Incentives through the cycle: microfounded macroprudential regulation[*]

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Abstract

We provide a new rationale for macroprudential capital regulation by developing a model where banks can privately undertake a costly effort and reduce the probability of adverse shocks to their asset holdings and liquidation (*deterioration* risk). Low *fundamental* risk guarantees benevolent funding conditions and banks are able to expand their balance sheet. The associated boost in asset demand and prices may jeopardize banks' incentives whenever the liquidation price raises. We show that a microprudential regulatory regime that disregards the equilibrium effect of asset prices on banks' effort performs poorly as low fundamental risk may induce high deterioration risk. Overall, we suggest a theoretical foundation for the countercyclical buffer of Basel III, since it prescribes a macroprudential regulatory regime in which the equilibrium feedback effect is fully taken into account by the authority.

Keywords: Macroprudential regulation, incentives, financial stability, Basel III, Value-at-Risk.

JEL Classification: E44; D86; G18

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1 Introduction

The fact that under certain conditions the financial system contributes with additional volatility to macroeconomic dynamics is nowadays a shared and well analyzed view (Kiyotaki and Moore (1997), Bernanke et al. (1999), for a recent survey Panetta et al. (2009)). And indeed, in the aftermath of the crisis, many analysts, commentators and policymakers blamed the financial industry for their devastating contribution to the run-up of the crisis (Brunnermeier (2009), Brunnermeier et al. (2009)).

Financial regulation also had some responsibilities. Flaws in microprudential rules have in fact provided bankers with head-we-win-tail-they-loose incentive structures, fostering excessive risk-taking, deterioration of lending standards and perverse behaviors (Borio (2008); Buiter (2007); Kashyap et al. (2007); for a discussion, see Cannata and Quagliariello (2009)). In the benevolent version of the story, bankers and individual institutions were not perfectly in the position to foresee the ongoing overheated dynamics and the imminent burst as they miss a bird's eye view of the economic system. In this respect, it was up to policymakers and regulatory authorities to address the problem of externalities that arise from the inefficient aggregate outcome of individually optimal decision-making. And they have failed to do so. While macroprudential issues were increasingly debated before the eruption of the crisis (Crockett (2000), Borio (2003)), they were mainly confined to macroprudential analysis, with almost no room for macroprudential policies, not to mention concrete tools (Clement (2010)).

A new macroprudential orientation to financial regulation has been undoubtedly one of the key blocks of the reform roadmap. The Financial Stability Board (2009), clearly stated that a macroprudential orientation focuses policy on avoiding damage to the financial system as a whole with an eye to the impact on the real economy. Accordingly, Bernanke (2009) pointed out the need to combine a systemwide, or macroprudential, perspective with firm-specific risk analysis to better anticipate problems that may arise from the interactions of firms and markets. These principles have been transposed in prudential regulation by the Basel Committee (2010). While the system-wide perspective cannot be circumscribed to it, most of the policy measures 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. In practice, it is still controversial what macroprudential policies are supposed to achieve. On the one hand, the most pragmatic view advises not to attach excessive emphasis to the potential of such instruments. Macroprudential tools should just aim at ensuring that financial intermediaries accumulate sufficient resources in good times when they are cheap and risk is underestimated that can be run-down in bad times with no or little repercussions to financial stability. On the other, according to a more ambitious view, the macroprudential policy should go hand in hand with monetary policy and directly aim at managing economic cycles (for a survey, see Galati and Moessner (2010)).

While the Basel Committee has endorsed a comprehensive reform including innovative countercyclical tools, the debate on macroprudential issues is still lively and answers to relevant questions are still not completely conclusive. In this work we tackle the following issues:

- First, which is the role of macro variables as asset prices in the allocation and in the build up of risk? In our model banks' utility and incentives crucially depend on asset prices. We argue that high asset prices may jeopardize incentives.
- Second, why and how should capital requirements evolve along the business cycle? The model highlights the drawbacks of microprudential risk-weighted capital requirement in line with the Basel II Accord and provides theoretical foundations to macroprudential buffers as in the Basel III proposal.
- Finally, and above all, some policymakers and academics (Borio et al. (2001)) argue that the cycle is endogenous to the behavior of financial institutions.[1] In this sense, the rationale of macroprudential regulation should go beyond the accumulation of capital in good times to be released when the bad times arrive. We provide insights that support this view highlighting the mutual interplay between macro variables, individual incentives of banks in implementing sound risk management and prudential rules.

We analyze macroprudential regulation using an incentives model in which banks can privately undertake a costly effort and reduce the probability of adverse shocks to their asset holdings and liquidation (*deterioration* risk). High effort (behave) reduces the probability of the adverse shock. Low effort (shirk) guarantees private benefits but increases the latter probability. In the bad state, the bank is forced to liquidate its initial asset holding and exits the economy at an interim stage. In the good state, the bank expands its balance sheet issuing new debt and purchasing new assets. The asset demand of the bank is affected

[1] According to Borio et al. (2001), financial institutions' decisions are frequently based on misperceptions of the evolution of risk over time. The stylized facts are simple. During expansions, intermediaries tend to underestimate risk exposures to risks, relaxing borrowers selection criteria and monitoring processes. Accordingly, they also reduce the amount of provisions for future losses. After the peak of the cyclical upturn, customers' profitability worsens, borrowers creditworthiness deteriorates and losses are revealed. This pattern is often coupled with the fall of asset prices that, in turn, further affects customers' financial wealth and depresses the value of collateral. Banks' exposures to credit risk increase, thus 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 economic downturn.

by a Value-at-Risk-type (VaR) constraint, as in Adrian and Shin (2010a).[2] The possibility to raise fresh funds and purchase new assets is a disciplinary device as it increases the good state payoff. On the other hand, the ability to extract a positive income in liquidation decreases the marginal utility of effort. Then, absent regulation, low fundamental risk (benign funding conditions) boosts asset demand and prices (see for instance Adrian and Shin (2010b)). This event would, in principle, ameliorates incentives. But, eventually, the surge in asset prices may rise the banks' income in liquidation, negatively affecting the opportunity cost of effort. In the model, a regulator is delegated to prevent non incentive compatible banks (those that are expected to exert low effort) to issue new liabilities and expand the balance sheet. Incentive compatibility is endogenously derived and takes the form of a condition on the minimum bank's equity (capital requirement).

We label as "microprudential" a regulatory authority that disregards the equilibrium feedback effect from asset prices to incentives. Conversely, the full effect of shocks to fundamentals are taken into account by the macroprudential authority. We show that (i) the microprudential capital requirement performs poorly in terms of banks' incentives and aggregate outcome and that (ii) the equilibrium/macroprudential capital requirement is increasing in the fundamental value of assets and decreasing with the fundamental risk. Therefore the model provides theoretical underpinnings to macroprudential capital buffer of the Basel III proposal as it advocates that capital requirements should be tighten in good times.

What is peculiar of our model is that it contemplates the need for a policy intervention as the consequence of improvements to fundamentals. Absent regulation, positive shocks exert two competing effects on incentives. Behaving banks with a positive asset demand sustain asset prices. This encourages (shirking) banks to free ride other banks' effort, enjoying private benefits from low effort and high prices in liquidation. In the expanding phase of the cycle, low risk and/or high asset value increase the balance sheet capacity of banks. The price externality triggered by behaving banks sows the seeds of the following downturn as it decreases the marginal value of effort so inducing the build up of deterioration risk. Our approach is thus complementary to standard models, which rely mainly, if not uniquely, on negative exogenous shocks and amplification mechanisms (see Rochet et al. (1996), Allen and Gale (2004)) and is more related to the endogenous risk literature (Morris and Shin (2003), Danielsson and Shin (2003)). Indeed, in the model, we can distinguish between two components of risk: a fundamental (perceived, exogenous) risk and an endogenous deterioration risk that depends on incentives. When fundamental risk is low – which typically happens in good times – banks become eager to

[2]This constraint can be interpreted as emerging both from the bank's risk management practices and/or from market investors' willingness to purchase only collateralized bank's debt. The magnitude of the haircut represents funding conditions for the bank (see below).

expand the balance sheet. This ameliorates incentives and, under a microprudential regulatory regime, determines the minimum incentive compatible equity to decrease. However, the indirect effect that goes through higher demand and asset prices, jeopardize incentives and operates in the opposite direction. Banks may be tempted to leverage the booming times to save on costly effort (high prices guarantees high payoffs from asset liquidation). This behavior, eventually, increases the overall risk in the economy. In this sense we suggest that the macroprudential orientation of regulation might effectively correct perverse behaviors and implement efficiency reducing the amplitude of boom-bust financially driven cycles.

Finally, our work is even related to recent researches on liquidity and leverage of financial intermediaries (Brunnermeier and Pedersen (2009), Adrian and Shin (2010b), Gai et al. (2010)). In our model, the fundamental risk of assets can be treated as the haircut that investors demand on secured lending to banks. When funding conditions are favorable (low haircut), banks are able to expand their balance sheet and increase their leverage. Higher demand of assets would amplify the first round effects in a spiral of increasing prices, more robust marked-to-market balance sheet and thinner haircuts. We argue that this process is not endless as high asset prices eventually distort banks incentives when shirking becomes attractive. Indeed, the model predicts that the marginal utility of effort would decline along the boom triggering, absent proper regulation, the inverse mechanism of massive liquidation (direct effect of diffuse shirking behavior), plunge in asset prices, margin calls and further asset liquidation. In other terms, the model suggests an intimate relationship between funding conditions and solvency (in our very stylized model, determined by effort): extremely favorable funding conditions may generate solvency problem when they jeopardize incentives to exert costly activities that preserve the fundamental value of assets. In this respect, the growth of the subprime market and securitization in the US in 2002-07 is a vivid and recent example; in particular, it can be truly crucial to appreciate the negative distortion of incentives induced by higher payoffs in liquidation induced by increasing asset prices; many argue that the deterioration of lending standard has been largely determined by the belief that increasing real estate prices would have continued to provide a floor to the value of assets.

In section 2.1 we describe the building blocks of the model. Then we analyze the determinant of the demand for assets and the bank's incentive problem (section 2.2 and 2.3). Capital requirements for banks, and their evolution in response to change in fundamentals, are derived from incentive compatibility in section 3. We analyze the microprudential regulatory regime (section 3.1): the authority disregards the effects of shock to fundamentals on asset prices and from asset prices to individual bank incentives. Section 3.2 introduces the macroprudential dimension of capital regulation. Section 4 concludes.

2 The model

2.1 Description

There are three dates: $t = 0, 1, 2$. Agents do not discount future cash flows. There are two types of agents: market investors and banks. Banks are risk neutral. Investors are perfectly competitive and demand a zero return. We assume investors purchase only collateralized bank's debt. We will see below that collateralization can be replaced with risk neutral investors and banks that operate under a Value-at-Risk constraint.

Banks have history and enter date 0 with a given balance sheet. Table 1 shows the bank's initial balance sheet.

Table 1: Bank's initial balance sheet

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

Each bank holds one project (asset) that is financed with equity e and with debt $1 - e$, issued before date 0 to market investors. The banking system is made up of a population of unit mass of banks that are distributed with respect to equity on the support $[e_m, e_M]$, where trivially $0 < e_m < e_M < 1$. Finally, assume banks cannot raise additional equity.

Assets have the following stochastic return structure: they need one unit of investment and payoff at date 2 a positive random amount $\bar{w}$ with expected value $E(\tilde{w}) = q > 1$, $\min(\tilde{w}) = q - z$ and $\max(\tilde{w}) = q + z$. We refer to $z \in (q - 1, q]$ as the fundamental risk of assets.[3]

At date 1, new projects can be financed: banks issue additional debt to market investors, purchase new assets and expand their balance sheet. In the economy, new projects are in a fixed supply S and payoff at date 2, with the same above-mentioned stochastic structure of initial projects. We label as "active" those banks that, at date 0, seek (or are able, see below) to be engaged in the balance sheet expansion. Remaining banks are called "inactive".

[3] Restrictions on z guarantee that the net value of the project is negative in some (bad) states ($q - z - 1 < 0$) and that the project's date 2 payoff is always non-negative ($q - z \geq 0$). According to the fully collateralized debt assumption, at the initial date

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

i.e. the bank's initial debt is not higher than the worst case asset value.

Central to our analysis is the fact that an active bank, between date 0 and 1, can privately undertake a costly effort and reduce the probability of adverse shocks to its asset holdings (deterioration risk). In other terms, the bank can shirk selecting activities that yield private benefits but that are detrimental to the value of the initial project. For instance, one can think at these activities as lack of monitoring due to limited managerial skills or attention of a banker that, when active, has to spend effort to (i) prevent the deterioration of the initial project and, at the same time, (ii) search for new profitable opportunities (projects, assets) to expand the balance sheet. Then, before purchasing new assets, an active bank may face an adverse shock to its initial asset holdings. One way to model the adverse shock is to assume that the initial project needs a reinvestment c to effectively payoff $\tilde{w}$ at date 2. The probability of the shock is $1-\pi$. If no reinvestment is made, the value of the project plunges to 0.

Assume that c is large enough $(q-z<1-e_M+c)$ so that investors would be unwilling to fund distressed banks with the additional amount c to guarantee the continuation of the initial project. Then, initial investors force liquidation trying to recoup the initial outlay from the liquidation of the asset. The distressed bank liquidates its initial asset and exits the economy.[4]

On the other hand, non-distressed banks are indifferent to purchase a new project at the price p or a deteriorated project from a distressed bank at the price $p-c$ (they have the same expected payoff). We refer to $p-c$ as the liquidation price. Note that, in general, the market price p of a new project cannot be lower than 1 (otherwise the project cannot be financed as it needs one unit of investment) and cannot exceed q (otherwise the bank is not willing to purchase it). Thus, $p \in [1, q]$.

2.2 The demand for assets

In this section, we derive the demand of assets of a bank with equity e. We follow Adrian and Shin (2010a) assuming that the asset demand x of the bank is affected by a Value-at-Risk (VaR) constraint

$$\text{VaR} \leq e$$

In general, the VaR constraint stipulates that the bank's equity is large enough so that the default probability is kept below some benchmark level. With no loss of generality, we impose the benchmark default level to be zero. In other terms, the VaR constraint guarantees that, at date 2, the minimum possible value of the bank's assets $(q-z)(x+1)$ is not lower than the value of the bank's debt, that is $1-e+px$. Note that this is equivalent to a full

[4]Indeed, in the event of asset deterioration and reinvestment c, investors would face losses whenever $\tilde{w}<1-e+c$, and this event has a positive probability.

collateralization requirement imposed by market investors.[5] In this "secured funding" interpretation, q is the value of the collateral and z is the magnitude of the haircut demanded by investors. With simple manipulations, the VaR constraint becomes

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

where the expression in curly brackets represents the worst case loss.

As the utility of banks is increasing in x (see below), the VaR constraint is always binding. Solving for x, the asset demand of a bank with equity e is

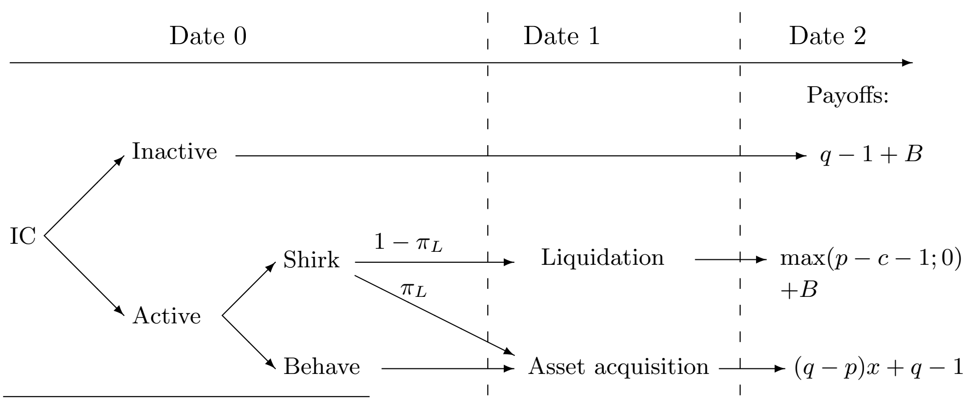
$$x = \frac{e - 1 + q - z}{p - q + z} \tag{2}$$

Note that, according to the condition (1), $x \geq 0$ when $e = e_m$ and $x > 0$ for all other banks. The demand of assets is increasing in the equity e, in the fundamental value of assets q and decreasing in the price p and risk z. According to the latter result, both individual and aggregate demand of assets are high when the fundamental risk is low.

2.3 The problem of the bank

As common in the literature of asymmetric information (see for instance Holmström and Tirole (1997)), the bank affects the probability of the adverse shock. When the bank *behaves* (high effort) the probability of deterioration is $1 - \pi_H$. Normalize $\pi_H = 1$. When the bank *shirks* (low effort), it accepts a higher probability of deterioration $1 - \pi_L > 0$. Low effort yields private benefits $B > 0$ to the bank.

Figure 1: The timing of events in the model.



[5] We can relax the full collateralization assumption without affecting our qualitative results. Partial collateralization translates into VaR constraints with some positive benchmark default probability.

The expected net payoff in the good state is

$$(q-p)x+q-1$$

where $q-p$ and $q-1$ are the expected returns of new and initial projects, respectively. In the case of liquidation, the bank's net payoff is

$$\max(p-c-1;0)$$

If the liquidation price is lower than the value of debt ($p-c<1-e$), the bank defaults. When $1-e \leq p-c<1$, the bank can repay the debt but erodes its equity by the amount $1-(p-c)$. In both these cases, the liquidation income is null. Finally, the bank's income in liquidation is positive when $p-c>1$. The bank's expected utilities are:

- if behaving:

$$E(u_H)=(q-p)x+q-1 \tag{3}$$

- if shirking:

$$E(u_L)=\pi_L[(q-p)x+q-1]+(1-\pi_L)\max(p-c-1;0)+B \tag{4}$$

- if inactive:

$$E(u_I)=q-1+B \tag{5}$$

Recall that, when inactive, banks do not face deterioration risk.

The quantity x represents a disciplinary device for the bank: shirking, increasing the probability of distress and liquidation, is more costly in terms of utility when the bank can purchase a larger amount of new assets.

3 Incentives and regulation

In this section we discuss incentives of banks and the role of regulation. In general, shirking is detrimental to the value of initial projects as it increases the expected cost $1+(1-\pi)c$. Moreover, low effort induces losses on equity holders and investors if $p-c<1$ and $p-c<1-e$, respectively.

We follow the "representation hypothesis" of Dewatripont and Tirole (1994) and introduce a scope for prudential regulation assuming that a regulatory authority is delegated to restrict the possibility for non incentive-compatible (shirking) banks to be active. Incentive compatibility states that the expected utility from behaving is higher than the expected utility from shirking:

$$E(u_H) \geq E(u_L)$$

To make things interesting we assume a positive mass of banks would prefer shirking both to high effort and to inactivity.[6]

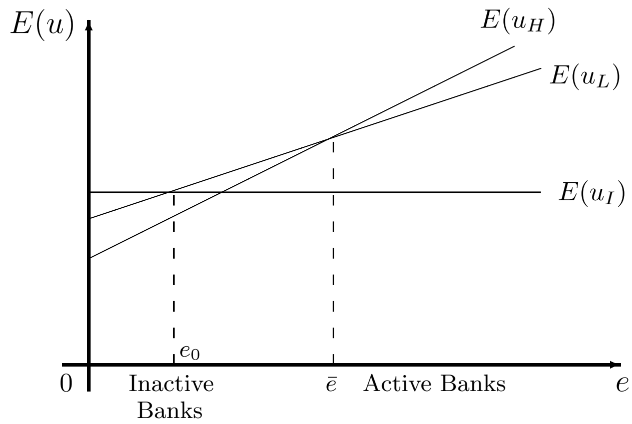
Using equation (3) and (4), the incentive compatibility constraint is

$$x \geq \frac{b - (q-1) + \max(p - c - 1; 0)}{q - p}$$

where $b = B/(1 - \pi_L)$ is a measure of private benefits. From the demand of assets (equation (2)), we derive a condition on equity:

$$e \geq \bar{e} \equiv \frac{p - q + z}{q - p}\left[b - (q-1) + \max(p - c - 1; 0)\right] + 1 - q + z \qquad (6)$$

Graph 1: Incentives and the capital requirement.



[6]The condition on x - and trivially on e - such that a bank would prefer shirking to inactivity is

$$x > \frac{1 - \pi_L}{\pi_L}\frac{q-1}{q-p}$$

On the other hand, banks with demand

$$x < \frac{1}{q-p}\left[\frac{B}{1-\pi_L} - (q-1)\right]$$

would prefer shirking to high effort. To guarantee that the intersection of the two sets is non empty, private benefits should be large enough:

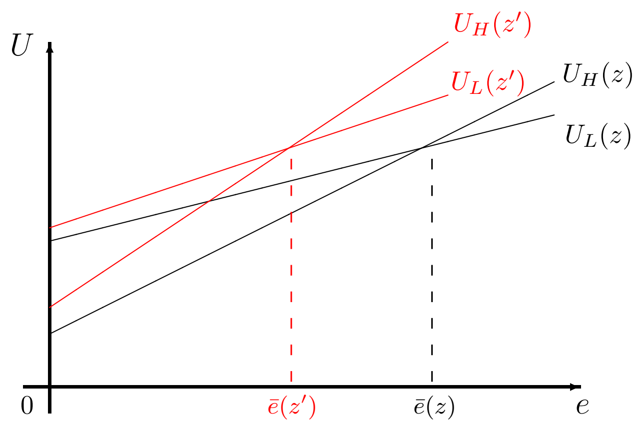
$$B > \frac{1-\pi_L}{\pi_L}(q-1)$$

The regulatory intervention sets an incentive compatibility constraint that is a capital requirement: only if the bank meets that requirement it is allowed to be active. Graph 1 depicts how the capital requirement would work in practice. The bank is endowed at date 0 with a certain amount of capital e, which determines its ability (quantity $x(e)$) to subscribe new assets under the VaR constraint. The quantity of assets, in turn, is a driver of the bank's incentives. The supervisory authority does not allow the bank to carry on actions that lead to value destruction and pursues this objective setting a minimum capital requirement (the policy instrument). Banks with equity $e \geq \bar{e}$ can be active as they are expected to put high effort and prevent asset deterioration.

3.1 Micropudential regulation

We analyze the effects of a decline in risk z and those of an increase of the fundamental value q of assets under two different regulatory regimes.[7] We refer to the first regime as *microprudential regulation*: the regulatory authority simply sets the capital requirement according to condition (6), taking p as given and fixed.

Graph 2: Decline in risk $z' < z$ and microprudential requirements.



Following a decline in risk $z' < z$, the minimum incentive compatible equity decreases. In the expanding phase of the cycle, when the fundamental risk is low (and haircuts become thinner), the minimum capital requirement declines as low risk relaxes the VaR constraint and the authority expects banks incentives

[7]In the rest of the work we concentrate on change in risk z but the effects of innovations of q have the same effects.

to be more easily aligned. Another way to visualize the same effect is the following: for any given amount of equity, the demand x is inversely related to risk. Therefore, low risk boosts incentives and the minimum equity decreases.

It is interesting to point out that, while the capital requirement used in our model is extremely simplified and very far from actual prudential rules, it still shows some characteristics that make it consistent with the Basel II risk-sensitive regulation. In particular, the time-dynamics is similar, with the minimum capital requirement decreasing in good times – as "point-in-time" risk declines – and increasing in bad times. In other words, our model is able to replicate Basel II cyclicality, even though via different drivers.

In this respect, we label Basel II regulation as *microprudential* in the sense that it disregards the feedback effect that macro variables (i.e. changes in asset prices) exert on banks' behavior. Indeed, as we will see below, the key point is that the decline in risk, besides the previously mentioned positive direct effect on incentives (and, under a microprudential regime, on capital requirement), increases the demand and the equilibrium asset price. This would feed back on incentives: from equations (3) and (4), incentives are jeopardized by p. High prices lower the bank's utility from high effort while increasing the income in liquidation.

3.2 Macroprudential regulation

In this section we analyze the equilibrium in the asset market at date 1. Adrian and Shin (2010a), in a similar setting, discuss the mechanism through which leveraged financial institutions' demand for assets generates an amplified response of asset prices to shocks to fundamentals. We first derive the equilibrium price as a function of the capital requirement $\bar{e}$ (price curve). Then we study the effects of a change in the fundamental risk of assets. Finally, we use the price curve and the incentive compatibility curve described by the equation (6), to compute the overall effect of shifts in z on the equilibrium capital requirement. Equating demand and supply of assets, we obtain an expression for the market clearing price:

$$\int_{\bar{e}}^{e_M} \frac{e-1+q-z}{p-q+z} \mathrm{d}G(e) = S \qquad (7)$$

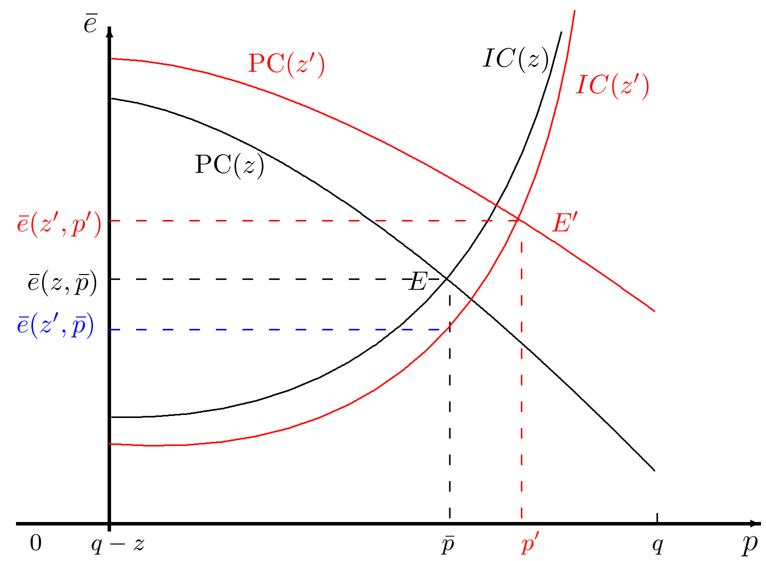
where the fraction is the asset demand of equation (2). $G(e)$ is the cumulative distribution function of banks with respect to equity. The L.H.S. is the aggregate demand of securities and S is the supply. To derive an explicit solution for the price curve, we study the case in which G is a uniform $U[e_m, e_M]$. With some algebra[8] we obtain the price equation:

[8] In the case of uniform distribution function, the relevant set of parameters is:

$$p = \frac{1}{S(e_M - e_m)}\left[\frac{e_M^2 - \bar{e}^2}{2} - (1-q+z)(e_M - \bar{e})\right] + q - z \qquad (8)$$

As one would expect, the price equation (8) establishes an inverse relationship between the capital requirement and the market clearing price.[9] Moreover, the price is decreasing in the fundamental risk of assets and increasing in q. A decline in risk z and/or an improvement of the fundamental value q both shift the price equation upward and make it flatter. Points E and E' in Graph 3 are, respectively, the equilibrium with z and z'. The IC curve represents the equation (6), namely the capital requirement as a function of the clearing price p.

Graph 3: Asset market equilibrium following a decline in risk $z' < z$.



Substituting equation (8) into equation (6), we obtain the equilibrium (macro-prudential) capital requirement as a function of fundamentals (z and q). In the relevant set of values for parameters, the capital requirement is

- A decreasing function of the fundamental risk z.

$$\frac{T}{z} \leq S \leq \frac{T}{1-q+z}$$

where $T = \frac{1}{e_M - e_m}\left[\frac{e_M^2 - \bar{e}^2}{2} - (1-q+z)(e_M - \bar{e})\right]$.

[9] Recall that $\bar{e} > e_m \geq 1 - (q - z)$).

- An increasing function of the fundamental value of assets q.

In other words, during the expanding phase of the cycle when fundamental risk is low and/or asset fundamental value is high the capital requirement that preserves incentive compatibility should increase.

More in details, when the authority disregards the effects of the shock on p (so taking $p = \bar{p}$ as given), the capital requirement declines from $\bar{e}(z, \bar{p})$ to $\bar{e}(z', \bar{p})$, following the downward shift of the IC curve. Trivially, this is not an equilibrium capital requirement as the clearing price would be much larger than $\bar{p}$. In that respect, the difference $\alpha \equiv \bar{e}(z', p') - \bar{e}(z', p)$ resembles the macroprudential buffer advocated in the Basel III Accord. From conditions (6) and (7), α is increasing in $z - z'$: the larger the decline in fundamental risk, the higher the buffer. Therefore, the policy response to a positive shock to fundamentals is simple. The undesirable consequences of too low capital requirements in good times can be mitigated by macroprudential buffers. Incentive compatible regulation should thus ensure that incentives are reinforced in favorable conditions via higher capital requirements, which take the form of macroprudential add-ons (in the model, the quantity α).

The PC curves have slight kinks at $p = 1 + c$. Indeed, there exists a risk level $\hat{z}$ such that for all $z < \hat{z}$, the equilibrium price guarantees a positive income in liquidation. This event magnifies incentive distortion and deserves a stronger regulatory intervention in terms of macroprudential buffers. In other terms, when the fundamental risk is particularly low, microprudential regulation would perform very poorly. In this respect, the model suggests a mechanism for a financial crisis with massive liquidation and unexpected losses. Assume an exogenous drop in the fundamental risk of assets. Under a microprudential regulatory regime, capital requirement would fall, according to equation (6). To decide their effort strategy, banks compute the expected price level from equation (7). Note that, low z and $\bar{e}$ both boost the expected demand and the expected market clearing price of assets. In this case, there would emerge a positive mass of banks that prefers shirking in the attempt to extract a high liquidation income. But eventually shirking banks would (i) induce a drop in the effective demand of assets (a fraction $1 - \pi_L$ of them would actually sell off assets in liquidation), (ii) impose losses on investors balance sheet if the actual liquidation price is small enough ($p - c < 1 - e$) and (iii) increase the overall expected cost of investment.

It is worth to emphasize that in our model, risk is actually made up of two components. The "fundamental risk" z and the "deterioration risk" associated to shirking behavior of banks. The latter is endogenous in the sense that it depends on incentives. Incentives move in response to fundamentals, to regulatory actions and to a macro variable as asset prices. When (the perception of - fundamental) risk is low, which typically happens in good times, banks' asset demand increases and this, in the first stage, is expected to improve their incentives. Ceteris paribus, this lowers the minimum incentive compatible equity that follows from condition (6). In the regulatory interpretation, in the expanding phase of the cycle, the microprudential minimum capital requirement declines as booming conditions boost effort and incentives are more easily aligned. Behaving banks exert a positive demand pressure on asset prices. This creates room for shirking banks to free ride other banks effort, enjoying both private benefits from low effort (B) and high income in liquidation ($p - c - 1$). In the expanding phase of the cycle, low risk and/or high asset value increase the balance sheet capacity of banks. The positive price externality triggered by behaving banks sows the seeds of the following downturn as it decreases the marginal value of effort so inducing the build up of deterioration risk. What microprudential regulation neglects is the other, indirect, equilibrium effect of lower perceived risk on banks' behavior. As a result, absent proper regulation, banks would take on more and more "deterioration risk" at the very moment when fundamental risk is perceived to be low.

The effects described above resemble Borio et al. (2001)'s idea that the credit cycle is endogenous with respect to the collective decisions of financial institutions.[10] And indeed our model shows - admittedly in a simplified setting - that 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).

4 Conclusions

In the aftermath of the financial crisis, a lively debate on the cyclicality of financial regulation and the possible options for mitigating it took place among policy makers, regulators and the industry. The outcome has been an unanimous 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 been generally neglected.

In this paper, we set up an incentive model in which banks face – beyond endogenous constraints that limit the size of their balance sheet – a capital regulation that also affects banks' ability to subscribe new assets. The objective of capital regulation is to ensure that banks put effort in their monitoring activities, thus avoiding too risky investments and containing the probability of deterioration of the quality of the asset side of their balance sheet. Banks' effort is affected both by micro (fundamentals) and macro (market) variables. While our aim is not to setup a general framework for banking regulation as

[10] According to Borio et al. (2001), those decisions are frequently based on misperceptions of the evolution of risk over time.

we concentrate only on one aspect of it, the model sheds some light on how microprudential rules (those that disregard the feedback effect of macro variables on incentives) may pose – particularly in benign economic conditions – wrong incentives to banks and suggests that a macro-perspective may be deemed necessary.

An illustrative example is a positive macro shock to fundamentals (say, a decline in the fundamental risk of assets). Favorable financial conditions affect bankers' incentives. In fact, the shock relaxes Value-at-Risk constraints (benevolent funding conditions) and boosts the ability of banks to expand the balance sheet (Adrian and Shin (2010a)) so increasing the optimal effort. Since banks are expected to voluntarily (endogenously) put high effort, (microprudential) capital requirements decrease. Lower capital requirements would add to other endogenous mechanisms and boost the demand for assets. Indeed, booming demand is the result of the procyclical behavior of leveraged financial institutions. Unfortunately, the soar in asset prices (and the associated high income in liquidation) feeds back on incentives and countervails the initial direct effect of the decline in fundamental risk: this implies that the effort in booming times may actually be lower than in normal times and that stricter capital requirements would be needed to avoid perverse behavior and value destruction. While the model is very simplified, the mechanisms it envisages are fully consistent with what happened before and during the big financial crisis.

There are two important policy implications of these results. First, banks plant in favorable conditions the seeds for future problems. In the dynamic version of the story, the initial improvement in fundamentals (that ameliorates incentives) is quickly coupled with the increase in the asset prices (that jeopardizes incentives). In this expanding phase, absent proper policy intervention on capital requirements, the incentive distortion is under way. Therefore, it is key that a macroprudential capital buffer is added to microprudential capital requirements to align incentives through the business cycle. Our evidence provides thus strong theoretical support for the Basel III countercyclical buffer.

Second, effective macroprudential policies should not only aim at the accumulation of reserves to be used when, somehow exogenously, "bad times arrive". Rather, they stand as effective policy tools to correct a class of distortions associated with the mutual 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. We leave this as an open issue for future research.

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