tag{15}$$

Form here it follows that in a capital scarce equilibrium we must have $m^* > 0$. To see this, note that by the incentive compatibility constraint (4) and assumption (2), $m^* = 0$ implies

$$R_1^* - (1-k^*)B^* \leq 0, \tag{16}$$

so the bankers' participation constraint (5) can only be satisfied for $k^* = 0$. But if the bankers are not investing their wealth $K > 0$ in bank capital, we must have $R_k = R_0$, which by (15) implies $m^* > 0$, which is a contradiction.[6]

Summing up, we have characterized a capital scarce equilibrium of the model by the following equations: the bankers' and the investors' participations constraints (5) and (6), which are satisfied with equality, the relationship between capital and monitoring (12), the first-order condition that determines the minimum feasible loan rate for the risky entrepreneurs (14), and the market clearing conditions, (7) and (8). Thus, we have six equations to determine six equilibrium variables: $R_0^*, R_1^*, R_k^*, k^*, B^*, m^*$. We have also shown that in this equilibrium banks choose a positive level of capital per unit of loans $k^* > 0$ and a positive level of monitoring $m^* > 0$. Finally, using the first-order condition (10) and the monitoring cost function (2), it follows that equilibrium monitoring satisfies

$$m^* = \frac{1}{\gamma}[R_1^* - (1-k^*)B^*]. \tag{17}$$

Thus, monitoring m^* will be proportional to the intermediation margin $R_1^* - (1-k^*)B^*$.

[6] Note that if $R_k = R_0$ (a capital abundant equilibrium), equation (15) implies $dR_1^*/dm < 0$, so we must have either $m^* = p$ (a corner solution in which risky projects become safe) or $k^* = 1$ (a corner solution in which banks are fully funded with equity). Which case obtains depends on whether the right-hand side of (12) evaluated at $m^* = p$ is smaller or greater than 1.

2.2 Comparative statics

We next illustrate the properties of the equilibrium for a particular parameterization of the model that yields a capital scarce equilibrium. In particular, apart from the quadratic monitoring cost function (2), we assume that the inverse loan demand functions $A(x_0)$ and $A(x_1)$ satisfy

$$A(x) = x^{-1/\sigma}, \tag{18}$$

where $\sigma > 1$.[7] We take $\gamma = 5$ in the monitoring cost function (2) and $\sigma = 2$ in the inverse loan demand function (18), and assume that the probability of failure of the projects of risky entrepreneurs in the absence of monitoring is $p = 0.2$.[8]

Figure 1 shows the effect of changes in investors' wealth W (for a given value of bankers' wealth K) on the equilibrium of the model. Panel A shows the effect on the aggregate investment of safe and risky entrepreneurs, x_0^* and x_1^*, respectively. An increase in W leads to an increase in the aggregate investment of both types of entrepreneurs. Given that $A(x_0) = R_0$ and $A(x_1) = R_1$, this implies that the rates R_0^* and R_1^* at which they borrow go down. The effect on the safe rate R_0^* is shown in Panel B, together with the effect on the return R_k^* of the wealth of bankers, which also goes down. Panel C shows that the increase in investors' wealth W reduces the representative bank's capital per unit of loans k^*, so leverage goes up. Finally, Panel D shows that the increase in W also reduces the monitoring intensity m^* of the representative bank, so its probability of failure goes up.

[FIGURE 1]

Figure 2 shows the effect of changes in bankers' wealth K (for a given value of investors' wealth W) on the equilibrium of the model. Panel A shows the effect on the aggregate investment of safe and risky entrepreneurs, x_0^* and x_1^*, respectively. An increase in K leads

[7] This assumption will be derived in Section 4 from the demand of a representative consumer with a utility function over the goods produced by the two types of entrepreneurs. It can also be derived from the demand of a set of final good producers that use entrepreneurs' output as an intermediate input; see Martinez-Miera and Repullo (2017).

[8] Parameters values are chosen for the purpose of illustrating the qualitative properties of the equilibrium of the model. They are not calibrated to yield realistic values of the endogenous variables.

to an increase in the aggregate investment of both types of entrepreneurs. Given that $A(x_0) = R_0$ and $A(x_1) = R_1$, this implies that the rates R_0^* and R_1^* at which they borrow go down. The effect on the safe rate R_0^* is shown in Panel B, together with the effect on the return R_k^* of the wealth of bankers, which also goes down. In contrast with the results in Figure 1, Panel C shows that the increase in bankers' wealth K increases the representative bank's capital per unit of loans k^*, so leverage goes down. Finally, Panel D shows that the increase in K also increases the monitoring intensity m^* of the representative bank, so its probability of failure goes down.

[FIGURE 2]

The previous results illustrate that, when both investors' wealth W and bankers' wealth K vary, what is key to determine the effect on financial stability is the direction and the relative magnitude of these changes. Moreover, although increases in both W and K (resulting, for example, from a global savings glut) lead to a fall in interest rates, bank leverage and risk-taking go up (as the evidence in Adrian and Shin, 2008, shows) only if the increase in W is more significant than the increase in K.

3 Policy Analysis

This section analyzes the effects on the equilibrium of the model of two possible instruments to control banks' risk-taking, namely a tightening of monetary policy and the introduction (and tightening) of capital requirements for banks.

3.1 Monetary policy

Monetary policy is modeled by introducing a new agent, the *central bank*, that can engineer a change in the safe interest rate R_0. A way in which this can be done in our model setup is by assuming that (i) there is a government with an amount of outstanding safe debt, and (ii) the central bank can increase or decrease the amount of government debt held by investors. This means that the initial wealth of investors W is divided between a part invested in funding safe entrepreneurs and banks, and another part invested in government debt.[9] From the perspective of individual investors, the division is immaterial since they get the same return, but it matters from an aggregate perspective because government debt in the hands of investors reduces the funds allocated to private investments, and hence changes the equilibrium of the model.

The equilibrium effects of a tightening of monetary policy that reduces the wealth that investors allocate to funding safe entrepreneurs and banks can be seen in Figure 1 by simply reinterpreting the variable in the horizontal axis as investors' privately invested wealth. Such tightening reduces aggregate investment of both types of entrepreneurs, increase the rates at which they borrow (in particular, the safe rate R_0^* that the central banks targets), increases the return of the wealth of investors and bankers, and reduces bank leverage and risk-taking.[10]

It should be noted that our modelling of monetary policy is silent for now about the implications for the balance sheet of the central bank, in particular what it will do with the (real) resources obtained by selling government debt.[11] What is key is that these resources are channeled to uses different from the funding of safe or risky entrepreneurs, so they have no impact on the equilibrium of the model.

3.2 Macroprudential policy

Macroprudential policy is modeled by introducing a new agent, the *macroprudential regulator*, that can set minimum capital requirements for banks, so their capital per unit of loans k cannot be below a lower bound $\overline{k}$. We assume that parameter values are such that the capital requirement is binding, and analyze the effect on the equilibrium of the model of tightening the requirement, that is increasing $\overline{k}$.

One interesting feature of the model with binding capital requirements is that, in a capital

[9] Alternatively, we could simply assume that the central bank sells its own liabilities (reserves remunerated at market rates) to investors.

[10] An expansionary monetary policy would lead to the opposite results, very much in line with the effects of a savings glut analyzed in Martinez-Miera and Repullo (2017).

[11] The welfare analysis of Section 4 introduces a return that the central bank gets from these resources.

scarce equilibrium, they determine the aggregate investment x_1^* of the risky entrepreneurs and hence the rate $R_1^* = A(x_1^*)$ at which they borrow from banks. To see this, notice that in such equilibrium all bankers' wealth K is invested in banks, so it must be the case that $\overline{k}x_1^* = K$, which implies $x_1^* = K/\overline{k}$. Hence, a tightening of the capital requirement $\overline{k}$ leads to a reduction in bank lending x_1^* and an increase in the lending rate R_1^* to risky entrepreneurs.

Figure 3 shows the effect of a tightening of a binding capital requirement $\overline{k}$ in a capital scarce equilibrium. Panel A shows that the aggregate investment x_0^* of safe entrepreneurs goes up, while the aggregate investment x_1^* of risky entrepreneurs goes down. We have already explained the latter effect. The former is simply a consequence that, by the market clearing conditions (7) and (8), we have $x_0^* + x_1^* = W + K$, so the fall in x_1^* implies an equivalent increase in x_0^*. Hence, the rate R_0^* at which safe entrepreneurs borrow goes down, while the rate R_1^* at which risky entrepreneurs borrow goes up. The effect on the safe rate R_0^* is shown in Panel B, together with the effect on the return R_k^* of the wealth of bankers, which also goes up due to the scarcity of bank capital induced by the regulation. Finally, Panels C and D show that the tightening of the capital requirement reduces bank leverage and risk-taking.

[FIGURE 3]

It should be noted that capital requirements increase financial stability through two channels. At the micro level, the increase in $\overline{k}$ has a direct effect on banks' monitoring incentives, since it increases the intermediation margin $R_1^* - (1 - \overline{k})B^*$ and hence, as implied by (17), bank monitoring m^*. At the macro level, the increase in $\overline{k}$ has an indirect effect on banks' monitoring incentives, since it increases the loan rate R_1^* and reduces the safe rate R_0^* and consequently the banks' borrowing rate B^*, which further increases the intermediation margin $R_1^* - (1 - \overline{k})B^*$ and bank monitoring m^*.[12]

[12] The macro effect would be smaller if there were an effective lower bound for the safe rate R_0^*, so some resources would be diverted to other uses such as storage.

3.3 Monetary policy with binding capital requirements

We next consider a situation in which capital requirements are already binding. In such situation, a tightening of monetary policy (a reduction in investors' wealth allocated to funding safe entrepreneurs and banks) has some surprising effects shown in Figure 4. Panel A shows that with binding capital requirements a tightening of monetary policy reduces the aggregate investment x_0^* of safe entrepreneurs but leaves unchanged the aggregate investment x_1^* of risky entrepreneurs (since as noted above $x_1^* = K/\overline{k}$). Hence, safe entrepreneurs borrow at higher rates (as shown in Panel B), but there is no effect on the borrowing rate of risky entrepreneurs. Since the capital requirement is binding, the tightening of monetary policy has no effect on bank leverage (Panel C). The increase in the safe rate R_0^* implies an increase in banks' borrowing rate B^* which is not translated into higher lending rates R_1^*, so the intermediation margin $R_1^* - (1 - \overline{k})B^*$ goes down. This implies that the return R_k^* of the wealth of bankers goes down (Panel B), and bank monitoring m^* also goes down (Panel D). Hence, we conclude that, in contrast with our previous result, when capital requirements are binding a tightening of monetary policy increases banks' risk-taking.

[FIGURE 4]

3.4 Discussion

We have shown that both a tightening of monetary policy (when capital requirements are not binding) and an increase in capital requirements (when they are) increase banks' monitoring intensity and hence reduce risk-taking. However, the channels whereby they operate are different. Tightening monetary policy reduces aggregate investment of both safe and risky entrepreneurs, increasing the rates at which they borrow. In contrast, increasing capital requirements shifts investment from risky to safe entrepreneurs. As a result safe entrepreneurs borrow at lower rates, while risky entrepreneurs borrow at higher rates.

These different effects follow from the fact that when tightening monetary policy the central bank reduces the resources that investors allocate to funding safe entrepreneurs and banks, effectively shrinking the supply of savings to the private sector (a savings dearth).

In contrast, a tightening of capital requirements leads to a redistribution of funds between safe and risky entrepreneurs, without any change in the aggregate supply of savings to the private sector.

The effect on financial stability of these two policies can be explained by reference to the relationship (17) between the equilibrium monitoring intensity m^* and the intermediation margin $R_1^* - (1-k^*)B^*$. An increase in monitoring m^* requires that the difference between the loan rate R_1^* and the payment promised to debtholders $(1-k^*)B^*$ goes up. Both policies increase R_1^* and both policies increase k^*, voluntarily in the case of the tightening of monetary policy and mandatorily in the case of the tightening of capital requirements, widening the intermediation margin. However, a tightening of monetary policy increases the equilibrium safe rate R_0^*, while an increase in capital requirements reduces it, which translates into opposite effects on the banks' borrowing rate B^*. Consequently, macroprudential policy appears to be a more effective instrument for containing banks' risk-taking incentives.

The analysis of the two policies combined as opposed to in isolation leads to some interesting results. Specifically, when banks' capital requirements are already binding, tightening monetary policy does not have any effect on the loan rate R_1^* while the payment promised to debtholders $(1-\overline{k})B^*$ goes up, due to the increase in the equilibrium safe rate R_0^*. Hence, in the presence of binding capital requirements a tightening of monetary policy increases banks' risk-taking incentives, a result that that highlights the relevance of the joint analysis of both policies.

These results provide support for the modified Jackson Hole consensus described in Section 1. It is true that monetary policy "gets in all of the cracks," which in the context of our model (and as long as capital requirements are not binding) implies reducing investment of both safe and risky firms. But banks' risk-taking incentives are driven by the spread between the return of their lending and the cost of their borrowing, a cost that goes up with tighter monetary policy. Thus, from this perspective, getting in all of the cracks can in fact be counterproductive.

However, this statement should be qualified whenever, as noted by Hanson et al. (2011), a tightening of capital requirements may shift some intermediation away from regulated banks and into the shadow banking system, reducing the effectiveness of macroprudential tools.[13] In such cases, the analysis in Martinez-Miera and Repullo (2018) shows that tightening monetary policy may be useful to prevent the expansion and reduce the risk of shadow banks, since their funding costs are directly related to the level of the safe rate targeted by the central bank.

4 Welfare

This section analyzes whether the laissez-faire equilibrium of the model is constrained efficient, that is, whether a social planner subject to the same moral hazard problem as the banks could improve upon the equilibrium allocation. We show that the equilibrium allocation is constrained inefficient: the social planner would shift investments toward safe entrepreneurs, which will widen the intermediation margin and increase monitoring, thereby ameliorating the moral hazard problem. Then, we consider the optimal stand-alone monetary policy, the optimal stand-alone level of the capital requirement, and the optimal combination of the two policies.

4.1 Social welfare function

To proceed with the welfare analysis we first have to derive the objective function of the social planner, which comprises: (i) the return of investors' wealth, (ii) the return of bankers' wealth, (iii) the consumers' surplus from entrepreneurial output, and (iv) the profits or losses of the central bank from open market operations, in the case of active monetary policy, which are assumed to be transferred to or from investors in a lump sum manner. All these amounts are measured in terms of a composite good available at $t = 1$.

The return of investors' wealth is simply the product of their initial wealth W by the safe rate R_0. Similarly, the return of bankers' wealth is the product of their initial wealth K by the return R_k, which according to the participation constraint (5) is defined net of

[13] In a similar vein, Tarullo (2019) writes: "The current regulatory framework does not deal effectively with threats to financial stability outside the perimeter of regulated banking organizations, notably from forms of shadow banking,"

monitoring costs.

To compute consumers' surplus from entrepreneurial output, we introduce a representative consumer with a utility function over the goods produced by the two types of entrepreneurs and the composite good. We assume that one unit of investment produces a unit of output, if successful. Hence, the output y_0 of the safe entrepreneurs equals their aggregate investment x_0, while the output of the risky entrepreneurs y_1 equals their aggregate investment x_1, with probability $1 - p + m$, and zero, otherwise.[14]

Following Martinez-Miera and Repullo (2017), we introduce the following utility function for the representative consumer

$$U = q + \frac{\sigma}{\sigma - 1}(y_0)^{\frac{\sigma-1}{\sigma}} + \frac{\sigma}{\sigma - 1}(y_1)^{\frac{\sigma-1}{\sigma}}, \tag{19}$$

where q is the consumption of the composite good, y_0 and y_1 are the outputs of safe and risky entrepreneurs, and $\sigma > 1$. The budget constraint of the representative consumer is

$$q + A_0 y_0 + A_1 y_1 = I, \tag{20}$$

where A_0 is the price of the output of the safe entrepreneurs (the deterministic return of their investment), A_1 is the price of the output the risky entrepreneurs (the success return of their investment), and I is her (exogenous) income.

Maximizing the utility function (19) subject to the budget constraint (20) gives the first-order condition

$$A_i = (y_i)^{-1/\sigma}, \tag{21}$$

for $i = 0, 1$. Substituting this result into the consumer's utility function, and using the fact that $y_0 = x_0$ with probability 1 and $y_1 = x_1$ with probability $1 - p + m$, gives the following measure of consumers' surplus

$$S = \frac{1}{\sigma - 1}(x_0)^{\frac{\sigma-1}{\sigma}} + (1 - p + m)\frac{1}{\sigma - 1}(x_1)^{\frac{\sigma-1}{\sigma}}. \tag{22}$$

[14] Recall that we are assuming that the outcome of the projects of risky entrepreneurs is driven by a single aggregate risk factor, which implies that the return of risky projects monitored with the same intensity will be perfectly correlated.

Importantly, the first-order condition (21) provides a rationale for the inverse loan demand function (18) used in our previous numerical analysis.

To compute the profits or losses of the central bank from open market operations, suppose that it tightens monetary policy by selling government debt for an amount equal to a proportion μ of the initial wealth W of investors. As noted in Section 3.1, the central bank channels these resources to uses different from funding of entrepreneurs. In particular, we will assume that it invests μW at a fixed rate R_{CB}. At the same time, the central bank loses the return of the government debt sold to investors, which yields the safe rate R_0. Hence, the profits or losses of the central bank from this operation are $\mu W(R_{CB} - R_0)$.[15] This amount is transferred (if positive) or taxed (if negative) in a lump sum manner to investors at $t = 1$.

Adding up the four elements of social welfare gives

$$SW = WR_0 + KR_k + \frac{1}{\sigma - 1}(x_0)^{\frac{\sigma-1}{\sigma}} + (1 - p + m)\frac{1}{\sigma - 1}(x_1)^{\frac{\sigma-1}{\sigma}} + \mu W(R_{CB} - R_0). \quad (23)$$

By the market clearing condition (7), rewritten to take into account that only a fraction $1 - \mu$ of investors' wealth is available for funding safe entrepreneurs and banks, we have

$$(1 - \mu)WR_0 = [x_0 + (1 - k)x_1]R_0. \quad (24)$$

And by the market clearing condition (8), together with the participation constraints (5) and (6) (which in equilibrium are satisfied with equality), we have

$$KR_k = x_1[(1 - p + m)R_1 - (1 - k)R_0 - c(m)]. \quad (25)$$

Putting together (24) and (25) yields

$$WR_0 + KR_k = x_0R_0 + (1 - p + m)x_1R_1 - x_1c(m) + \mu WR_0. \quad (26)$$

Substituting this result into (23), and using the fact that $R_0 = A(x_0) = (x_0)^{-1/\sigma}$ and $R_1 = A(x_1) = (x_1)^{-1/\sigma}$, we get the following expression of social welfare

$$SW = \frac{\sigma}{\sigma - 1}(x_0)^{\frac{\sigma-1}{\sigma}} + (1 - p + m)\frac{\sigma}{\sigma - 1}(x_1)^{\frac{\sigma-1}{\sigma}} - x_1c(m) + \mu WR_{CB}. \quad (27)$$

[15] The same result obtains if central bank sells its own liabilities (reserves remunerated at the safe rate R_0) to investors for an amount μW, and invests them at the rate R_{CB}.

The first term in (27) is the welfare associated with the output of safe entrepreneurs, the second term is the welfare associated with the output of risky entrepreneurs, the third term subtracts the costs of monitoring risky entrepreneurs, and the last term is the return of the investments of the central bank.

4.2 Constrained inefficiency of equilibrium

To show that the laissez-faire equilibrium allocation is constrained inefficient, we set $\mu = 0$ so the central bank does not operate, and consider the maximization of the social welfare function (27) subject to the first-order condition (10) that characterizes the banks' choice of monitoring, the investors' participation constraint (6), and the market clearing conditions (7) and (8). Multiplying the first-order condition (10) by $(1-p+m)x_1$, and using the investors' participation constraint (6) (written as an equality) and the market clearing condition (8), gives

$$(1-p-m)x_1R_1 = (x_1 - K)R_0 + (1-p-m)x_1c'(m). \tag{28}$$

Substituting $R_0 = A(x_0) = (x_0)^{-1/\sigma}$, $R_1 = A(x_1) = (x_1)^{-1/\sigma}$, and $x_1 - K = W - x_0$ (implied by the market clearing conditions (7) and (8)) into this expression and rearranging gives

$$(1-p+m)(x_1)^{\frac{\sigma-1}{\sigma}} = (W - x_0)(x_0)^{-1/\sigma} + (1-p+m)x_1c'(m). \tag{29}$$

Using this result, the social welfare function (27) simplifies to

$$SW = \frac{\sigma}{\sigma-1}W(x_0)^{-1/\sigma} + \left[\frac{\sigma}{\sigma-1}(1-p+m)c'(m) - c(m)\right]x_1. \tag{30}$$

Consider now a marginal reduction in the investment x_1 of risky entrepreneurs (and the corresponding marginal increase in the investment x_0 of safe entrepreneurs). In the laissez-faire allocation the equilibrium loan rate R_1^* is obtained by solving (13) subject to (12), so by the first-order condition (14) we have $dR_1^*/dm = 0$. Hence, a marginal reduction in x_1 that increases the loan rate $R_1 = A(x_1)$ leads to a very large increase in monitoring. But by the properties of the monitoring cost function (2) we have

$$\frac{\partial SW}{\partial m} = \left[\frac{\sigma}{\sigma-1}(1-p+m)c''(m) + \frac{1}{\sigma-1}c(m)\right]x_1 > 0. \tag{31}$$

Hence, the small reduction in x_1 is more than compensated by the large increase in m, so both the first and the second terms in the social welfare function (30) go up. In other words, the laissez-faire equilibrium allocation is constrained inefficient.[16]

The intuition for this result is as follows. Competition among banks leads to intermediation margins and monitoring intensities that are too low. By moving investment from risky to safe entrepreneurs, the social planner widens intermediation margins and increases bank monitoring, which leads to higher social welfare.

4.3 Welfare analysis of monetary and macroprudential policies

We now introduce the two policies analyzed in Section 3, and consider the maximization of the social welfare function (27) using these policies. Let us denote by $SW(\mu, \overline{k})$ the social welfare associated with a monetary policy that mops up a fraction μ of the initial wealth W of investors, and a macroprudential policy that sets a minimum capital requirement $\overline{k}$ for banks. We proceed by first analyzing the welfare effects of a stand-alone monetary policy, maximizing $SW(\mu, 0)$, then analyze the welfare effects of a stand-alone macroprudential policy, maximizing $SW(0, \overline{k})$, and finally consider the joint maximization of $SW(\mu, \overline{k})$.

The welfare analysis of monetary policy requires to specify the rate R_{CB} at which the central bank invests the real resources obtained by selling government debt. To avoid biasing the result in a positive or a negative direction (by setting an arbitrarily high or low R_{CB}), we will assume that R_{CB} equals the initial equilibrium safe rate R_0^*. Under this assumption, the effect of a tightening of monetary policy ($\mu > 0$) on social welfare is shown in Panel A of Figure 5.[17] The function $SW(\mu, 0)$ is concave, increasing for small values of μ and decreasing thereafter. Thus, a small tightening of monetary policy, which according to the results in Section 3 increases bank monitoring, is welfare improving, but beyond certain point it does reduce welfare. Panel B of Figure 5 shows the distributional effects of such policy. Investors

[16] As noted in Section 2.1, the function whose minimum determines the equilibrium loan rate is convex in m, so for $R_1 > R_1^*$ there are two solutions for m. But by (31) we have $\partial SW/\partial m > 0$, so the highest solution is the one that maximizes social welfare.

[17] For expositional purposes we plot the safe rate R_0 in the horizontal axis instead of μ, as both are measures of monetary policy tightness.

are better off (before the lump-sum taxes they have to pay to cover the losses of the central bank), because the equilibrium safe rate goes up. Bankers are (mildly) better off. Consumers are worse off, since the investment of both safe and risky entrepreneurs goes down. Finally, the central bank incurs in losses, since the safe rate raises above the rate R_{CB} that the central bank obtains from its investment of μW.

[FIGURE 5]

The effect of a tightening of capital requirements on social welfare is shown in Panel A of Figure 6. The function $SW(0, \overline{k})$ is flat for values of the minimum capital requirement $\overline{k}$ below the initial equilibrium k^* (not shown in the figure), and then it is concave, increasing for values of $\overline{k}$ close to k^* and decreasing thereafter. Thus, a small tightening of macroprudential policy, which according to the results in Section 3 increases bank monitoring, is welfare improving. However, due to the scarcity of bank capital, a very high capital requirement is not optimal, as it leads to an excessive reduction in the investment of risky entrepreneurs. Panel B of Figure 6 shows the distributional effects of such policy. Bankers are better off, since the equilibrium return of bank capital goes up, but investors are worse off, since the equilibrium safe rate goes down. Finally, consumers are (mildly) better off as a result of the shift from risky to safe investments (and the reduction of the risk of the former).

[FIGURE 6]

We next compare the effects of monetary and macroprudential policies in two dimensions: financial stability, proxied by equilibrium bank monitoring, and social welfare. Figure 7 represents monitoring in the horizontal axis and welfare in the vertical axis. The red line shows the combinations of monitoring and welfare corresponding to increasing values of $\mu > 0$, while the blue line shows the combinations of monitoring and welfare corresponding to increasing values of $\overline{k} > k^*$(the initial equilibrium capital per unit of loans). The results show that macroprudential policy is not only much more effective on the financial stability front, since it can lead to a higher level of monitoring, but also dominates monetary policy on the social welfare front. The intuition for this result follows from the analysis of the constrained inefficiency of the laissez-faire equilibrium. The second-best policy is to shift investment from risky to safe firms, something that is achieved by tightening capital requirements.[18] In contrast, tightening monetary policy reduces the investment of risky and also safe firms, decreasing consumers' surplus and eventually welfare.

[FIGURE 7]

Finally, the green line in Figure 7 shows the social welfare associated with the optimal combination of monetary and macroprudential policies for a given level of monitoring m, that is a solution to

$$\max_{(\mu,\overline{k})} SW(\mu,\overline{k}) \text{ subject to } m(\mu,\overline{k}) = m, \tag{32}$$

where $m(\mu,\overline{k})$ denotes the equilibrium monitoring associated with a monetary policy that mops up a fraction μ of the initial wealth W of investors, and a macroprudential policy that sets a minimum capital requirement $\overline{k}$ for banks. By construction, the green line is above the the blue line, corresponding to using only macroprudential policy, and it is also above the red line, corresponding to using only monetary policy. The additional increase in welfare delivered by the combination of both policies is achieved by a further increase of capital requirements that is accompanied by a tightening of monetary policy, which dampens the fall in the safe rate.

As can be seen in Figure 7, we find that the optimal combination of monetary and macroprudential policies is closer in terms of both financial stability and social welfare to the optimal stand-alone macropudential policy than to the optimal stand-alone monetary policy. This is consistent with our previous discussion on the comparison of both policies, as the constrained efficient allocation entails a shift of investment from risky to safe entrepreneurs, something that is directly achieved by tightening capital requirements. In fact, by adjusting investments in the two types of firms, macroprudential policy can implement the constrained

[18] As noted above, we are implicitly assuming that the tightening of capital requirements does not shift some intermediation into an unregulated shadow banking system, which would reduce the effectiveness of such policy.

efficient allocation for the case where the central bank does not operate (setting $\mu = 0$ in the social welfare function (27)). This allocation is characterized by a lower safe rate, relative to the laissez-faire allocation, due to the higher investment of safe entrepreneurs. Hence, our assumption that the rate R_{CB} at which the central bank invests the real resources obtained by selling government debt equals the (higher) initial equilibrium safe rate implies that a tightening of monetary policy, which transfers resources to a safe asset with a higher return, is optimal. Moreover, this allows for a further increase in capital requirements, so the optimal combination of both policies entails tightening them relative to the optimal stand-alone macropudential policy.

5 Concluding Remarks

This paper proposes a stylized general equilibrium model to analyze the effects of monetary and macroprudential policies on financial stability. The model builds on the setup of Martinez-Miera and Repullo (2017) in which competitive banks can reduce the probability of default of their loans by monitoring their borrowers at a cost. We assume that monitoring is not observed by debtholders, so there is a moral hazard problem, and we note that in this setup banks may be willing to use equity finance in order to ameliorate the moral hazard problem and reduce the cost of their debt.

The model features two types of entrepreneurial firms. Safe firms borrow directly from investors, while risky firms borrow from banks in order to take advantage of monitoring and reduce their borrowing costs. Banks in turn are funded with (uninsured) debt provided by investors and (inside) equity provided by bankers. We take the initial wealth of investors and bankers as given, and characterize the equilibrium of the model. Financial stability is proxied by the monitoring intensity of risky entrepreneurs by banks, which is in turn driven by their intermediation margin.

We use this model to analyze the effect on financial stability of tightening monetary policy, modeled by raising the safe interest rate via open market sales of government debt by a central bank, and macropudential policy, modeled by raising capital requirements for banks.

We show that both policies are effective in improving banks' monitoring incentives, through an increase in the intermediation margin. However, there are significant differences. Tighter capital requirements shift investment toward safe firms, decreasing safe rates, whereas tighter monetary policy reduces investment for both safe and risky firms, increasing safe rates, so the effect on the margin is smaller. Consequently, macroprudential policy appears to be a more effective instrument for reducing risk-taking by banks. Moreover, we also show that in the presence of binding capital requirements a tightening of monetary policy increases risk-taking by banks. This result highlights the importance of analyzing the interaction of both policies.

We complete our discussion by providing a welfare analysis of the model, showing that the laissez-faire equilibrium allocation is constrained inefficient, because competition among banks leads to intermediation margins and monitoring intensities that are too low. Hence, there is a role for government intervention. In particular, we show that tightening monetary and macroprudential policies, on their own, increase welfare. Moreover, we also show that their optimal combination is closer in terms of both financial stability and social welfare to the optimal stand-alone macropudential policy than to the optimal stand-alone monetary policy. In this sense, the results of the paper provide support for the view that macroprudential policy should be the primary tool for addressing risks to financial stability.

We would like to conclude with a few remarks. First, we assume that the outcome of the projects of risky entrepreneurs is driven by a single aggregate risk factor, so in equilibrium their returns are perfectly correlated. This assumption greatly simplifies the analysis, and provides a stark description of the effects of an extreme realization of a systematic risk factor. However, at the cost of greater complexity, it would be possible to analyze a setup in which there is imperfect default correlation, using for example the single risk factor model of Vasicek (2002), as in Martinez-Miera and Repullo (2010).

Second, our model of monetary policy abstracts from nominal frictions and simply assumes that the central bank that can raise the real interest rate via open market sales of government debt that reduce the funds that investors allocate to private investments. This assumption allows for a clearer understanding of the mechanisms whereby monetary policy may contribute to financial stability. But at the end of the day, one would like to have a more realistic model of monetary policy.

Third, following Martinez-Miera and Repullo (2017), our setup could be used as a building block of a dynamic model in which investors and bankers are infinitely lived and their wealth is endogenous. Specifically, their wealth at any date would be the outcome of their investment decisions at the previous date together with the realization of a systematic risk factor that determines the return of the projects of risky entrepreneurs.

Finally, it is important to note that our conclusion in favor of using macroprudential tools as the primary instrument to enhance financial stability should be qualified in situations in which, as analyzed in Martinez-Miera and Repullo (2018), the presence of a shadow banking system may reduce the effectiveness of these tools.

Appendix

This Appendix shows that perfect competition in the market for risky loans leads to an equilibrium in which the representative bank lends at the minimum feasible rate R_1^* defined in (3). We first characterize the bank's choice of capital per unit of loans k, interest rate B offered to investors, and monitoring intensity m for any $R_1 \geq R_1^*$, showing that k and B are decreasing and m is increasing in R_1. We then show that bank profits are increasing in R_1 for $R_1 \geq R_1^*$. But since profits are zero for $R_1 = R_1^*$, we conclude that the only possible equilibrium loan rate is R_1^*.

Consider a representative bank that given the loan rate R_1 and the returns R_0 and R_k required by investors and bankers (with $R_k > R_0$ as in a capital scarce equilibrium), sets a capital per unit of loans k. The bank's choice of borrowing rate B^* and monitoring intensity m^* is given by the solution of the bank's incentive compatibility constraint (4) and the investors' participation constraint (6) (written as an equality). Solving for B^* in (6) and substituting it into the first-order condition (10) that characterizes the bank's incentive compatibility constraint (4) gives condition (11). The right-hand side of (11) is convex in m^*, so in general there will be two solutions for m^*. Solving for B^* in (6), substituting it into the bank's objective function, and differentiating with respect to m^* gives

$$\frac{d}{dm^*}\left[(1-p+m^*)R_1 - (1-k)R_0 - c(m^*) - R_k k\right] = R_1 - c'(m^*),$$

which is positive by (10). Hence, whenever there are two solutions to (11), the bank will strictly prefer the highest one, simply denoted m^*.

The bank's choice of capital per unit of loans k^* is obtained by solving

$$\max_k \left[(1-p+m^*)R_1 - (1-k)R_0 - c(m^*) - R_k k\right].$$

The first-order condition that characterizes the solution to this problem is

$$\left[R_1 - c'(m^*)\right]\frac{\partial m^*}{\partial k} = R_k - R_0.$$

Using (11) and $c''(m^*) = \gamma$, this condition reduces to

$$\left[\frac{\gamma(1-p+m^*)^2}{(1-k^*)R_0} - 1\right]^{-1} = \frac{R_k - R_0}{R_0}.$$

Now consider two loan rates R_1 and R_1', with $R_1' > R_1$, and denote by k and k', B and B', and m and m' the values of capital per unit of loans, borrowing rate, and monitoring intensity corresponding to them. Our previous result together with the assumption $R_k > R_0$ implies

$$\frac{\gamma(1-p+m)^2}{(1-k)R_0} = \frac{\gamma(1-p+m')^2}{(1-k')R_0}.$$

Hence, using (11) and $R_1' > R_1$ we have

$$\frac{R_1 - \gamma m}{1-p+m} = \frac{R_1' - \gamma m'}{1-p+m'} > \frac{R_1 - \gamma m'}{1-p+m'},$$

which implies $m' > m$ and $k' < k$. Also, by (6) $m' > m$ implies $B' < B$. Thus, we conclude that an increase in the loan rate R_1 leads to an increase in the monitoring intensity m and a reduction in the borrowing rate B. Since the increase in R_1 improves monitoring incentives, the bank optimally reduces its capital per unit of loans k.

Now by the envelope theorem we have

$$\frac{d}{dR_1}\left[(1-p+m^*)R_1 - (1-k^*)R_0 - c(m^*) - R_k k^*\right] = 1-p+m^* > 0.$$

Moreover, we have shown in the text that at the minimum feasible rate R_1^* the banks' participation constraint (5) is binding. Hence, bank profits are zero when $R_1 = R_1^*$ and are positive and increasing thereafter, so the only possible equilibrium loan rate is R_1^* obtained by solving (13) subject to (12).

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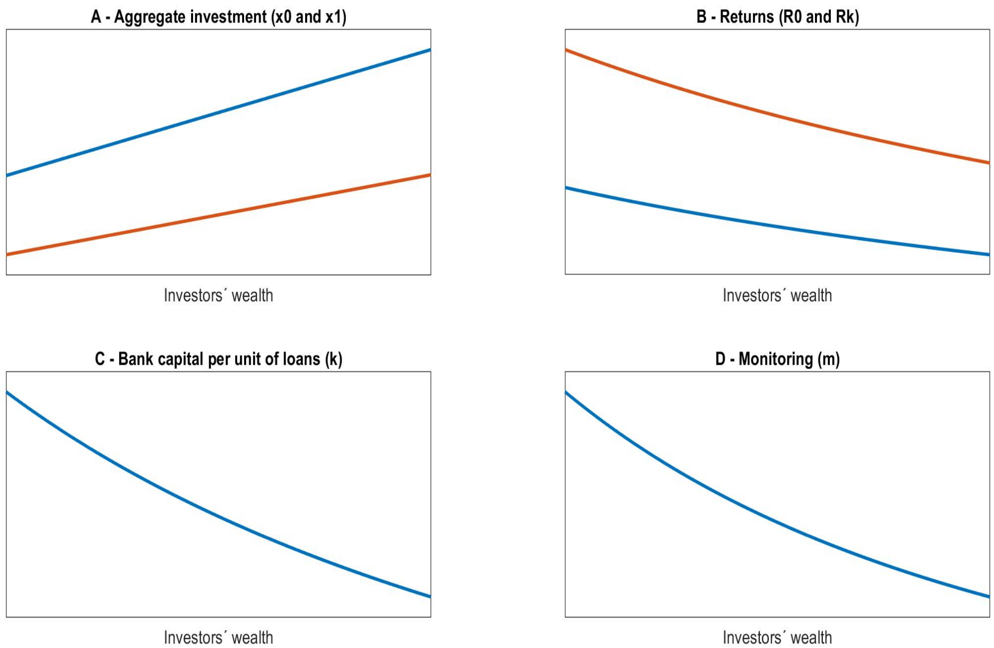

Figure 1. Changes in investors' wealth

This figure shows the effects of an increase in investors' wealth on aggregate investments of safe (top line) and risky entrepreneurs (Panel A), returns on wealth of investors (bottom line) and bankers (Panel B), bank capital per unit of loans (Panel C), and bank monitoring (Panel D).

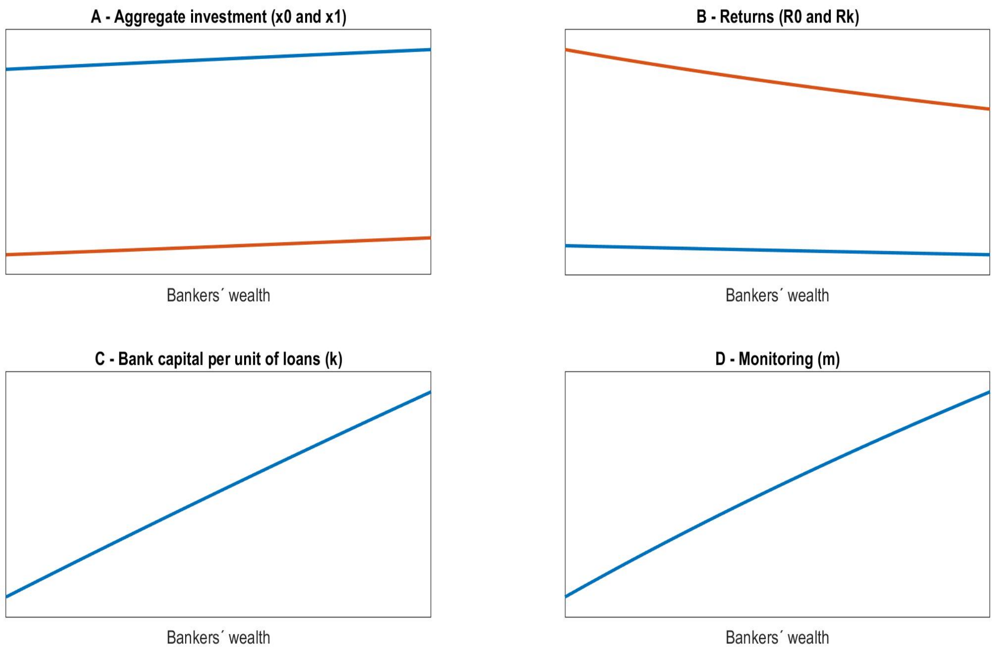

Figure 2. Changes in bankers' wealth

This figure shows the effects of an increase in bankers' wealth on aggregate investments of safe (top line) and risky entrepreneurs (Panel A), returns on wealth of investors (bottom line) and bankers (Panel B), bank capital per unit of loans (Panel C), and bank monitoring (Panel D).

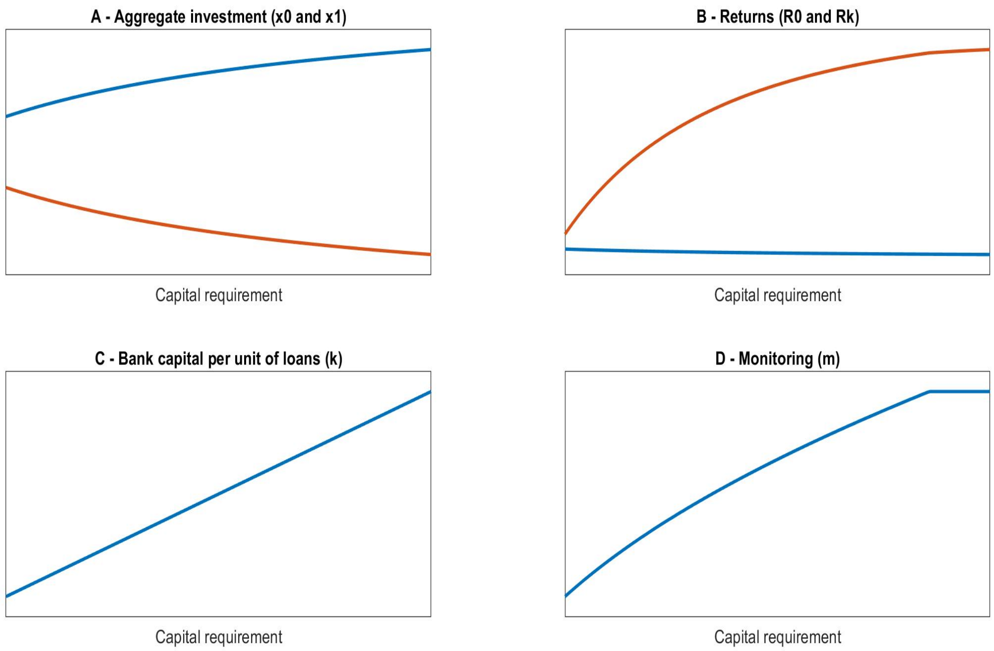

Figure 3. Tightening capital requirements

This figure shows the effects of tightening capital requirements on aggregate investments of safe (top line) and risky entrepreneurs (Panel A), returns on wealth of investors (bottom line) and bankers (Panel B), bank capital per unit of loans (Panel C), and bank monitoring (Panel D).

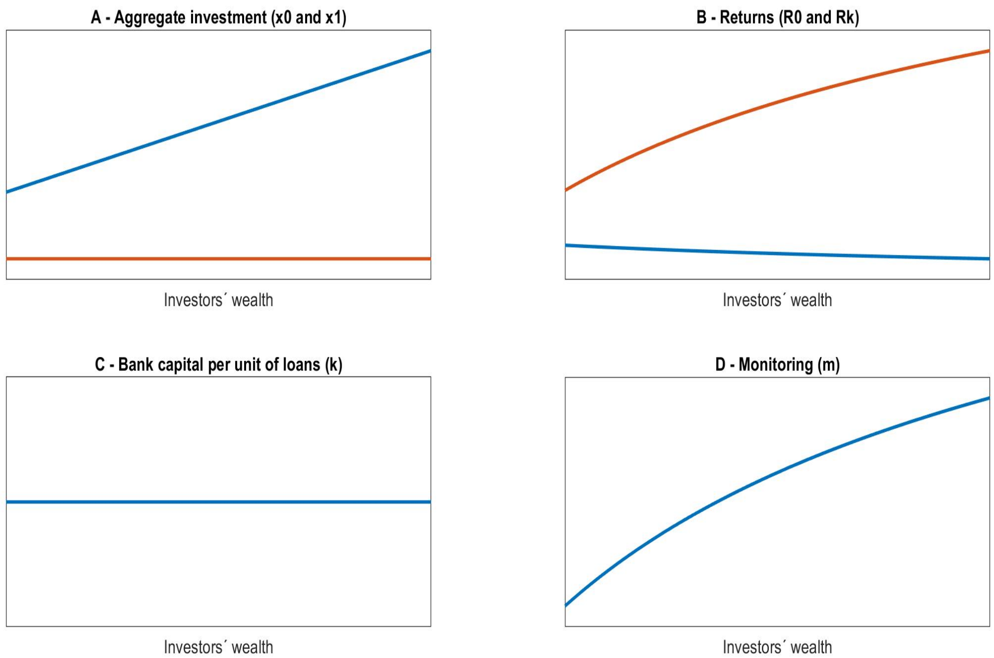

Figure 4. Tightening monetary policy with binding capital requirements

This figure shows the effects of tightening monetary policy (shift to the left in investors' wealth) in the presence of binding capital requirements on aggregate investments of safe (top line) and risky entrepreneurs (Panel A), returns on wealth of investors (bottom line) and bankers (Panel B), bank capital per unit of loans (Panel C), and bank monitoring (Panel D).

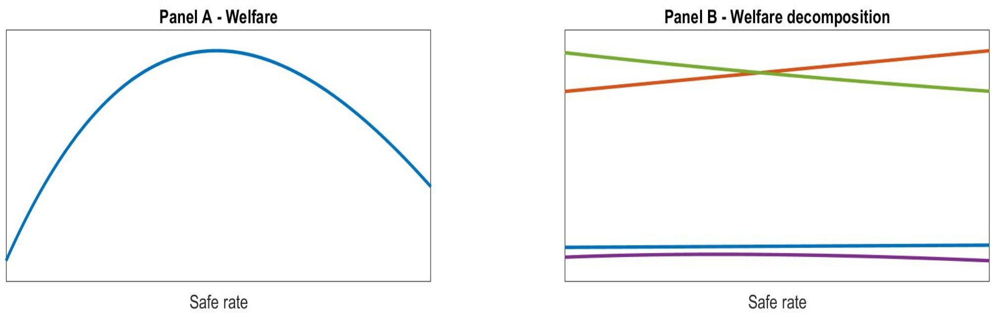

Figure 5. Welfare effects of monetary policy

This figure shows the effects of tightening monetary policy (increase in the safe rate) on social welfare (Panel A) and its decomposition (Panel B) among investors (red line), bankers (blue line), consumers (green line), and the central bank (purple line).

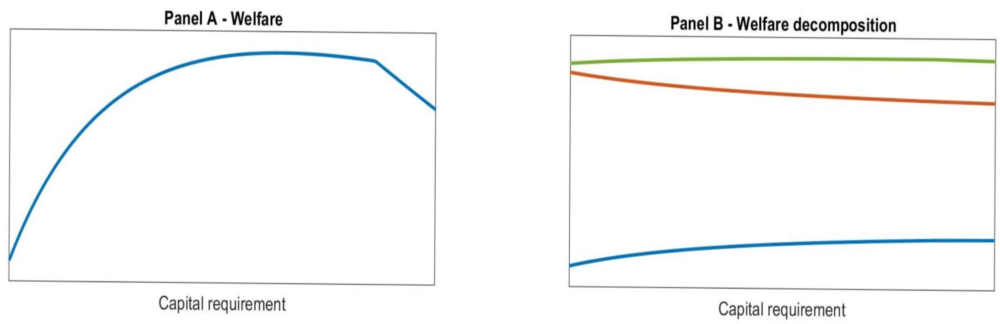

Figure 6. Welfare effects of capital requirements

This figure shows the effects of tightening capital requirements on social welfare (Panel A) and its decomposition (Panel B) among investors (red line), bankers (blue line), and consumers (green line).

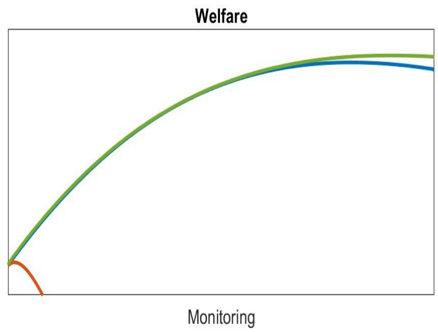

Figure 7. Monitoring and welfare under different policies

This figure shows the combination of monitoring and social welfare that obtains under stand-alone monetary policies (red line) and stand-alone macroprudential policies (blue line). The figure also shows social welfare under the optimal combination of both policies for a given level of monitoring (green line).