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INCENTIVES THROUGH THE CYCLE: MICROFOUNDED MACROPRUDENTIAL REGULATION

by Giovanni di Iasio* and Mario Quagliariello†

Abstract

We provide a micro-based rationale for macroprudential capital regulation by developing a model in which bankers can privately undertake a costly effort and reduce the probability of adverse shocks to their asset holdings that force liquidation (*deterioration risk*). Low *fundamental risk* of assets guarantees benevolent funding conditions and banks are able to expand their balance sheets. The high continuation value would, in principle, improve incentives. However, the rise in asset demand and prices may jeopardize bankers' efforts whenever the liquidation price is high enough. This imposes socially inefficient liquidation which can be corrected with a capital requirement that aligns bankers' incentives. We show that a microprudential regulatory regime that disregards the equilibrium effect of asset prices on incentives performs poorly as low fundamental risk may induce high deterioration risk. Overall, the model suggests a theoretical foundation for the countercyclical capital buffer of Basel III, since it prescribes a macroprudential regulatory regime in which the equilibrium feedback effect is fully taken into account.

JEL Classification: E44, D86, G18.
Keywords: macroprudential regulation, incentives, financial stability, Basel III, Value-at-Risk, market-based financial intermediaries, financial crises.

Contents

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* Bank of Italy, Financial Stability Unit.

† European Banking Authority.

1 Introduction

With the unfolding of the financial crisis that erupted in 2007, many analysts and policy-makers acknowledged the existence of several flaws in the regulatory environment. Microprudential regulatory frameworks, by focusing on the soundness of financial institutions taken in isolation and disregarding the effects of macroeconomic variables and exposures to common risk factors, were identified among the culprits of the crisis (Borio (2008)). In this scenario, a new macroprudential orientation of financial regulation has been a key direction of the reform roadmap. Macroeconomic variables such as credit growth and asset price dynamics have been recognized as potential indicators of overheated economic conditions. General macroprudential principles have been transposed to the global regulatory framework by the Basel Committee (2010). While the system-wide perspective cannot be circumscribed to it, most of the policy measures have focused on procyclicality. In particular, the Committee introduced countercyclical capital buffers above minimum capital requirements that banks are required to build-up in buoyant economic conditions. However, the debate on the functioning of macroprudential tools is still lively and answers to relevant questions are not yet conclusive. Above all, a general agreement on the underlying market failure and distortions that increase the likelihood and the severity of financial crises is still lacking.

In the specific case of the US subprime crisis, two broad and competing interpretations of its roots have emerged. In the first one, well-informed insiders involved in the mortgage business engineered a class of entities and activities, often called the shadow banking system (Pozsar et al. (2010)), to exploit regulatory arbitrage opportunities and take advantage of uninformed outsiders, e.g. shareholders of money market funds and taxpayers. This explanation deals with a *distortion of incentives* of insiders.[1] The second interpretation focuses on the *distortion of beliefs* of the players in the intermediation chain, from home-buyers to ultimate investors, who formed overly-optimistic expectations about the evolution of the US housing market.[2] The inside-job and the bubble explanations are often intended to be highly orthogonal.[3] Such a net separation is crucial, partly because the two interpretations have sharply different policy implications in terms of financial regulation, monetary policy and crisis management.

This paper builds a simple theoretical setup to (i) frame the macroprudential regulation of financial intermediaries as an effective policy tool to curb socially inefficient risk-taking in a boom and (ii) examine the mutual interaction between the distortion of incentives and the distortion of beliefs to improve our understanding of the financial cycle.

The first part of the paper shows that the inner procyclicality of market-based financial intermediation systems may well be responsible for the *distortion of incentives* of insiders (henceforth, for the sake of brevity, bankers). The banker has the possibility to reduce the probability of adverse shocks to asset holdings (deterioration risk) that force liquidation, by seeking sound and

[1] See, for instance, Rajan (2006), Kashyap et al. (2007), Borio (2008), Acharya and Richardson (2009).

[2] For a recent contribution, see Case et al. (2012); for a complete survey on the psychology of the 2007 financial crisis, see Barberis et al. (2010).

[3] Foote et al. (2012).

privately costly risk management strategies (monitoring). In good times, i.e. when the fundamental risk of assets is low and/or balance sheets are robust, banks face easy funding conditions. The large balance sheet capacity boosts asset demand and prices (Brunnermeier and Pedersen (2009), Adrian and Shin (2010b)). The equilibrium market price of assets positively affects the payoff of the banker in the event of liquidation. Therefore, it emerges as a key driver of incentives and determines the overall deterioration risk in the economy. A distortion of incentives in good times is the building block of our model.

The second part of the paper shows that the distortion of incentives may become pervasive and generate a financial crisis, with plunging asset prices and a credit crunch, when coupled with a *distortion of beliefs*. We depart from our rational expectations baseline model assuming that individual bankers disregard the equilibrium depressing effect of their poor risk management on asset prices. The expectation of buoyant asset prices induces a widespread asset quality deterioration in the economy that ultimately forces many banks to liquidate at the same time. Plunging asset prices impose losses along the intermediation chain and, possibly, a credit crunch. In this respect, the paper introduces a mechanism to generate financial crises that are the result of neglected risk in good times and that do not rely on adverse exogenous shocks.

Our argument has direct policy implications in terms of financial regulation. These are the key questions and the main results of the paper:

- **Asset prices and risk-taking.** Is there a specific role for asset prices in the build-up of risks along the expanding phase of the cycle? In market-based financial intermediation systems, fundamentals and balance sheet variables of the leveraged financial sector determine the price of risky assets. In good times, the large balance sheet capacity of banks boost the demand and the price of assets, so increasing the banker's income in liquidation and reducing the optimal effort in monitoring. One implication is that *deterioration* (endogenous) risk is high when the *fundamental* (exogenous) risk of assets is low.

- **Regulation and the cycle.** New macroprudential rules envisage cycle-dependent capital regulation. Why should capital requirements evolve along the business cycle? Deterioration risk eventually imposes socially inefficient liquidation that can be corrected with a capital requirement that aligns bankers' incentives. In particular, (i) the equilibrium (macroprudential) capital requirement is higher in good times and (ii) microprudential rules would perform poorly in terms of bankers' incentives and aggregate outcome. In this sense, the model provides theoretical underpinnings to the macroprudential capital buffer presented in the Basel III proposal.

- **The rationale of macroprudential regulation**: a passive capital buffer accumulation in good times or an active countercyclical policy?[4] We are of the view that the cycle is

[4]The most pragmatic view advises one not to exaggerate the potential of macroprudential tools: they should only aim at ensuring that financial intermediaries accumulate sufficient resources in good times (when they are cheap and when risk is underestimated) that can be run-down in bad times with few or no repercussions on financial stability (for a survey, see Galati and Moessner (2010)).

endogenous to the behavior of financial institutions (Borio et al. (2001)).[5] Our model explicitly illustrates how financial institutions take decisions based on the incentives, including those posed by capital regulation that, thus, represents an effective tool to reduce a class of distortions in the expanding phase of the cycle. The forces that lead to the upswing may carry the seeds of the subsequent downswing. In that respect, we are aligned with the spirit of Minsky's financial instability hypothesis, which does not rely upon negative exogenous shocks to generate business cycles fluctuations (and financial instability).

Relationships with the literature. Our work relates to three strands of the literature. First, it is closely related to recent research that is expanding the large literature on financial accelerators (Kiyotaki and Moore (1997), Bernanke et al. (1999), for a survey see Panetta et al. (2009)). Brunnermeier and Pedersen (2009) have a model of a mutually reinforcing mechanism between market and funding liquidity. Tight funding liquidity limits intermediaries' ability to take risky positions. These conditions, by lowering the market liquidity of assets, leads to higher volatility and to a further tightening of funding conditions. The reverse process is at work in the expanding phase of the cycle. Geanakoplos (2010) builds a theory of the leverage cycle: supply and demand of funds determine both the price (interest rate) and the quantity (margin) in equilibrium. Variations in leverage give rise to asset price booms. Eventually, bad news or changes in the mood of traders induce massive de-leveraging and disruptive adjustments. Adrian and Shin (2010a) reconsider the role of the balance sheet of financial intermediaries as a key driver of the financial cycle and of the pricing of risk. Adrian and Shin (2010b) provide substantial empirical evidence of the leverage cycle and show how marked-to-market balance sheets can induce boom-bust cycles: favorable funding conditions improve financial intermediaries' ability to expand their balance sheets and adjust leverage. A greater demand for assets amplifies the first-round effects in a spiral of increasing prices, more robust marked-to-market balance sheets and thinner haircuts. With respect to this literature, one original contribution of our paper is that it explains why the cumulative process of higher prices and stronger balance sheet cannot be endless. During the boom, high asset prices progressively distort bankers' incentives, with the privately costly strategy of performing sound risk management becoming less and less attractive. This is detrimental to the long-term value of investment (high deterioration risk). When this type of risk materializes, massive liquidation triggers the negative spiral of fire sales, lower prices, weaker balance sheets. A close relationship emerges between funding conditions and solvency (in our very stylized model, affected by banker risk management choices): extremely favorable funding conditions may generate solvency problems when incentives to exert costly activities that preserve the value of assets are jeopardized.

The second stream of literature regards regulation. Our model contemplates the need for a policy intervention, namely a tightening of capital requirements, to align incentives in good

[5]The usual story is that, during booms, intermediaries tend to underestimate exposure to risks, relaxing selection criteria of borrowers and monitoring procedures. After the peak of the cyclical upturn, customers' profitability worsens, borrowers' creditworthiness deteriorates and losses are revealed. This pattern is often coupled with a fall in asset prices which, in turn, further affects customers' financial wealth and depresses the value of collateral. Banks' exposures to credit risk increase, requiring larger provisions and higher levels of capital, at the very moment when capital is more expensive or simply not available. Intermediaries may react by reducing lending, thus exacerbating the effects of the economic downturn.

times. On the one hand, the link between capital and incentives has been extensively explored. Holmström and Tirole (1997) model a moral hazard problem which creates the need for a capital requirement that provides bankers with proper incentives to exert costly monitoring activities.[6] On the other, the theoretical grounding to macroprudential regulation is often "externality-based" and relies mainly on negative exogenous shocks and amplification mechanisms due, for instance, to contagion and interconnectedness (Allen and Gale (2000), Caballero and Simsek (2009)) or to fire sales (Lorenzoni (2008), Shleifer and Vishny (2010), Diamond and Rajan (2011)). Our approach calls for a regulatory intervention in good times. In this sense, it is complementary to standard models of financial cycles.

Finally, our work is related to the endogenous risk literature (Morris and Shin (2003), Danielsson and Shin (2003)). These contributions provide insights regarding the endogenous component of risk, i.e. the one generated by individual responses to (even small) exogenous shocks. In our model we can distinguish between two components of risk. The first, the fundamental risk, is related to the stochastic structure of returns of assets and is determined by exogenous factors. As this type of risk can be controlled for, contingent contracts can implement efficiency in risk allocation. The second component has a truly endogenous nature. We call it deterioration risk and it depends on the effort choice of bankers. Good fundamentals (low exogenous risk) may eventually increase the overall risk in the economy as banks may be tempted to take advantage of booming times (high prices) to save on costly effort.

2 The model

2.1 Basic setup

For the sake of simplicity we do not use a fully-fledged dynamic model, but its two periods equivalent.

Table 1: Bank's balance sheet at $t = 0$

Assets	Liabilities
1, project	$1 - e$, debt e, equity

Agents. There are two types of agent: market investors and bankers. Agents do not discount future cash flows. Investors are in a large number, are perfectly competitive and passively purchase bank debt. The generic banker is protected by limited liability, runs a bank that enters at $t = 0$ with a given balance sheet (Table 1) and operates under a Value-at-Risk constraint (VaR).[7] The

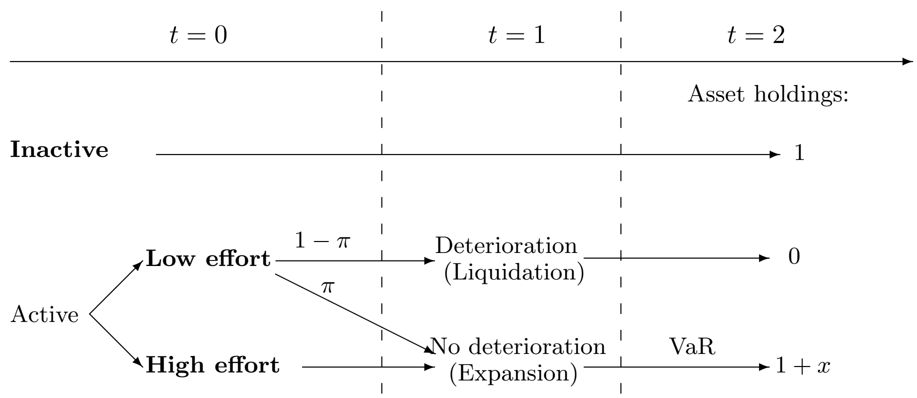
[6] The literature on the impact of capital on the bank's value and incentives is extensive. See for instance Dell'Ariccia and Marquez (2006), Allen et al. (2011), Mehran and Thakor (2011), Koehn and Santomero (2012).

[7] In general, the VaR stipulates that the default probability of the bank is kept below some threshold value. See section (2.2) for details.

banking system is made up of a continuum of mass $K < 1$ of banks, heterogenous with respect to their initial equity $e \in [e_m, e_M]$. For the sake of simplicity, we take $e_M - e_m \equiv K$.

At $t = 0$, each bank holds one project (legacy asset) that is financed with equity e and with debt $1 - e$.

Figure 1: The timing of events in the model



Assets and fundamental risk. Each and every project in the economy needs one unit of initial investment and pays at $t = 2$ a positive random amount $\tilde{w}$, with expected value $q > 1$ and support $[q - z, q + z]$. The realizations $\tilde{w}$ are independent across assets and banks. We refer to q and z as the *fundamental* expected value and risk of assets, respectively. The value of the asset at $t = 2$ is always positive $(q - z > 0)$ but the net value is negative in some states $(q - z - 1 < 0)$.

Moral hazard and deterioration risk. At $t = 0$ the banker decides whether to expand the balance sheet at $t = 1$ (being *active*), or *inactive*. Being active implies a deterioration risk: in the case of deterioration, the initial project needs a reinvestment c at $t = 1$ to effectively pay $\tilde{w}$ at $t = 2$.[8] If no reinvestment is made, the value of the project inevitably plunges to 0. The shock is large enough that a distressed bank will always liquidate the legacy asset and exit the economy (see section (2.2)). Inactive bankers do not run any deterioration risk and take the net value of their initial asset. The banker's *action* affects the probability of deterioration. The active banker can choose between *high effort* (behave) and *low effort* (shirk, misbehave). The probability of deterioration is zero if the banker exerts high effort. However, high effort has a private cost B for the banker. Low effort implies a positive probability $1 - \pi$ of deterioration.[9]

[8] As in Holmström and Tirole (1998).

[9] The underlying story to motivate the structure of payoffs can be the following. The banker performs two key functions, as in Thakor (1996): pre-lending screening of projects (credit analysis) and post-lending monitoring (supervision of the borrower's management of the asset financed). Assume that, at date 0, each banker is endowed with one unit of (free) effort, uses this unit of effort to lower (to zero) the probability of deterioration of the asset, that is they perform monitoring. The banker may seek to expand the balance sheet at date 1, purchasing new assets. Pre-lending screening is needed to avoid lemon assets and requires one unit of effort as well. This additional unit of effort is costly in terms of utility. Screening is not needed for inactive bankers, so they use their free effort unit for monitoring activity, running no risk of asset deterioration. Active bankers choose whether to bear the effort cost or to shirk, saving on the effort cost, using their effort endowment in screening activity (the loss from

At $t = 1$, active non-distressed banks receive additional investment opportunities. New projects are available in the economy and can be financed: banks can issue additional debt and purchase new assets. New projects are in a fixed supply S, they payoff at $t = 2$ and share the same stochastic structure as initial projects. Let p denote the $t = 1$ market-clearing price of assets.[10] In general, $p \geq 1$, otherwise the project cannot be initiated as it requires one unit of investment, and $p \leq q$, or else the bank is not willing to purchase it.

Market for assets. At $t = 1$, the market for assets opens. Distressed banks liquidate their initial assets. Active non-distressed banks issue new debt and expand the balance sheet. They are indifferent between purchasing a new project at the price p or a deteriorated project from a distressed bank at the liquidation price $p - c$ (the two assets have identical expected payoffs). The liquidation income of the banker is $l(p) = \max(p - c - 1; 0)$. Inactive banks do not participate in the market.

Overview. The model shares the general scheme of Adrian and Shin (2010a) in which we introduce a moral hazard problem to study the incentives of the banker and capital regulation. Good fundamentals relax the VaR (Section 2.2), boost the return on equity and affect the continuation value (charter value of the bank) positively. In principle, the incentives of the banker improve in good times, when the balance sheet capacity of banks is large (Section 2.3). However, the equilibrium effect of the increased demand for assets is an amplified surge in asset prices. The latter raises the banker's income in liquidation, in turn negatively affecting the effort choice. In the aggregate, there emerges a mutual influence between (i) fundamentals that affect the VaR, (ii) bankers' incentives and behavior that determines the probability of liquidation and (iii) the equilibrium market clearing price, a key driver of incentives for bankers (Section 2.4). The initial equity of the banker represents a disciplinary device: the higher the equity, the larger the amount of assets the banker can purchase when avoiding deterioration, the higher the expected net return of effort. A regulator is delegated to prevent bankers that are expected to exert low effort from being active. This incentive compatibility is endogenously derived and takes the form of a capital requirement (Section 3). We analyze the equilibrium with regulation and argue that, under general conditions, the capital requirement improves efficiency. In Section 4, we introduce a distortion of beliefs and present a mechanism for financial crises triggered by positive shocks to fundamentals.

2.2 The VaR and the demand for assets

In this section, we derive the amount of assets x that a (non-distressed) bank with equity e is able to purchase at $t = 1$. It represents a key determinant of the banker's payoff (see Section 2.3). We follow Adrian and Shin (2010a) by assuming that the bank operates under a VaR constraint so

purchasing/financing a lemon is lower than the expected cost of asset deterioration). In the latter case, the lack of monitoring induces a positive probability of deterioration. In a similar spirit, Ruckes (2004) has a model in which the cycle, namely the default probabilities of borrowers, affects the profitability of banks' screening activities.

[10] It represents how the expected return q is shared between the banker, who takes $q - p$, and the borrower, i.e. the seller of the asset, who takes $p - 1$. As borrowers play a completely passive role, we do not introduce them explicitly in the model.

that its demand for assets depends on its equity position and on the fundamental value and risk of assets. In general, the VaR stipulates that the bank's equity is large enough to keep the default probability below some benchmark level. With no loss of generality, we impose the benchmark default level to be zero.

The bank is required to meet the VaR at all dates. This has two implications. First, at $t = 0$ the equity of the banker must be high enough:

$$q - z > 1 - e_m \tag{1}$$

The left hand side is the worst-case value of the bank assets. The right hand side represents the amount the (least capitalized) bank must repay at $t = 2$. Condition (1) guarantees that the debt of all banks at $t = 0$ is *fundamental* risk-free.

The second implication is that the bank is forced to liquidate the asset and exit the economy at $t = 1$ when the deterioration shock is large enough, that is when

$$q - z < 1 - e_M + c \tag{2}$$

The right hand side of condition (2) is the debt that the (most capitalized) bank must repay when it raises the additional c to withstand the reinvestment cost. Indeed, in principle, the distressed bank has two options at $t = 1$: to raise the amount c from market investors and bring the initial project to completion or to liquidate the asset and exit the economy. Condition (2) guarantees that the bank must liquidate, obtaining the amount $p - c$ from the sale.[11] Summing up, when the deterioration shock hits, the VaR induces the bank to liquidate the asset.

Finally, and most importantly, the VaR limits the amount of assets that banks can purchase at $t = 1$, as the minimum possible value of the bank's assets $(q - z)(x + 1)$ must not be lower than the value of the bank's debt, that is $1 - e + px$. The VaR constraint can be re-written as

$$e - \{[p - (q - z)]x + [1 - (q - z)]\} \geq 0$$

where the expression in curly brackets represents the worst-case loss. Solving for x, the asset demand of a bank with equity e is

$$x \leq \frac{e - 1 + q - z}{p - q + z} \tag{3}$$

The demand is increasing in equity e and in the fundamental value of assets q and decreasing in price p and in risk z.

The VaR assumption can be interpreted as the participation constraint of market investors who are willing to purchase only collateralized bank debt. In the secured funding interpretation, q is the value of the collateral and z is the haircut. For this reason, we sometimes refer to good fundamentals as buoyant funding conditions for banks. A zero benchmark default level in

[11] With liquidation, after repaying the debt, the bank obtains $p - c - (1 - e)$ with certainty. With the reinvestment, the latter quantity decreases to $q - z - (1 - e + c)$ as, by construction, $p \geq 1 > q - z$.

the VaR interpretation is equivalent to a full collateralization requirement in the secured funding interpretation. Trivially, partial collateralization translates into VaR constraints with some positive benchmark default probability. We can relax the full collateralization assumption without affecting our qualitative results.

2.3 The problem of the banker

The banker chooses the action to maximize her expected payoff. The three actions are stay inactive, be active with high effort or be active with low effort. The expected payoff when inactive:

$$E(U^I) = q - 1 \tag{4}$$

where $q-1$ is the expected net value of the initial asset. The expected payoff from high effort:

$$E(U^H) = (q - p)x + (q - 1) - B \tag{5}$$

where $q-p$ and $q-1$ are the expected net value of new and initial projects, respectively. B is the private cost of high effort. The expected payoff from low effort:

$$E(U^L) = \pi[(q - p)x + (q - 1)] + (1 - \pi)l(p) \tag{6}$$

where, as before, $1-\pi$ is the probability of deterioration. The actions of bankers in the economy crucially affect the market equilibrium at $t = 1$. In the next sections we examine the solution without moral hazard ($B = 0$) as a benchmark case, the equilibrium with moral hazard without regulation and, finally, the solution with a regulator that imposes a capital requirement designed to prevent equilibrium shirking.

2.4 Asset prices and moral hazard

Leveraged financial institutions' demand for assets generates an amplified response of asset prices to shocks to fundamentals, as in Adrian and Shin (2010a). For the sake of comparability, we first briefly derive the solution without the moral hazard problem, i.e. we take $B = 0$ as a benchmark case.

No moral hazard. Trivially, when there is no effort cost, all bankers prefer high effort. $E(U^H)$ is always increasing in x, so the condition (3) holds with the equality. Equating demand and supply of assets, the market-clearing condition can be expressed as

$$\int_{e_m}^{e_M} \frac{e - 1 + q - z}{p^{FB} - q + z} \mathrm{de} = S \tag{7}$$

The left-hand side is the aggregate demand for assets, increasing in the balance-sheet capacity of banks.[12] As one would expect, good fundamentals (high $q-z$) and a robust balance sheet (large e_M and e_m) boost asset prices. From equation (7), following a positive shock to fundamentals, the amplified response of asset prices obtains as the equilibrium price should respond more than proportionally to restore the equality between demand and supply.

Moral hazard without regulation. When high effort is costly ($B>0$), a moral hazard problem may emerge and the banker may try to save on effort cost, jeopardizing the expected net value of their initial project. Let p^{UR} be the equilibrium price in the unregulated solution. Using equations (5) and (6), for an active banker, the condition of preferring high effort to low effort can be written as a condition on the demand x:

$$E(U^H) \geq E(U^L) \quad \Longleftrightarrow \quad x \geq \frac{1}{q-p^{UR}}\left[\frac{B}{1-\pi}-(q-1)+l(p^{UR})\right] \tag{8}$$

Condition (3), that relates the initial equity positively to the amount of assets the bank can purchase at $t=1$, holds with the equality as the expected payoff of the banker is always increasing in x. Therefore, it is possible to express condition (8) in terms of the equity:

$$e \geq e^{UR} \equiv \frac{p^{UR}-q+z}{q-p^{UR}}\left[\frac{B}{1-\pi}-(q-1)+l(p^{UR})\right]+1-q+z \tag{9}$$

The equity has a disciplinary effect on the effort choice. The higher the initial equity (the lower the leverage), the larger the balance-sheet capacity and the continuation/charter value of the bank, and the higher the cost of the deterioration shock and liquidation in terms of expected payoff. For the same reason, the cut-off e^{UR} is decreasing in q and increasing in z, as good fundamentals boost the charter value of the bank.

Similarly, comparing equations (4) and (6), the condition of preferring low effort to inactivity is:

$$e \geq e_0^{UR} \equiv \frac{p^{UR}-q+z}{q-p^{UR}} \cdot \frac{1-\pi}{\pi}\left[q-1-l(p^{UR})\right]+1-q+z \tag{10}$$

Combining conditions (9) and (10), a positive mass of bankers exert low effort if

$$e^{UR}-e_0^{UR} \equiv \frac{p^{UR}-q+z}{q-p^{UR}}\left\{\frac{B}{1-\pi}-\frac{1}{\pi}\left[q-1-l(p^{UR})\right]\right\}>0 \tag{11}$$

The quantity $e^{UR}-e_0^{UR}$ is always increasing in p^{UR} and it is positive when the price of assets is high enough, that is when

$$p^{UR}>q+c-\frac{\pi}{1-\pi}B \tag{12}$$

When condition (12) holds, high asset prices make low effort attractive over other actions, and this eventuality plays a crucial role in the model. In this case, the market clearing condition is:

[12] According to condition (1), all banks can participate to the market for assets. Note that when the latter condition is not met, some poorly capitalized banks would be required to downsize the balance sheet to meet the VaR. This event is not interesting *per se* and would not alter the qualitative results of the model.

$$\pi \int_{e_0^{UR}}^{e^{UR}} \frac{e-1+q-z}{p^{UR}-q+z}\mathrm{de} + \int_{e^{UR}}^{e_M} \frac{e-1+q-z}{p^{UR}-q+z}\mathrm{de} = S + (1-\pi)(e^{UR}-e_0^{UR}) \tag{13}$$

The first addendum on the left-hand side is the demand for assets from bankers that seek low effort and survive (no deterioration). The second one is the demand from bankers that exert high effort. The aggregate demand is decreasing with p^{UR} partly because high asset prices, curbing the expected return of effort, induce some bankers to shift from high to low effort. The right-hand side is the supply of new assets S plus assets in liquidation from distressed banks, non-decreasing with p^{UR}.

Equation (13) shows the key mechanism of the distortion of incentives in good times. In the terminology of Adrian and Shin (2010a), robust equity positions and good fundamentals boost the balance sheet capacity of banks. The demand pressure on asset prices reduces the price of the fundamental risk, namely the difference $q - p^{UR}$ between the expected payoff from the risky asset and its price. However, in our model, asset prices have an equilibrium feedback effect on effort choice and deterioration risk: the possibility to liquidate assets at a high price decreases the marginal return of effort. In other terms, a low price of the fundamental risk reduces the cost, in terms of banker expected payoff, of the deterioration risk-taking. At the equilibrium, the adjusting variables in equation (13) are the market clearing price and the mass of bankers that prefer low effort. In the next section we discuss the implications of low effort in terms of efficiency and analyze the role of a regulatory authority in curbing perverse incentives.

3 Incentives and regulation

When asset prices are buoyant, some bankers prefer low effort. This strategy is detrimental in terms of efficiency as it increases the expected cost of the investment on the initial project. The expected value of the initial project of a behaving banker is $q-1$ and the one of a shirking banker is $q-1-(1-\pi)c$, where c is the reinvestment cost and $(1-\pi)c$ representing a pure deadweight loss. This argument is perfectly valid even when investors are repaid in full and bank's debt is risk free. In particular, condition (12) and the full repayment of bank's debt (the clearing price is larger than the debt of the more indebted active bank) are perfectly compatible.[13] In this section we assume this is the case. According to this consideration, we examine the case in which a regulatory authority is delegated to preserve incentives, restricting the ability to be active of bankers that are expected to exert low effort.

Moral hazard with regulation. Similarly to condition (9), the capital requirement e^R that rules out low effort in equilibrium is

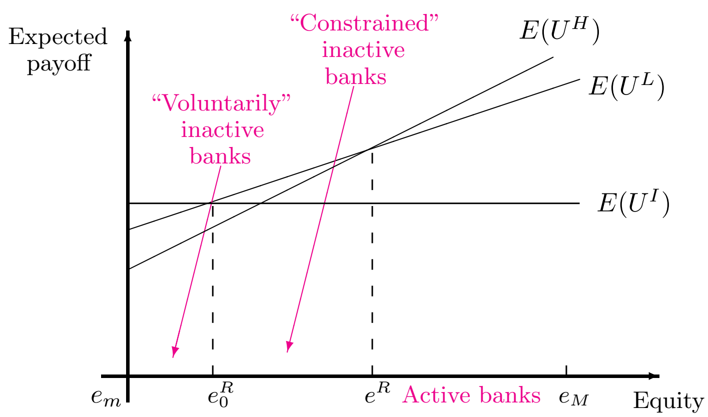
$$e^R = \frac{p^R - q + z}{q - p^R}\left[\frac{B}{1-\pi} - (q-1) + l(p^R)\right] + 1 - q + z \tag{14}$$

[13]In formulae: $p \geq 1 - e_0^{UR}$.

where p^R is the associated equilibrium price that satisfies the market clearing condition

$$\int_{e^R}^{e_M} \frac{e-1+q-z}{p^R-q+z} \mathrm{d}e = S \tag{15}$$

Graph 1: Incentives and the capital requirement



Graph 1 is a simplified representation of the incentives and payoffs of bankers and describes how the capital requirement would work in practice. Bankers that run banks with initial equity $e \geq e^R$ can be active as they are expected to exert high effort. Banks with $e \leq e_0^R$ voluntarily decide not to expand their balance sheet and stay inactive.[14] Finally, banks with $e \in (e_0^R; e^R)$, in the graph labelled "constrained" inactive banks, are affected by the authority's intervention and are forbidden to participate to the asset market at $t = 1$.

The regulatory intervention affects the equilibrium. The market clearing price is a function of the capital requirement e^R that determines the mass of active banks. The capital requirement of equation (14) is monotonically increasing in p^R. Moreover, the left-hand side of equation (15) is monotonically decreasing in e^R and in p^R. Therefore, in the plane (e^R, p^R), there exists a unique crossing between the curves described by the two equations. Equation (14) captures the effect of prices on incentives: the higher the price, the worse the incentives, the higher the capital requirement. Equation (15) reflects the effect of the capital requirement on the market clearing price: the higher e^R, the lower the aggregate demand for assets, the lower p^R.

Macroprudential regulation. The role of regulation in the model is quite simple. Fundamentals affect the demand for assets and their prices. On the other hand, asset prices affect the payoff of individual banks, changing the margins of banks and the net utility of effort. As in

[14]Similarly to equation (10), we have

$$e \geq e_0^R \equiv \frac{p^R - q + z}{q - p^R} \cdot \frac{1-\pi}{\pi} \left[q - 1 - l(p^R) \right] + 1 - q + z$$

Section 2.4, without regulation, low effort may be attractive for some bankers, implying inefficient reinvestment costs. The role of the regulatory authority is to set a capital requirement that prevents banks that are expected to exert low effort from participating in the market for assets. This policy is macroprudential in nature as it explicitly accounts for a clear role of a macro variable, namely asset prices, in determining the appropriate level for the policy instrument.

Incentives through the cycle and regulation. One of the results of the paper is to provide microfounded support to the idea of a capital requirement that varies along the business cycle. A simple comparative statics exercise can be carried out, assuming a shock to the fundamental risk of assets, z.[15] For this purpose, consider the behavior of the marginal banker with equity e_z^R, the latter being the equilibrium capital requirement when the risk is at level z. Assume an infinitesimal decline of size Δz. In the case where the authority does not adjust the capital requirement, the new equilibrium will be such that:

- The new market clearing asset price $p_{z-\Delta z}^R$ increases above p_z^R. Indeed, *ceteris paribus*, the balance-sheet capacity of banks increases, putting a positive pressure on prices. In this case, from equation (15), the price variation is larger than Δz. The amplified response in asset prices is particularly significant when banks' balance sheets are especially robust.

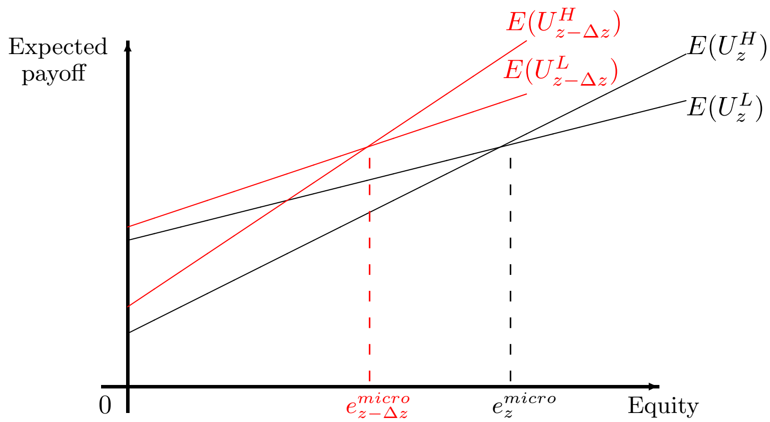
- A positive mass of bankers seek low effort. *Ceteris paribus*, the higher individual demand must be counterbalanced by some bankers that exert low effort in equilibrium. In particular, the lower the deterioration probability $1-\pi$, the larger the mass of shirking bankers required to compensate for the lower fundamental risk. The latter represents an additional procyclical amplification mechanism, as the deterioration probability is expected to be low in good times.

The new equilibrium exhibits a combination of the previous two effects. Indeed, higher asset prices would eventually jeopardize incentives, decreasing the net value of effort. Therefore, the marginal banker with equity e_z^R would switch from high to low effort. This consideration suggests that the regulatory authority should increase the capital requirement to prevent shirking at the equilibrium. In particular, the difference $\alpha \equiv e_{z-\Delta z}^R - e_z^R > 0$ can be interpreted as the *macroprudential capital buffer* envisaged in the Basel III Accord. Regulation should thus ensure that incentives are reinforced in favorable conditions via higher capital requirements, which take the form of macroprudential add-ons.

Microprudential regulation. For the sake of our discussion, it is interesting to analyze the implications of a regulatory policy regime that neglects the equilibrium effect of asset prices on incentives. In this sense, we label this regime *microprudential.* In principle, if the authority focuses solely on the incentives of each individual banker taken in isolation, condition (9) suggests that the microprudential capital requirement e^{micro} will decline as, with benevolent funding conditions, the authority expects bankers' incentives to be more easily aligned. Graph 2 describes the decline in the microprudential capital requirement that would follow from a decline of the fundamental risk of assets.

[15] Similar results can be obtained with other types of positive shocks.

Graph 2: Decline in risk and microprudential requirements



However, the microprudential capital requirement favors shirking at the equilibrium, as $e^{micro}_{z-\Delta z} < e^R_{z-\Delta z}$. Indeed, a larger mass of banks would be active, boosting the demand for assets. In this case, as mentioned earlier, the two adjusting variables are the asset price and the mass of shirking bankers.

While the microprudential capital requirement used in our model is extremely simplified and very far from actual prudential rules, it still has some interesting features that make it consistent with the Basel II fundamental risk-sensitive regulation. In particular, the time-dynamics are similar, with the minimum capital requirement decreasing in good times - as "point-in-time" fundamental risk declines - and increasing in bad times. In other words, our model is able to replicate Basel II cyclicality, although via different drivers. In this respect, we label Basel II regulation *microprudential* in the sense that it disregards the feedback effect that macro variables (asset prices) exert on banks' behavior.

4 Financial crises

In this section we present a departure from the benchmark rational expectations model discussed in the first part of the paper. In particular, we consider individual bankers which disregard the general equilibrium effect of low effort strategies on asset prices. There are many ways to rationalize this behavior. One rational expectations-based explanation hinges upon implicit guarantees from the official sector that reduce the cost of a crisis for financial firms. Farhi and Tirole (2012) build an elegant theoretical framework that interprets the socially inefficient private risk-taking in terms of a collective moral hazard problem on the side of banks that expect a public bailout in a crisis. In the same line, Tirole (2012) highlights the role of public interventions that "liquefy" or "rejuvenate" the asset market (e.g. TARP I and II programs in the US, Security Market Programme and

Covered Bonds Purchase Programme I and II in the Euro zone). In the logic of our model, the expected *ex-post* support to asset prices or to bank's net worth may jeopardize incentives and encourage deterioration risk *ex-ante*. Departing from rational expectations, Gennaioli et al. (2012) have a model of financial fragility in which both investors and financial intermediaries do not attend to certain types of risk (local thinking). In a similar spirit, in this section we treat the event of widespread deterioration risk as a type of risk not fully embedded in the expectation formation model of individual bankers. However, the literature on financial fragility focuses on the build-up of vulnerabilities that expose the system to massive damages even in the presence of small adverse shocks. For instance, Lorenzoni (2008) has a model of inefficient credit booms: atomistic bankers do not take into account the general equilibrium effect of asset sales on prices in a crisis triggered by an adverse aggregate shock, whose effects are magnified by inefficient ex-ante over-borrowing. Conversely, in our model, the initial trigger of the crisis is a positive shock to fundamentals. Individual bankers neglect the possibility of diffuse deterioration risk. They expect an amplified response of asset prices and decrease the effort in the monitoring activity. In the terminology of the introduction, neglected deterioration risk is at the root of a *distortion of beliefs* that, in turn, magnifies the effects of the *distortion of incentives*. The materialization of the endogenous deterioration risk is the final trigger of the crisis with massive liquidation, plunging asset prices and, possibly, a credit crunch.

More in detail, in the solution without regulation described by equations (9) and (13) a large mass of shirking bankers would emerge as they fail to account for the negative effect on prices induced by the widespread low effort and deterioration risk. Let $\hat{p}$ be the expected price of assets which, in this case, would differ from the realized market price p^*.[16] The condition of preferring high effort to low effort is:

$$x \geq \frac{1}{q-\hat{p}}\left[\frac{B}{1-\pi} - (q-1) + l(\hat{p})\right] \tag{16}$$

or, in terms of equity:

$$e \geq \hat{e} \equiv \frac{\hat{p}-q+z}{q-\hat{p}}\left[\frac{B}{1-\pi} - (q-1) + l(\hat{p})\right] + 1 - q + z \tag{17}$$

The mass of shirking bankers is

$$\hat{e} - \hat{e}_0 = \frac{\hat{p}-q+z}{q-\hat{p}}\left\{\frac{B}{1-\pi} - \frac{1}{\pi}\left[q-1-l(\hat{p})\right]\right\} \tag{18}$$

The equilibrium price p^* follows from the market clearing condition:

$$\pi \int_{\hat{e}_0}^{\hat{e}} \frac{e-1+q-z}{p^*-q+z}\mathrm{d}e + \int_{\hat{e}}^{e_M} \frac{e-1+q-z}{p^*-q+z}\mathrm{d}e = S + (1-\pi)(\hat{e}-\hat{e}_0) \tag{19}$$

A fraction $1-\pi$ of shirking bankers would be hit by the deterioration shock and would actually

[16] For the sake of simplicity, one can take $\hat{p}$ from equation (7). In general, it would suffice for bankers to underestimate the pervasiveness of the moral hazard problem and of the associated deterioration risk.

sell off assets in liquidation (the last addendum in the right-hand side of equation (19)). The market clearing price would plunge and, if shirking were pervasive enough, market investors would take a hit (when $p^* - c < 1 - e$). The clearing price p^* is decreasing in $\hat{p}$: the higher the expected price (which still depends positively on fundamentals), the larger the shirking at the equilibrium, the lower p^*. Note that it may well be the case that $p^* < 1$. As the price must always be not lower than 1 (the cost of the project), there would be a credit rationing and only a fraction of the assets in the economy would be financed/brought to completion (credit crunch). Inefficiencies would go beyond the losses associated with reinvestment costs and entail a restriction of the credit to the economy. Therefore a regulatory authority that adjusts the capital requirement properly (see Section 3) would improve efficiency, both protecting market investors, in the spirit of the "representation hypothesis" of Dewatripont and Tirole (1994), and reducing systemic risk and the probability of financial crises.

5 Conclusions

In the aftermath of the recent financial crisis, a lively debate on the cyclicality of financial regulation and the possible options for mitigating it took place among policymakers, regulators and the industry. The outcome has been a call for a macroprudential approach to regulation. However, the discussion has been largely on the policy side, while the theoretical underpinnings of macroprudential devices have generally been neglected. In this paper, we set up an incentive model in which the financial sector faces a capital regulation that ultimately affects its aggregate leverage and equilibrium asset prices. The objective of capital regulation is to ensure that bankers put effort into their risk management activities, thus limiting the probability of a deterioration in the quality of the asset side of their balance sheets. Incentives are affected by both micro (fundamentals) and macro (market) variables. While our aim is not to set up a general framework for banking regulation as we concentrate only on one aspect of it, the model nonetheless sheds some light on how microprudential rules (those that disregard the feedback effect of macro variables on incentives) may create the wrong kind of incentives through the cycle.

While the model is extremely simplified, the mechanism it envisages is fully consistent with developments before and during the financial crisis. There are two important policy implications of our results. First, banks sow the seeds for future problems in good times. A macroprudential approach is necessary to align incentives through the business cycle. Our results thus provide theoretical support for the Basel III countercyclical buffer. Second, effective macroprudential policies should not only targeted to the accumulation of buffers to be used when, somehow exogenously, "bad times come". Rather, they stand as effective policy tools to correct a class of distortions associated with the mutually reinforcing interaction between leveraged institutions' balance-sheet positions, increasing asset prices and incentives to provide sound risk management. On the other hand, the realignment of incentives may require severe buffer levels, and their costs in terms of credit supply should not be neglected. Alternative policy tools could directly and indirectly tackle our issue of incentive distortion. For instance, short-term interest rates are important in influencing the size of market-based financial intermediary balance sheet and may constitute a complementary policy tool. Moreover, and particularly in the current crisis environment, extraordinary interventions of the official sector largely affect the dynamics of asset prices in several markets. On the one hand, they may restore market functioning; on the other, they may reduce the long-term private cost of risk for financial firms, sowing the seeds of the next crisis. We leave these questions open for future research.

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