The Disturbing Interaction Between Countercyclical Capital Requirements and Systemic Risk*

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Abstract

We consider an economy in which cycle-neutral capital requirements are costly because they expose banks to fluctuations in aggregate funding conditions. Countercyclical capital requirements – which impose lower capital demands in bad aggregate states – have the potential to improve welfare. However, we show that such capital requirements also have a cost as they increase systemic risk taking at banks. This is because they insulate banks against economy-wide fluctuations (but not against bank-specific risk) and thus create incentives to invest in correlated activities. As a result, the economy's sensitivity to aggregate conditions increases and credit crunches may become more likely when countercyclical policies are in place. By contrast, efficient capital requirements incentivize banks to make less correlated investments – which reduces both systemic risk-taking and procyclicality.

Keywords: systemic risk, regulation, procyclicality

JEL classification: G01, G21, G28

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1 Introduction

A key focus of the debate on the design of future financial regulation is on whether the financial system responds efficiently to shocks. While prior to the crisis the focus was on models in which the economy adjusts optimally to shocks, there is a growing consensus that this is inappropriate when it comes to the financial system. In particular, there is the widespread view that the financial system exacerbates shocks over the cycle, leading to excessive lending in boom times and sharp contractions in lending when conditions deteriorate. Common explanations for this are based on the fact that agents in the financial system are often subject to constraints that tend to amplify shocks, such as borrowing constraints that fluctuate with asset prices, risk-sensitive capital requirements or remuneration schemes based on relative performance.

Spurred by the experience of the crisis of 2007-2009, there is now a broad move towards policies that mitigate procyclicality, the tendency of the financial system to amplify shocks over the cycle. For one, the new Basel Accord incorporates capital buffers that are built up in good times and can be run down when economic conditions deteriorate. In addition, the liquidity coverage ratio of Basel III – which aims at safeguarding banks against short-term outflows – contains a countercyclical element to the extent that such liquidity buffers are released in bad times. On the accounting side, there is a discussion about whether mark-to-market accounting – which has the potential to amplify the impact of asset price changes – should be suspended when prices are depressed. There is also a growing debate about whether monetary policy should "lean against the wind" with respect to the financial cycle, that is, raise interest rates when the economy experiences excessive credit expansion, but lower interest rates in times of significant contraction in lending or general stress in the financial system.

In this paper we argue that procyclicality cannot be separated from a second dimension of the systemic risk: the extent to which institutions in the financial system are correlated with each other.[1] Such correlation can arise through various channels: herding in invest-

[1] It is common in the literature to see procyclicality and correlation risk as the two key – but separate – drivers of systemic risk (e.g., Borio (2003)).

ment activities, the use of common funding sources, interconnectiveness through interbank linkages, but also because of convergence of risk management practices and trading strategies. In particular, we show that there is a two way interaction between the two dimensions of systemic risk: policies that target procyclicality affect the correlation of banks in the financial system but bank correlation (and policies that mitigate it) also influences procyclicality. It is thus not possible to address the two dimensions of systemic risk in isolation, which has profound implications for the design of regulation.

We consider an economy in which banks face shocks to their funding costs. There is a role for capital requirements because bank capital reduces moral hazard (akin to Holmström and Tirole (1997)). Constant (cycle-neutral) capital requirements create a simple form of procyclicality in this model. When financing conditions in the economy are unfavorable, it becomes expensive for banks to fulfill these capital requirements. This reduces bank profits and may result in an (inefficient) reduction in lending. We show that welfare-maximizing capital requirements – taking as given correlation of risks in the financial system – are countercyclical: when the economy is in a good state (and funding costs are low) it is optimal to require banks to hold capital sufficient to contain moral hazard, while in bad states (when costs are sufficiently high) it becomes optimal to forego the benefits from bank capital. Essentially, such capital requirements increase welfare in the economy by lowering the impact of funding shocks on banks.

We next endogenize the correlation of risks across banks. We allow banks to choose between economy-wide funding and a bank-specific funding source (this can be interpreted as a choice between market and retail financing). If banks choose economy-wide funding, their funding costs become fully correlated. However, banks individually do not perceive the full cost of correlation. This is because correlation makes it more likely that banks jointly experience situations in which funding conditions are prohibitive, in which case a credit crunch in the economy occurs (while if only one bank faces high costs, the other bank can take over its activities). Banks thus have incentives to correlate more than what is socially efficient. We show that countercyclical capital requirements worsen this problem. The reason is simple: countercyclical capital requirements increase correlation incentives by reducing a bank's expected cost of being exposed to aggregate uncertainty (but not the cost arising from bank-specific shocks). In particular, a bank that continues to use bank-specific funding runs the risk that it faces high funding costs at a time when funding costs in the economy are low, in which case it would be subject to high capital requirements when it is most costly.

Countercyclical capital requirements thus trade off benefits from reducing the impact of a given shock on the financial system ex-post with higher correlation of risks in the financial system ex-ante. Their overall welfare implications are hence ambiguous. Perversely, we show that countercyclical policies may even *increase* procyclicality. The reason is that by inducing banks to become more correlated, they make the financial system more exposed to aggregate shocks, which may result in a greater likelihood of a credit crunch. We show that the appeal of capital requirements that can be set depending on the state of the economy is further reduced when the regulator has problems of commitment. This is because a regulator always faces the temptation of lowering capital requirements ex-post when conditions are not favorable – even though this may not be optimal. Carrying out countercyclical policies in a discretionary fashion – as envisaged by Basel III – may hence have its costs.

There is an alternative to countercyclical policies in our model: the regulator can incentivize banks to become less correlated (for example, by charging higher capital requirements for correlated banks). We show that such a policy (if feasible) dominates countercyclical policies. This is because it addresses the two dimensions of systemic risk at the same time: it discourages correlation but also makes the system less procyclical as more heterogenous institutions will respond less strongly to aggregate shocks. In contrast – as argued before – countercyclical policies improve systemic risk among one dimension at the cost of worsening it along another one.[2]

The key message of our paper is that the two dimensions of systemic risk (correlation and procyclicality) are inherently linked. The consequence is that policies addressing one

[2] Developing countries tend to use reserve requirements in a countercyclical fashion (Federico et al. (2012)) and we provide some evidence in this paper that the banking systems of countries that used that tool to a larger extent exhibits higher correlation.

risk dimension will also affect the other dimension – and possibly in undesired ways. This needs to be taken into account by regulators when implementing macroprudential policies. While our model is set in the specific context of capital requirements and banks, the basic message applies also to other forms of countercyclical policies, such as macroeconomic stabilization policies. For example, an interest smoothing policy by the central bank insulates banks against aggregate fluctuations in interest rates[3] and likewise increase incentives for taking on correlation risk.

Related literature Our paper connects two strands of literature. The first investigates whether banking regulation should condition on the economic cycle.[4] Kashyap and Stein (2004) argue that capital requirements that do not depend on economic conditions are suboptimal and suggest that capital charges for a given unit of risk should vary with the scarcity of capital in the economy. Repullo and Suarez (forthcoming) demonstrate that fixed risk-based capital requirements (such as in Basel II) result in procyclical lending. They also show that banks have an incentive to hold pre-cautionary buffers in anticipation of capital shortages – but that these buffers are not effective in containing procyclicality. As a result, introducing a countercyclical element into regulation can be desirable. Martínez-Miera and Suarez (2012) consider a dynamic model where (flat) capital requirements reduce banks' incentives to take on aggregate risk (relative to investment in a diversified riskless portfolio). The reason is that capital requirements increase the value of capital to surviving banks in a crisis. This in turn provides banks with incentives to invest in safer activities in order to increase the chance of surviving when other banks are failing (the "last bank standing" effect). A last-banking standing effect is also present in our model (it restrains banks' correlation incentives – but not sufficiently so) but in contrast to Martínez-Miera and Suarez it does not interact with capital requirements.

A second strand of the literature analyzes the incentives of banks to correlate with

[3] Recent literature also suggests that central banks may want to vary interest rates in an (effectively countercyclical) way in order to reduce the cost of financial crises (e.g., Diamond and Rajan (2011) and Freixas et al. (2011)).

[4] See Galati and Moessner (2011) for a general overview over macroprudential policies.

each other. In particular, it has been shown that inefficient correlation may arise from investment choices (e.g., Acharya and Yorulmazer (2007)), diversification (Wagner (2011) and Allen et al. (2012)), interbank insurance (Kahn and Santos (2010)) or through herding on the liability side (Segura and Suarez (2011), Stein (2012) and Farhi and Tirole (2012)). In Acharya and Yorulmazer (2007) regulators cannot commit not to bail out banks if they fail jointly. Anticipating this, banks have an incentive to invest in the same asset in order to increase the likelihood of joint failure. In contrast, the effect in our paper is not due to commitment problems and arises because there are benefits from letting capital requirements vary with the state of the economy. Another difference to Acharya and Yorulmazer (and most other papers on herding) is that correlation in the banking system – by itself – can be desirable as cycle-dependent capital requirements then reflect well the individual conditions of banks (by contrast, if banks' funding conditions are largely driven by idiosyncratic factors, varying capital requirements with the aggregate state provides limited benefits). Farhi and Tirole (2012) – like our paper – consider herding in funding choices. They show that when the regulator lacks commitment, bailout expectations provide banks with strategic incentives to increase their sensitivity to market conditions. While in Farhi and Tirole (as well as Acharya and Yorulmazer (2007)) bank choices are strategic complements, in our setting a bank gains from the insurance provided by countercyclical policies irrespective of what other banks do.

Our paper also relates to the long-standing literature on macroeconomic stabilization policies – as for example analyzed in the context of the textbook IS-LM model. This literature has focused on the ability of these policies to insulate the economy from (aggregate) shocks – taking as exogenous the risk exposures of firms (or banks) in the economy. Since stabilization policies reduce the cost of aggregate shocks in a similar way as countercyclical capital requirements, our paper suggests that they can have potentially undesired effects by changing the incentives of firms to expose themselves to the aggregate cycle.

The remainder of the paper is organized as follows. Section 2.1 sets up the model. Section 2.2 first solves for optimal capital requirements assuming that banks cannot independently modify their funding choices. Section 2.3 then considers the case where banks funding choices are endogenous. Section 3 analyzes commitment problems. Section 4 discusses the results and Section 5 concludes.

2 Model

2.1 Setup

There are two banks in the economy (bank A and B) and there are three dates. At date 0 each bank chooses a funding source (more on this later). At date 1 banks invest in projects and raise funds. Projects mature at date 2.

We start with the description of date 1. At this date, each bank has access to one project. A project requires one unit of funds at date 0 and pays off R at date 2 with probability p ($p \in (0,1)$) and zero otherwise. The opportunity cost of funds in the economy is one and projects have a positive expected value ($pR - 1 > 0$). Banks have access to a monitoring technology; if a bank chooses to monitor, the project's success rate increases by $\Delta p > 0$ ($p + \Delta p \leq 1$). There are (non-monetary) monitoring costs c per project. Monitoring is unobservable and we assume it to be cost-effective ($\Delta pR - c > 0$).

Banks can raise funds for project finance through a mix of equity and deposits. Deposits are fully insured; as a result depositors require a repayment of one independently of the risk profile of the bank. Banks have to pay a deposit insurance fee f per unit of deposits. This fee cannot condition on the monitoring decision but is set such that (in equilibrium) the deposit insurance fund breaks even (in expectation). The insensitivity of the deposit insurance fee to monitoring creates a role for regulation. In particular, we assume that $c > \Delta p(R - 1)$, so banks will not monitor if they are only deposit-financed – even though monitoring is socially desirable. The regulator can address this inefficiency by requiring banks to hold a minimum amount of capital k. Capital incurs an additional cost of $\rho > 0$ (relative to (fairly-priced) deposits); banks thus never hold capital in excess of this amount. In order to finance one project they will hence raise capital of k and deposits of $d = 1 - k$.

We add the following three elements to an otherwise standard setup. First, we assume that each bank's cost of capital at date 1 is variable. In particular, we assume that a bank's (net) cost (ρ^A or ρ^B) is uniformly distributed on $[0, 2\mu]$ with mean μ. Varying capital costs introduce a role for capital requirements that depend on the state of the economy. We assume that the support of the distribution is sufficiently large to obtain interior solutions for capital requirements (this is ensured by $2\mu > \frac{4}{3}\frac{\Delta pR - c}{\frac{c}{\Delta p} - (R-1)}$).

Second, we assume that with probability p_F a bank finds itself without access to funding at date 1 (or, equivalently, that funding costs are prohibitively high). In such a case, the bank cannot undertake its project. However, it can sell the project to the other bank – provided that this bank has access to funding. In that case, the acquiring bank can double its financing (raising equity of $2k$ and deposits of $2(1-k)$) to undertake the project. The funding shock introduces a systemic element in the analysis. In particular, a situation in which both banks turn out to be without funding becomes particularly costly since then no project can be undertaken (while in all other situations, both projects are undertaken).

Third, we assume that banks can influence the correlation of their funding conditions. At date 0, each bank can either choose a systemic funding source (common to both banks) or an alternative source (only available to this bank). This can be interpreted as banks investing in access to market funding[5] or specializing on retail financing (by building up a local base of investors). When both banks choose the systemic source, we assume that their date-1 capital costs as well as the funding shocks are perfectly correlated. In all other cases, they are uncorrelated. The banks' date-0 funding choices are summarized by Ψ, which is either $\{S, S\}$, $\{S, I\}$, $\{I, S\}$ or $\{I, I\}$ (S and I denote systemic and alternative funding, respectively). We allow the regulator to condition capital requirements on systemic funding costs (denoted by ρ^S) but not on a bank's individual funding condition. The possibility for banks to influence their funding costs adds an additional element to the regulator's problem. In particular, banks may respond to anticipated capital requirements by modifying their funding sources. This may constrain the regulator's ability to set optimal capital requirements.

Several comments are in order. While the model focuses on systemic risk on the funding side, we have chosen to do so mainly for analytical convenience. Similar effects arise if

[5] See Farhi and Tirole (2012) for examples how financial institutions can increase their exposure to market funding.

correlations arise on the asset side.[6] Furthermore, capital costs in our model are a cost to the economy (and not just a transfer from banks to equity holders). Such a cost arises when equity finance causes agency problems, or because there is a limited pool of bank capital (e.g., Holmström and Tirole (1997)), in which case capital holders may have different opportunity costs because of different investment opportunities or limited consumption smoothing. Finally, we associate fluctuations in the cost of bank capital with fluctuations in the overall state of the economy. In good times (expansions), informational asymmetries are limited and there is plenty of capital available to finance banks. The cost of raising capital is then low. Conversely, in bad times (recessions), capital costs will be high.[7]

Timing

The timing is as follows. At date 0 the regulator announces how date-1 capital requirements will bet set depending on the state of the economy. These capital requirements can be summarized by a function $k(\rho^S)$ (the special case of flat capital requirements arises when k does not depend on ρ^S). Following this, each bank chooses its funding type, S or I. At date 1, nature decides whether a bank has access to funding and capital costs realize. A bank without access to funding may sell its asset to the other bank and stops operating. Following this, each remaining bank raises equity $k(\rho^S)$ and deposits $1 - k(\rho^S)$ per project and pays the deposit insurance fee f per unit of deposits. After financing, banks decide whether or not to monitor. At date 2, projects deliver.

2.2 First best regulation

We first analyze optimal regulation assuming that the funding choice of banks can be set by the regulator at date 0 (together with the capital requirements). The solution to the regulator's problem hence comprises bank funding types Ψ and a policy rule $k(\rho^S)$. We solve the model by backward induction. We first analyze banks' monitoring decisions and

[6] In particular, our model is equivalent to a model where banks at date 0 can choose to invest in systemic or alternative projects that have uncertain funding needs (or uncertain interim pay-offs) at date 1.

[7] See Martínez-Miera and Suarez (2012) for an analysis for how bank capital and its cost fluctuate with the state of the economy.

the outcome in the market for bank projects at date 1. Next, we solve for the regulator's problem.

Monitoring decisions

At the final stage at date 1, banks have access to either zero, one or two projects. At this stage, also capital costs and capital requirements $k(\rho^S)$ are known. Banks without access to projects stop operating. Banks with projects raise capital $k(\rho^S)$ and deposits $1 - k(\rho^S)$ per project.[8]

The expected (per-project) pay-off for a bank with funding costs ρ with monitoring ($M = 1$) and without monitoring ($M = 0$) is given by

$$\pi|_{M=1} = (p + \Delta p)[R - (1 - k)] - (1 + \rho)k - (1 - k)f - c \quad \text{with monitoring,} \tag{1}$$

$$\pi|_{M=0} = p[R - (1 - k)] - (1 + \rho)k - (1 - k)f \quad \text{without monitoring.} \tag{2}$$

The first term in (1) and (2) is the expected project return net of repayments to depositors in the case of success. The second term is the cost of raising capital, the third is the deposit insurance fee f (which is insensitive to the monitoring decision) times the amount of deposit financing $d = 1 - k$. The final term in (1) is the (per-project) monitoring cost c.

Comparing the two expressions we find that the expected payoff is lower without monitoring whenever capital $k < \overline{k}$, with

$$\bar{k} := \frac{c}{\Delta p} - (R - 1). \tag{3}$$

Thus, for $\bar{k} < k$, the bank will not monitor its projects, while for $\bar{k} \geq k$ it will monitor all its projects. Note that $\overline{k}$ does not depend on a bank's capital cost ρ. Note also that from the assumptions on positive NPV and cost-effective monitoring we have $\overline{k} \in (0, 1)$.

Project transfers

At this stage of date 1, funding shocks are realized. A bank that finds itself without access to funding can sell its project to the other bank. This is only feasible if the other bank has

[8] We assume that (at given capital requirements) banks find it optimal to invest. This assumption is not essential since a regulator would never find it optimal to set capital requirements such that banks do not invest (such capital requirements would be dominated by setting zero capital requirements).

access to capital. In that case both supply and demand for the project are fully inelastic for a range of prices (the bank without funding is willing to sell the asset for any non-negative price, while the acquiring bank is willing to purchase the asset for any price up to a threshold). We eliminate multiple equilibria by assuming that the takeover occurs at a price of zero (as we discuss later, this is not essential for the results). There are thus three outcomes: i) both banks have access to funding and hence no project is transferred, ii) only one bank has access to funding in which case it acquires the project from the other bank at a price of zero, iii) no bank has access to funding in which case no project is transferred and no project can be financed.

The regulator's problem

The regulator maximizes (utilitarian) welfare W in the economy, consisting of the sum of the pay-offs to bank owners, depositors, capital providers and the deposit insurance fund. Welfare is thus equal to the expected surplus from undertaking projects in the economy.

The expected surplus on an individual project – conditional on being undertaken – is:

$$W^S = \mathrm{E}\left[(p + M\Delta p)R]\right] - 1 - \mathrm{E}[\rho^S k] - \mathrm{E}[Mc] \qquad \text{with systemic funding,} \tag{4}$$

$$W^I = \mathrm{E}\left[(p + M\Delta p)R\right] - 1 - \mathrm{E}[\rho^I k] - \mathrm{E}[Mc] \qquad \text{with alternative funding.} \tag{5}$$

The surplus consists of the expected return on the project, $\mathrm{E}\left[(p + M\Delta p)R\right]$, minus the opportunity cost of one unit of funds in the economy, 1, minus the extra cost from raising bank capital, $\mathrm{E}[\rho^S k]$, minus monitoring costs, $\mathrm{E}[Mc]$. The deposit insurance fee f does not appear in this equation since it is a transfer between bank owners and the deposit insurance fund and hence does not affect the economy's surplus.

Total welfare is then the product of the surpluses on each undertaken project and the expected number of projects. In the case $\{I, I\}$ projects are either undertaken if no bank receives the funding shock (this occurs with probability $(1 - p_F)^2$) or if one of the banks receives the funding shock (occurring with probability $2(1 - p_F)p_F$). In each of these cases two alternative projects can be financed, thus total expected surplus in the economy is $2(1 - p_F)^2 W^I + 4(1 - p_F)p_F W^I$. In the cases $\{S, I\}$ and $\{I, S\}$ the probability of projects being funded is the same as for $\{I, I\}$. However, in each case where funding takes place, now one alternative and one systemic project gets funded. Total surplus is then $(1-p_F)^2(W^S+W^I)+2(1-p_F)p_F(W^S+W^I)$. Finally, in the case of systemic funding at both banks ($\{S,S\}$), projects are only funded if the systemic funding shock does not arrive. The probability of this is $1-p_F$ and hence total surplus is $2(1-p_F)W^S$.

Summarizing, we hence have that welfare under the various funding choices is given by:

$$W^{\{I,I\}} = 2(1-p_F)^2W^I + 4(1-p_F)p_FW^I \tag{6}$$

$$W^{\{S.I\}} = W^{\{I,S\}} = (1-p_F)^2(W^S+W^I) + 2(1-p_F)p_F(W^S+W^I) \tag{7}$$

$$W^{\{S,S\}} = 2(1-p_F)W^S. \tag{8}$$

Welfare may differ across the cases, first, because the expected number of projects financed differs. In particular, in the case of correlated funding, only $2(1-p_F)$ projects are financed in expectation, while in all other cases the expected number of projects undertaken is $2(1-p_F)^2+4(1-p_F)p_F = 2(1-p_F)(1+p_F)$. Second, the expected surpluses for projects with systemic and alternative finance may differ ($W^S \neq W^I$) because the expected cost of raising capital in accordance with regulatory requirements ($\mathrm{E}[\rho^S k]$ and $\mathrm{E}[\rho^I k]$) may not be the same.

Notice that alternative funding at both banks ($\{I,I\}$) is (weakly) welfare dominated by a situation with systemic funding at one bank and alternative funding at another bank ($\{S,I\}$ or $\{I,S\}$). The expected number of undertaken projects is the same in either situation but in the latter case more projects with systemic funding are undertaken. Such projects have at least as high a surplus as alternative projects – given that the regulator can vary capital requirements with the funding costs. Hence, welfare is higher (from $W^S \geq W^I$, we have that $W^{\{S.I\}} = W^{\{I,S\}} \geq W^{\{I,I\}}$). Note also that the cases of $\{S,I\}$ and $\{I,S\}$ are fully symmetric. In searching for optimal funding choices we can hence constrain ourselves to comparing the case of $\{S,S\}$ (correlated funding) and $\{S,I\}$ (mixed funding).

We first solve for the welfare-maximizing policy function, $k^*(\rho^S)$, for given funding choices ($\{S,S\}$ or $\{S,I\}$).

Proposition 1 *Optimal capital requirements take the form*

$$k^*(\rho^S) = \begin{cases} \bar{k} & \text{if } \rho^S \leq \hat{\rho}^* \\ 0 & \text{otherwise,} \end{cases} \tag{9}$$

where $\hat{\rho}^*$ *is given by*

$$\hat{\rho}^* = \begin{cases} \hat{\rho}^{\{S,S\}^*} = \frac{\Delta pR - c}{\bar{k}} & \text{if } \Psi = \{S,S\} \text{ (correlated funding)} \\ \hat{\rho}^{\{S,I\}^*} = 2\frac{\Delta pR - c}{\bar{k}} - \mu & \text{if } \Psi = \{S,I\} \text{ (mixed funding).} \end{cases} \tag{10}$$

Proof. *Observe first that* $k \in (0, \bar{k})$ *or* $k > \bar{k}$ *is never optimal as in either case the regulator can lower capital requirements (and thus the cost of capital to banks) without reducing monitoring. The regulator hence only has to consider two levels of capital requirements:* $k = 0$ *and* $k = \bar{k}$*. It is easy to see that it is optimal to set* $k = \bar{k}$ *if* ρ^S *is smaller than a certain threshold, say* $\hat{\rho}$*, and relax capital requirements otherwise. Consider first correlated funding* ($\Psi = \{S,S\}$)*. In this case, only systemic projects are undertaken (when no project is undertaken, capital requirements are irrelevant). The surplus from undertaking two systemic projects with* $k = 0$ *and* $k = \bar{k}$ *is* $2W^S\big|_{k=0} = 2(pR-1)$ *and* $2W^S\big|_{k=\bar{k}} = 2((p+\Delta p))R - 1 - \widehat{\rho}\bar{k} - c)$*, respectively. Equating these expressions and solving for* $\widehat{\rho}$ *we find that the critical capital cost that makes it optimal to set* $k = \bar{k}$ *(and hence to induce effort) is* $\hat{\rho}^{\{S,S\}^*} = \frac{\Delta pR - c}{\bar{k}}$*. Consider next mixed financing* ($\Psi = \{S,I\}$)*. Then, whenever projects are financed in the economy, one systemic and one alternative project are undertaken. The respective surpluses without and with capital are then* $W^S\big|_{k=0} + W^I\big|_{k=0} = 2(pR-1)$ *and* $W^S\big|_{k=\widehat{k}} + W^I\big|_{k=\widehat{k}} = 2((p+\Delta p)R - 1 - \frac{\widehat{\rho}+\mu}{2}\bar{k} - c)$*, where we have used that* $E[\rho^I] = \mu$*. We hence obtain for the critical threshold that* $\hat{\rho}^{\{S,I\}^*} = 2\frac{\Delta pR - c}{\bar{k}} - \mu$*. Note that the solutions are interior (*$\widehat{\rho}^* \in (0, 2\mu)$*) by the assumption on the cost effectiveness of monitoring (*$\Delta pR - c > 0$*) and the assumption on the support of the distribution (*$2\mu > \frac{4}{3}\frac{\Delta pR - c}{\frac{c}{\Delta p} - (R-1)}$*).* ■

Proposition 1 implies that optimal regulation is countercyclical: when the economy is in a good state (and capital costs are low), it is optimal to set high capital requirements. Conversely, in bad states when capital is costly, it is optimal to set low (zero) capital requirements.

Corollary 1 *Optimal regulation is countercyclical (that is, $Cov(k^*(\rho^S), \rho^S) < 0$).*

Proof. *We have that* $Cov(k^*(\rho^S), \rho^S) = \frac{\bar{k}}{2\mu}\int_0^{\widehat{\rho}^*}(\rho^S - \mu)d\rho^S = \frac{\widehat{\rho}^*\bar{k}}{2\mu}(\frac{\widehat{\rho}^*}{2} - \mu) < 0$ *for* $\widehat{\rho}^* \in (0, 2\mu)$. ■

The intuition is straightforward: while the benefits from monitoring are independent of the state, the cost of inducing monitoring are higher in bad states of the world when capital is costly.

Proposition 1 also shows that the state of the economy where it is optimal to lower capital requirements depends on the funding choices of banks (except for the special case of $\frac{\Delta pR-c}{k} = \mu$ where we have that $\hat{\rho}^{\{S,S\}^*} = \hat{\rho}^{\{S,I\}^*}$). This has the following implications for countercyclicality:

Corollary 2 *The efficient degree of countercyclicality is lower under mixed funding than under correlated funding if* $\frac{\Delta pR-c}{k} \neq \mu$.

Proof. *From* $Cov(k^*(\rho^S), \rho^S) = \frac{\bar{k}}{2\mu}\widehat{\rho}^*(\frac{\widehat{\rho}^*}{2} - \mu)$ *(see proof of Corollary 1) we have that the covariance* $Cov(k^*(\rho^S; \hat{\rho}), \rho^S)$ *attains its minimum at* $\hat{\rho} = \mu$ *and is a monotonous function on the intervals* $[0, \mu]$ *and* $[\mu, 2\mu]$. *The corollary then follows from the fact that for* $\hat{\rho}^{\{S,S\}^*} < \mu$ *we have* $\hat{\rho}^{\{S,I\}^*} < \hat{\rho}^{\{S,S\}^*}$ *and that for* $\hat{\rho}^{\{S,S\}^*} > \mu$ *we have* $\hat{\rho}^{\{S,I\}^*} > \hat{\rho}^{\{S,S\}^*}$.
■

The reason for this is that countercyclical capital requirements reduce average funding costs only at one of the banks under mixed funding (the one with systemic funding). Thus, the gains from countercylicality are lower and hence it is optimal to provide less of it.

Proposition 1 states the optimal policy rule for given funding choices. The optimal funding choice can then be found by comparing the welfare levels that attain under either funding choice, presuming that the regulator implements the respective policy rules as in Proposition 1.

In order to obtain an intuition for the determinants of the optimal funding choice, let us presume for a moment that the regulator imposes the same policy rule – characterized by a threshold $\widehat{\rho} \in (0, 2\mu)$ – under either type of funding. In this case we obtain from comparing (7) and (8) that systemic funding provides higher welfare than mixed funding if and only if

$$W^S(\widehat{\rho}) - W^I(\widehat{\rho}) > p_F(W^S(\widehat{\rho}) + W^I(\widehat{\rho})). \tag{11}$$

The term $W^S(\widehat{\rho}) - W^I(\widehat{\rho})$ represents the gains from correlated funding, arising because under correlated funding one more project is financed with systemic funding instead of alternative funding. From (4) and (5) we have that

$$W^S(\widehat{\rho}) - W^I(\widehat{\rho}) = \mathrm{E}[\rho^I k] - \mathrm{E}[\rho^S k] = -Cov(k(\widehat{\rho}), \rho^S), \tag{12}$$

which is strictly positive whenever the policy rule is countercyclical. The source of these gains is that under countercyclical capital requirements systemic projects have lower expected funding costs as capital requirements then tend to be low when capital is costly.

The term $p_F(W^S(\widehat{\rho}) + W^I(\widehat{\rho}))$ is the cost of correlated funding. It arises because when one bank moves from alternative to systemic funding (and the other bank already uses systemic funding), projects can no longer be transferred if a funding shock arrives at either bank. This reduces welfare in the case where the alternatively financed bank could previously continue the asset of the systemically financed bank (the cost of this are $p_F W^S$ in expected terms). Additionally, it also leads to losses in the case where the systemic bank continued the asset of the alternative bank. The expected costs from the latter are $p_F W^I$, bringing the total expected cost of systemic funding to $p_F W^S + p_F W^I$.

When the regulator also optimally sets capital requirements under either type of funding, additional effects occur because the optimal policy rule depends on the funding choice. From equations (7) and (8) we then have that the benefits from correlated funding are higher when

$$2E[W^S(\hat{\rho}^{\{S,S\}^*})] > (1 + p_F)E[W^S(\hat{\rho}^{\{S,I\}^*}) + W^I(\hat{\rho}^{\{S,I\}^*})]. \tag{13}$$

Proposition 2 *Correlated funding is optimal if and only if*

$$p_F < \frac{2(\Delta pR - c) - \frac{(\Delta pR - c)^2}{\mu \bar{k}} - \frac{\mu \bar{k}}{2}}{4(pR - 1) - 2(\Delta pR - c) + 2\frac{(\Delta pR - c)^2}{\mu \bar{k}} + \frac{\mu \bar{k}}{2}} \tag{14}$$

Proof. *See Appendix.* ■

Condition (14) implies that the net gains from correlated funding are higher when the likelihood of a funding shock, p_F, is low. This is – as discussed before – because the cost of correlated funding arise due to the fact that project transfers in the event of a funding shock are no longer possible.

2.3 Optimal capital requirements when correlation choices are private

We now assume that the regulator cannot control the funding choice of banks. The consequence is that the funding choices have to be privately optimal for banks at date 0. Specifically, at date 0 the regulator announces the policy rule $k(\rho^S)$ and following this banks make funding choices Ψ. We constrain the analysis of the policy rule to step functions as in (9) with a threshold $\widehat{\rho} \in (0, 2\mu)$ and we solve the model again backwards.

Monitoring decisions and project transfers

Date 1 is unchanged. Banks continue to monitor if and only if capital requirements are sufficiently high ($k \geq \bar{k}$). In addition, if one bank cannot raise funds but the other can, the latter bank takes over the project.

Banks' funding choices

In the second stage of date 0 banks choose their source of funding, taking as given the policy rule $k(\rho^S)$. We assume that banks play Nash – that is, each bank chooses the funding source that maximizes its expected profit taking as given the funding choice of the other bank. We focus on pure strategies.

A bank's total expected profit depends both on the expected number of projects that can be undertaken as well as the expected profits from undertaking a project. The latter are:

$$\pi^S = \mathrm{E}[(p + M\Delta p)(R - (1-k))] - \mathrm{E}[(1+\rho^S)k] - \mathrm{E}[Mc] - (1-k)f \quad \text{with systemic funding,} \tag{15}$$

$$\pi^I = \mathrm{E}[(p + M\Delta p)(R - (1-k))] - \mathrm{E}[(1+\rho^I)k] - \mathrm{E}[Mc] - (1-k)f \quad \text{with alternative funding.} \tag{16}$$

Note that profit differs from the social surplus (equations (4) and (5)) because a bank does not internalize the expected cost to the deposit insurance, $(1 - \mathrm{E}[p + M\Delta p])(1-k)$ but also because banks have to pay the deposit insurance fee f. However, since the deposit insurance fee is fairly priced in expectation, these effects cancel from the perspective of date 0. In particular, we have that the fee is equal to the expected loss to the deposit insurance fund: $f = 1 - \mathrm{E}[p + M^*\Delta p]$ (where M^* denotes the equilibrium date-1 monitoring choice). From this it follows that $\pi^S(M^*) = W^S$ and $\pi^I(M^*) = W^I$.

We derive next a bank's total expected profit under the four possible funding outcomes ($\{S,S\}$, $\{S,I\}$, $\{I,S\}$ and $\{I,I\}$). Note first that profits are zero whenever the bank receives the funding shock. We can hence focus on comparing expected profits conditional on funding being available to the bank. Table 1 summarizes these pay-offs from the perspective of bank A (the payoffs of bank B are the transpose of the payoff matrix of bank A). When both banks have chosen systemic funding, bank A's expected profit is π^S. This is because in this case bank B does not receive the funding shock as well and hence no transfer of projects occurs. When bank A has alternative funding in place (while bank B has chosen systemic funding), bank B will receive the funding shock with probability p_F, in which case bank A can finance an additional project. The expected gains are hence $(1 + p_F)\pi^I$. Similarly, in the cases where bank B has chosen alternative funding, the expected profits for bank A are $(1+p_F)\pi^S$ if itself it has chosen systemic funding and $(1+p_F)\pi^I$ otherwise.

From Table 1 we can derive the equilibrium funding choices for a given policy rule. Note first that alternative funding at both banks ($\{I,I\}$) cannot be an equilibrium. This is because either bank could then increase its pay-off by switching to systemic funding. Table 1 shows that expected profit changes by $(1+p_F)\pi^S - (1+p_F)\pi^I = (1+p_F)(-Cov(k(\widehat{\rho}), \rho^S))$ in this case; which is positive for $\widehat{\rho} \in (0, 2\mu)$. Thus, in any equilibrium at least one bank

		Bank A	
		Systemic	Alternative
Bank B	Systemic	π^S	$(1+p_F)\pi^I$
	Alternative	$(1+p_F)\pi^S$	$(1+p_F)\pi^I$

Table 1: Expected payoffs of bank A conditional on obtaining funding.

will choose systemic funding and we assume without loss of generality that this is bank B. From Table 1 we have then that it is optimal for bank A to choose systemic funding as well iff $\pi^S > (1+p_F)\pi^I$. Using that $\pi^S = W^S$ and $\pi^I = W^I$, and rearranging we obtain for this condition at a given policy rule $\widehat{\rho}$:

$$W^S(\widehat{\rho}) - W^I(\widehat{\rho}) > p_F W^I(\widehat{\rho}). \tag{17}$$

The left hand side of this expression is the benefit from choosing systemic funding, equal to $-Cov(k, \rho^S)$, as before. It arises because under systemic funding the bank can benefit from the countercyclicality of capital requirement which reduces its average capital costs. The right-hand side is the cost from systemic funding. This cost is due to the bank losing the possibility to purchase the asset of the other bank when it fails.[9]

From the above condition one can derive the condition for when banks choose correlated funding and when not.

Proposition 3 *For a given policy rule (represented by a threshold value $\widehat{\rho}$), banks choose correlated funding if and only if*

$$p_F < \frac{\frac{\hat{\rho}}{2\mu}\overline{k}(\mu - \frac{\hat{\rho}}{2})}{pR - 1 + \frac{\hat{\rho}}{2\mu}(\Delta pR - c - \mu\overline{k})}. \tag{18}$$

Proof. See Appendix. ∎

[9] This is akin to the "last bank standing" effect in Perotti and Suarez (2002) that makes banks' risk choices strategic substitutes. Note that we have assumed that the surplus in asset transfers goes to the acquiring bank. If, on the other hand, it goes to the failing bank, similar cost of systemic funding arises because a bank is then no longer able to sell projects to the other bank.

The numerator in (18) represents the benefits from systemic funding arising because it lowers average capital costs for a bank. This can be appreciated by noting that the probability of capital requirements being imposed is given by $\frac{\hat{\rho}}{2\mu}$ and the average capital costs per unit of capital are μ under alternative funding, while they are only $\frac{\hat{\rho}}{2}$ under systemic funding.

Comparing equation (17) with the condition for the social optimality of correlated funding for a given policy rule (equation (11)), we see that the conditions differ because of the additional term $p_F W^S(\widehat{\rho})$ in (11). This term arises because if bank A becomes systemic, bank B loses the possibility of acquiring the project of bank A (as funding shocks are then fully correlated). As such situations arise with probability p_F, the expected cost for bank B is $p_F W^S(\widehat{\rho})$. Since this effect is not internalized by bank A, the condition for private optimality of correlated funding is less strict than the social one.[10] This leads us to the following corollary:

Corollary 3 *For a given policy rule, banks may choose correlated funding even though mixed funding is optimal. This occurs when condition (11) is not fulfilled but condition (17) is fulfilled.*

From this it follows that there are situations where the first best is no longer attainable. These are situations where the first best requires mixed funding (equation (14) is not fulfilled) but given the first best policy function for mixed funding $\hat{\rho}^{\{S,I\}^*}$, banks choose correlated funding:

Corollary 4 *The first best outcome may no longer be attainable. This occurs when condition (14) is not fulfilled but condition (18) is fulfilled at $\widehat{\rho} = \widehat{\rho}^{\{S,I\}^*}$.*

[10] Excessive correlation arises in our analysis from an interbank externality due to market incompleteness. The externality is analogous to a fire-sale externality (e.g., Lorenzoni (2008)) where the funding position of one bank affects other banks because of the possibility to acquire assets when forced liquidations take place. It is also important to notice that the externality does not depend on who gets the surplus from project transfers. For example, when the surplus goes to the selling bank, the externality arises because when a bank moves to systemic funding it no longer can acquire the project of the other bank (thus posing an externality to the seller of the project).

The regulator's problem

If the conditions in Corollary 4 are not satisfied, the first best outcome is attainable even when the regulator cannot control banks' funding choices. In this case, the optimal funding decision is still determined by the condition in Proposition 2 and the corresponding capital requirements are given by Proposition 1. We next analyze the case where the regulator is constrained by banks' private funding incentives. That is, the first best stipulates mixed funding but under the optimal policy rule for mixed funding ($\widehat{\rho}^{\{S,I\}^*}$) banks would choose high correlation. The regulator is hence left with two choices: either she implements a policy rule where banks choose correlated funding, or she adjusts the policy rule such that a mixed funding equilibrium arises.

Consider first that the regulator implements correlated funding. In this case banks' funding choices do not constrain the optimal policy rule (since by Corollary 3 banks have a bias towards correlated funding). The regulator can hence set the threshold to $\widehat{\rho}^{\{S,I\}^*}$. Consider next that the regulator chooses to implement low correlation (mixed funding). In this case, the regulator is constrained by banks' funding choices, that is, condition (18) will hold with equality. The optimal policy rule given this constraint, denoted $\hat{\rho}^{\{S,I\}^c}$, will hence differ from the first best one for mixed funding ($\hat{\rho}^{\{S,I\}^*}$).

Thus, the only difference to the welfare comparison for the first best is that the policy rule for mixed funding is $\hat{\rho}^{\{S,I\}^c}$ (the policy rule at which equation (18) binds) instead of $\hat{\rho}^{\{S,I\}^*}$. We hence obtain (similar to equation (13)) that correlated funding is optimal if and only if

$$2E[W^S(\hat{\rho}^{\{S,S\}^*})] > (1+p_F)E[W^S(\hat{\rho}^{\{S,I\}^c}) + W^I(\hat{\rho}^{\{S,I\}^c})]. \tag{19}$$

Explicit solutions are no longer attainable, but it can still be shown that for small p_F correlated funding is optimal, while for large p_F mixed funding is optimal.

Proposition 4 *Assume that the first best is not attainable (that is, the conditions in Corollary 4 are met). Then*

(i) for sufficiently small p_F the optimal policy rule is $\widehat{\rho}^{\{S,S\}^*} = \frac{\Delta pR-c}{k}$ and banks choose correlated funding;

(ii) for sufficiently large p_F the optimal policy rule is

$$\hat{\rho}^{\{S,I\}^c} = \begin{cases} \mu(1+p_F) - \frac{p_F(\Delta pR-c)}{\bar{k}} + \sqrt{\left(\mu(1+p_F) - \frac{p_F(\Delta pR-c)}{\bar{k}}\right)^2 - 4\mu\frac{p_F(pR-1)}{\bar{k}}} & \text{if } \frac{\Delta pR-c}{\bar{k}} - \mu > 0 \\ \mu(1+p_F) - \frac{p_F(\Delta pR-c)}{\bar{k}} - \sqrt{\left(\mu(1+p_F) - \frac{p_F(\Delta pR-c)}{\bar{k}}\right)^2 - 4\mu\frac{p_F(pR-1)}{\bar{k}}} & \text{otherwise} \end{cases} \tag{20}$$

and banks choose mixed funding.

Proof. *See Appendix.* ■

The optimal policy rule under mixed funding, $\hat{\rho}^{\{S,I\}^c}$, implies less countercyclicality than the first best one:

Corollary 5 *If a constrained policy maker wants to implement mixed funding, she has to reduce countercyclicality relative to the first best ($-Cov(k(\hat{\rho}^{\{S,I\}^c}), \rho^S) < -Cov(k(\hat{\rho}^{\{S,I\}^*}), \rho^S)$).*

Proof. Follows from comparing $\hat{\rho}^{\{S,I\}^c}$ and $\hat{\rho}^{\{S,I\}^*}$. ■

The reason for this is – as explained before – that banks' incentives to choose systemic funding are increasing in countercyclicality. Thus, in order to induce mixed funding, a constrained regulator has to lower countercyclicality.

3 The role of credibility

The previous section relaxed the assumption that the regulator can control funding choices. In this section we relax in addition the assumption that the regulator can commit to a policy rule. For this we assume that the regulator decides about the policy rule at the same time when banks choose their funding source; specifically, the regulator and the two banks play Nash at date 0. This is a modification to the timing of actions that neither changes private nor social pay-offs.

As discussed in the previous section, any Nash-equilibrium will either involve both banks choosing systemic funding (correlated funding) or one bank choosing systemic and the other one alternative funding (mixed funding). The regulator's best response to either of these two outcomes is the first-best policy of Section 2.2. Thus, she sets $\hat{\rho}^{\{S,S\}^*} = \frac{\Delta pR-c}{\bar{k}}$

if banks haven chosen correlated funding and $\hat{\rho}^{\{S,I\}^*} = 2\frac{\Delta pR-c}{\bar{k}} - \mu$ in the case of mixed funding. In order for correlated funding to be a Nash-equilibrium we hence have to check whether correlated funding is an optimal response to $\hat{\rho}^{\{S,S\}^*}$. Similarly, in order for mixed funding to be an equilibrium we need that it is an optimal response to $\hat{\rho}^{\{S,I\}^*}$.

Consider first the case where the first best is attainable under commitment (that is, the conditions of Corollary 4 do not hold). In this case, banks do not have an incentive to deviate from a first-best policy rule ($\hat{\rho}^{\{S,S\}^*}$ or $\hat{\rho}^{\{S,I\}^*}$). Hence, correlated funding is an optimal response to $\hat{\rho}^{\{S,S\}^*}$ and mixed funding an optimal response to $\hat{\rho}^{\{S,I\}^*}$. Thus, the first best outcome is still an equilibrium (there may be other equilibria as well, but we rule out such equilibria because they will be welfare dominated).

Consider next the case where the first best is not attainable under commitment (the conditions in Corollary 4 hold). In this case banks find it optimal to deviate from the first-best policy for mixed funding. There is hence no equilibrium with mixed funding and we only have the correlation equilibrium in which the regulator chooses $\hat{\rho}^{\{S,S\}^*}$.

We summarize

Proposition 5 *Lack of commitment changes the equilibrium if and only if the policy maker is constrained and finds it optimal to implement mixed funding under commitment. In this case the new equilibrium is given by the policy rule* $\hat{\rho}^{\{S,S\}^*}$ *and banks choose correlated funding.*

The proposition shows that without commitment, the equilibrium sometimes involves correlated funding – even when the second-best under commitment stipulates mixed funding (the reverse cannot occur). In these cases, welfare is further reduced since the regulator can no longer implement the second-best policy of the previous section. The costs of countercyclical policies due to systemic risk-taking are thus amplified when the regulator lacks commitment.

4 Discussion

Countercyclical capital requirements versus ex ante measures to control systemic risk Our model suggests that if tools are available that can directly influence the correlation choices of banks,[11] they are to be preferred over countercyclical measures. This is because reducing correlation has two benefits. First, it lowers the likelihood that worthwhile projects in the economy can no longer be financed, essentially mitigating a *credit crunch*. Second, it reduces the sensitivity of banks' funding conditions (and hence profits) to the aggregate state of the economy, and in that sense lowers procyclicality. Countercyclical capital requirements, in contrast, have the cost of increasing correlation risk – as we have shown. Perversely, they can even increase sensitivity of the economy to aggregate conditions as higher correlation means that funding conditions depend more on the aggregate state (it is easy to see that this occurs when the regulator sets the extent of countercyclicality such that condition (18) is fulfilled).

Bank-specific capital requirements The cost of countercyclical policies (in the form of higher correlation) could be avoided entirely if capital requirements can be made contingent on individual bank's funding conditions (ρ^A and ρ^B). In this case regulators can isolate banks against fluctuations in their own costs and there is hence no longer an incentive for them to increase exposure to the aggregate state. In fact, in such a situation banks would always choose alternative investments as this provides them with the possiblity of acquiring assets from the other bank. However, such capital requirements do not seem attractive for several reasons. First, they have high informational requirements as the regulator then needs to observe individual bank conditions. Second, there are issues of inequality and competition as weaker banks would be automatically subjected to looser regulation. Third, it creates obvious moral hazard problems to the extent that banks can influence their funding conditions.

[11] Examples of such tools include capital requirements based on measures of banks' systemic importance, such as the CoVar (Adrian and Brunnermeier, 2011) or the Systemic Expected Shortfall (Acharya et al., 2012).

Cross-border banks The current proposal for Basel III includes macroprudential policies that are to be carried out at the country-level. Our analysis suggests that this may have unintended effects. In particular, it may cause a retrenchment of internationally operating banks, leading to a greater focus on their respective home countries. This is because when countercyclical macroprudential policies condition on the state of the domestic economy, operating a branch in another country imposes a cost to a bank that is similar to the one that arises from alternative funding in our model: a bank risks that the foreign country is in a recession while the domestic economy is doing well, in which case it would be subjected to high capital requirements at times of high funding costs. Macroprudential policies at the country-level may thus reduce the incentives to operate internationally.

Managerial Herding The mechanism that leads to higher correlation in our model (arising because countercyclical policies reduce expected costs at banks) is only one possible one. For instance, countercyclical policies may also be conducive to managerial herding. This is because such policies make it more likely that following alternative strategies results in underperformance relative to peers as the manager then cannot benefit from the smoothing of performance enjoyed by banks that follow correlation strategies.

Countercyclical Policies in Developing Countries Our analysis suggests a positive relation between the extent to which regulators use macroprudential tools to offset economic fluctuations and the extent to which banks correlate with each other. While with the exception of Spain, capital requirements have not been consistently used for macroprudential purposes, Federico et al. (2012) show that many developing countries have made active use of reserve requirements over the business cycle. Defining countercyclicality as the correlation of reserve requirements with GDP, they find that the majority of these countries used reserve requirements in a countercyclical fashion.

Figure 1 plots their measure of countercyclicality against the average pairwise correlation of banks in the respective countries.[12] Consistent with theory, we indeed observe

[12] Correlations are calculated based on the weekly stock returns of all listed banks in the year prior to September 2012. Six countries had to be dropped due to an insufficient number of listed banks.

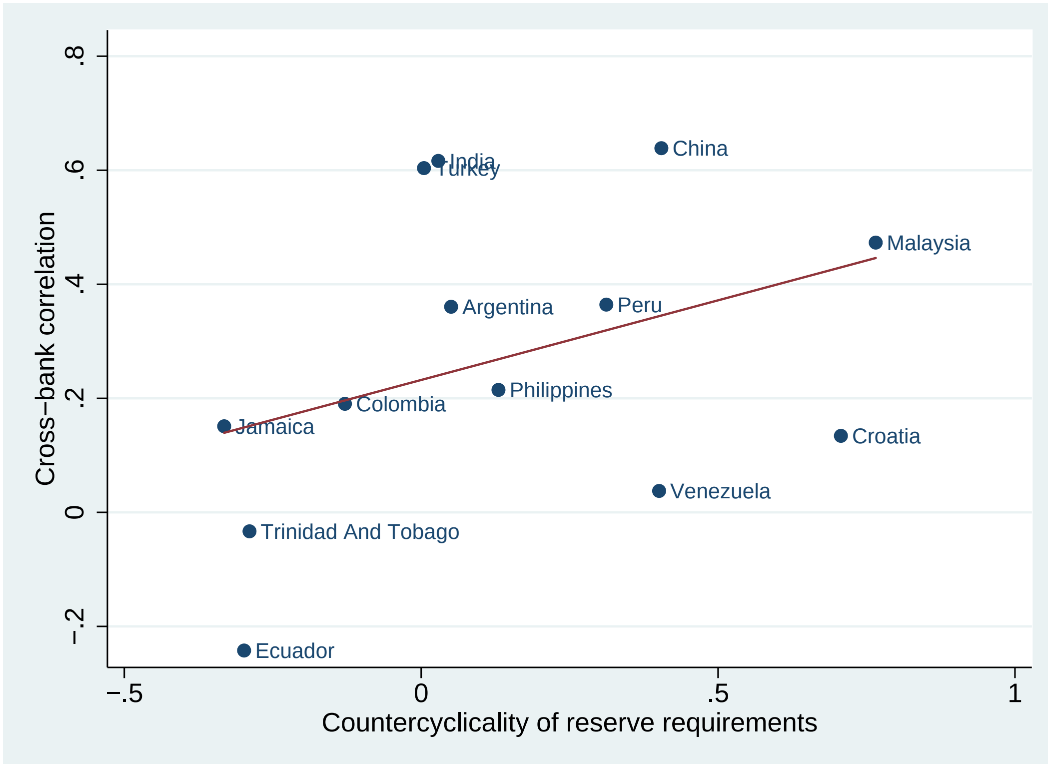

Figure 1: Countercyclicality of reserve requirements is the correlation between the cyclical component of reserve requirements and real GDP (source: Federico et al. (2012)). Cross-bank correlation is the average pairwise correlation of banks using weekly stock returns from September 2011 to September 2012.

a positive relationship between countercyclicality and bank correlation: the correlation coefficient is 0.38 (albeit insignificant due to the small number of observations).

5 Conclusion

We have developed a simple model in which there is a rationale for regulation in reducing the impact of shocks on the financial system. In addition, in this model aggregate risk is endogenous since banks can influence the extent to which they correlate with each other. We have shown that countercyclical macroprudential capital requirements – while reducing the impact of shocks on the economy ex-post – provide banks with incentives to become more correlated ex-ante. This is because such capital requirements lower a bank's cost from exposure to aggregate risk – but not the cost arising from taking on idiosyncratic risks. The overall welfare implications of countercyclical policies are hence ambiguous and it may be optimal to limit the extent of countercyclicality.

Our results have important consequences for the design of macroprudential policies. First, policy makers typically view different macroprudential tools in isolation: there are separate policies for dealing with procyclicality (e.g., countercyclical capital requirements) and correlation risk (e.g., higher capital charges for Systemically Important Financial Institutions as under Basel III). Our analysis suggests that there are important interactions among these tools. In particular, policies that mitigate correlation are a substitute for countercyclical policies since lowering correlation also means less procyclicality (while the reverse is not true). This suggests that if regulators prefer to employ a single policy instrument (for political or for practical reasons), they should focus on reducing cross-sectional risk rather than on implementing countercyclical measures.

Second, Basel III envisages countercyclical capital buffers that are imposed when (national) regulators deem credit expansion in their country excessive.[13] Such discretionary buffers create a new time-inconsistency problem since a regulator will always be tempted to lower capital requirements in bad times, while it will be difficult for regulators to withstand pressure and raise capital requirements in boom times. Our analysis suggests in that context that providing domestic regulators with the option to modify capital requirements during the cycle may be counterproductive for the objective of containing systemic risk as it may increase banks' correlation incentives.

Finally, while our model considers capital requirements as policy tool, any alternative policy that smooths the impact of aggregate shocks will likewise suffer from the problem that it increases correlation incentives in the economy. Our argument hence applies to a wide range of policies, ranging from countercyclical liquidity and reserve requirements, suspension of mark-to-market pricing in times of stress to general macroeconomic stabilization policies (such as interest rate smoothing by the central bank).

[13] BCBS (2010) and Drehmann et al. (2011) recommend the buffer be linked to the gap between the credit-to-GDP ratio of a country and its trend. Repullo and Saurina (2011) warn that overreliance on such measures can lead to increased procyclicality because of imperfections in the credit-to-GDP gap measure.

Appendix

Proof of Proposition 2. From (4) and (5) we have that

$$W^S(\hat{\rho}^{\{S,S\}^*}) = pR - 1 + \frac{\hat{\rho}^{\{S,S\}^*}}{2\mu}(\Delta pR - c - \frac{\hat{\rho}^{\{S,S\}^*}}{2}\overline{k}), \tag{A1}$$

$$W^S(\hat{\rho}^{\{S,I\}^*}) = pR - 1 + \frac{\hat{\rho}^{\{S,I\}^*}}{2\mu}(\Delta pR - c - \frac{\hat{\rho}^{\{S,I\}^*}}{2}\overline{k}), \tag{A2}$$

$$W^I(\hat{\rho}^{\{S,I\}^*}) = pR - 1 + \frac{\hat{\rho}^{\{S,I\}^*}}{2\mu}(\Delta pR - c - \mu\overline{k}). \tag{A3}$$

Inserting into condition (13) and solving for p_F yields (14). ■

Proof of Proposition 3. Rearranging equation (17), we obtain $p_F < \frac{W^S(\widehat{\rho})-W^I(\widehat{\rho})}{W^I(\widehat{\rho})}$. Writing (A2) and (A3) for $\widehat{\rho}$ (instead of $\hat{\rho}^{\{S,I\}^*}$) and inserting into the previous inequality yields equation (18). ■

Proof of Proposition 4. We have that $2E[W^S(\hat{\rho}^{\{S,S\}^*})] > E[W^S(\hat{\rho}^{\{S,S\}^*})+W^I(\hat{\rho}^{\{S,S\}^*})] > E[W^S(\hat{\rho}^{\{S,I\}^c}) + W^I(\hat{\rho}^{\{S,I\}^c})]$. Hence equation (19) is fulfilled for sufficiently small p_F, in which case full correlation is optimal. The regulator is then unconstrained and optimally sets $\rho = \hat{\rho}^{\{S,S\}^*}$. For sufficiently large p_F, the right hand side of equation (19) will exceed the left hand side. Then mixed funding is optimal and the regulator is constrained by condition (18). From imposing equality in (18) and solving for ρ we find – in general – the two following solutions:

$$\hat{\rho}_{1,2}^{\{S,I\}^c} = \mu(1+p_F) - \frac{p_F(\Delta pR - c)}{\overline{k}} \pm \sqrt{\left(\mu(1+p_F) - \frac{p_F(\Delta pR - c)}{\overline{k}}\right)^2 - 4\mu\frac{p_F(pR-1)}{\overline{k}}} \tag{21}$$

Without loss of generality, assume $\hat{\rho}_1 < \hat{\rho}_2$. The regulator chooses the threshold that yields higher social surplus. Comparing welfare levels evaluated at the two threshold candidates we find

$$W^{SI}(\hat{\rho}_2) > W^{SI}(\hat{\rho}_1) \quad \text{if} \quad \frac{\Delta pR - c}{\overline{k}} - \mu > 0$$

$$W^{SI}(\hat{\rho}_2) < W^{SI}(\hat{\rho}_1) \quad \text{if} \quad \frac{\Delta pR - c}{\overline{k}} - \mu < 0,$$

which explains the conditionality in (20). ■

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