

Cordella, Tito; Pienknagura, Samuel

Article

Macroprudential policies from a microprudential angle: A note

Latin American Journal of Central Banking (LAJCB)

Provided in Cooperation with:

Center for Latin American Monetary Studies, Mexico City

Suggested Citation: Cordella, Tito; Pienknagura, Samuel (2020) : Macroprudential policies from a microprudential angle: A note, Latin American Journal of Central Banking (LAJCB), ISSN 2666-1438, Elsevier, Amsterdam, Vol. 1, Iss. 1/4, pp. 1-7, <https://doi.org/10.1016/j.latcb.2020.100005>

This Version is available at:

<https://hdl.handle.net/10419/336296>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by-nc-nd/4.0/>



Macprudential policies from a microprudential angle: A note[☆]

Tito Cordella^{a,*}, Samuel Pienknagura^b

^a The World Bank, 1818 H St. NW, Washington, DC 20433, USA

^b International Monetary Fund, 700 19th St. NW, Washington, DC 20431, USA



ARTICLE INFO

JEL classification:

G21

G28

Keywords:

Macprudential regulation

Microprudential regulation

Bank risk-taking

ABSTRACT

The standard macroprudential models focus on externalities and treat all prudential instruments as alternative, but equivalent, forms of Pigouvian taxes. This paper explicitly models individual banks' risk choices and shows that different prudential instruments affect banks' risk-taking incentives differently. Thus, conflicts may arise between the micro- and macroprudential stance.

1. Introduction

The active use of prudential instruments to control credit volumes and allocations fell into disgrace in the 1990s, when the regulatory pendulum swung toward financial liberalization.¹ Then, in 2008, the global financial crisis hit financially developed economies hard and exposed the limits of the existing prudential framework in dealing with systemic risk. This swung the pendulum back, and the active use of prudential instruments such as reserve requirements, loan-to-value ratios, taxes on credit, and capital requirements to smooth the credit cycle and avert major crises (macroprudential policies, according to the current jargon) gained momentum. The global financial crisis also uncovered the dangerous liaisons between micro- and macrostability and forced macroeconomists to give a serious look at the interaction between business cycles and financial frictions.² The latter began to be incorporated in standard DSGE models and with them the rationale for macroprudential policies became evident.³

However, in (necessarily) stylized DSGE models, taxes on debt, capital, and liquidity requirements end up being equivalent forms of Pigouvian taxation that can effectively deal with the negative overborrowing externalities.⁴ This raises the ques-

[☆] We thank Pierluigi Bologna, Giovanni Dell'Ariccia, Augusto de la Torre, Jose Luis Diaz Sanchez, Alain Ize, Carlos Vegh and participants at the Conference at the Central Bank of Turkey and CEMLA (Mexico City), and two anonymous referees for helpful comments and suggestions. The usual disclaimers apply.

^{*} Corresponding author.

E-mail addresses: tcordella@worldbank.org (T. Cordella), spienknagura@imf.org (S. Pienknagura).

¹ This regulatory view was supported by macroeconomic models built in a Modigliani-Miller world where the absence of financial frictions made regulation and supervision unnecessary. Even when macro models such as Bernanke and Gertler (1996) and Kiyotaki and Moore (1997) highlighted the possibility that simple agency problems could lead to potentially dangerous credit cycles, the idea of using prudential instruments to smooth business cycle fluctuations was considered *pass*. Given such a background, it is not surprising that prudential regulation was generally analyzed in micro-models (as the one surveyed in Freixas and Rochet (2008)) and its macroeconomic impact generally overlooked.

² Usually in the form of collateral constraints that create externality problems that lead to episodes of overborrowing and subsequent Fisherian deflation.

³ Macroprudential policies force agents to internalize the external cost of borrowing making the economy less vulnerable to financial crises. This is the argument for Pigouvian taxes in Jeanne and Korinek (2010), and Bianchi (2011).

⁴ Bianchi (2011) formally proves the equivalence between these different instruments.

tion of how robust such results are—that is, whether such equivalence results still hold or not in a more micro-founded model.

This is the question we address in this paper. Using a very stylized model in which a bank maximizes profits by choosing lending rates and the riskiness of its portfolio, we show that, from a microprudential perspective, the choice of macroprudential instruments does indeed matter. It is true that capital requirements and reserve requirements have an adverse effect on banks' incentives to lend, which means that all these instruments successfully address overborrowing externalities. However, while capital requirements make banks more prudent by increasing their skin in the game, reserve requirements make banks engage in riskier behavior. These results should not be seen as arguments against the use of specific macroprudential instruments. Rather, they highlight the complex interactions between different policy instruments and objectives.

There are a number of studies discussing the purposes of macroprudential regulation in dealing with different kinds of externalities, and a growing body of research looking at the effectiveness of macroprudential measures in smoothing the business cycle; Galati and Moessner (2011) and Hanson et al. (2011) are excellent surveys. However, little is still known about how the choice of different prudential instruments affects the incentives of the single institutions to take on risk. This paper is an attempt to fill such a gap.

The model we present is similar to Dell' Ariccia et al. (2014) who study the interaction between monetary policy and the capital structure of banks. The questions we raise in this paper are similar to those in De Nicolo' et al. (2012), who study how, in the presence of credit and liquidity risk, capital and liquidity requirements affect a bank's risk-taking incentives in a calibrated dynamic model. Calomiris et al. (2015) discuss the relative effectiveness of capital and cash requirements and, differently from our paper, they find that reserve requirements may be an effective tool to decrease default risk. However, the channel they emphasize is the decrease in leverage, which, in our model, can only be achieved through tougher capital requirements. Altunba et al. (2017) empirically study the link between macroprudential policies and risk. They find that a tightening of macroprudential policies is associated with a reduction in bank risk. However, their empirical strategy does not distinguish between macroprudential instruments, which is the goal of this paper. Other authors have identified additional unintended consequences stemming from the use of macroprudential policies. Bengui and Bianchi (2018) find that macroprudential policies can lead to higher risk-taking by banks in a model where there are unregulated and regulated financial institutions. In their setting, the increase in risk is driven by unregulated institutions who take on more risk as the aggregate economy becomes less risky. Finally, Forbes (2019) discusses how financial linkages may affect the effectiveness of macroprudential policies in the presence of international spillovers.

2. The model

2.1. The bank's problem

We focus our analysis on a representative monopolistic competitive bank facing a downward sloped demand curve for loans L , $L = (A - \beta R)$, with R denoting the interest rate offered by the bank. Notice that A can be thought of as a measure of the strength/quality of the demand for credit, and β as an inverse measure of the bank's market power. In addition to the lending rate, the bank also chooses the riskiness of its portfolio. Here, we model the choice of risk as the choice of a level of monitoring effort q , $q \in [0, 1]$, exerted by the bank, which also represents the probability that the loan is repaid; we further assume that the cost of monitoring is $c(q) = \frac{cq^2}{2}$ per dollar lent. Hence, in our model, the bank succeeds with probability q and fails with probability $(1 - q)$.

Monitoring costs are borne by the bank before returns are realized. Monitoring can be thought of as a nonpecuniary cost associated with screening efforts; however, we prefer to interpret our set-up more broadly, and think of it as a reduced form of a model in which the bank chooses among portfolios with different risk return profiles.⁵

As for the source of funding, theoretically, banks can choose between demand deposits and capital. However, we assume that (i) deposits are fully insured and are supplied inelastically at an interest rate r , and (ii) the cost of raising capital is $r + \kappa$, where $\kappa > 0$ is the wedge between the cost of capital and the interest rate. Hence, because of such a wedge, in the absence of capital requirements, the bank will rely exclusively on the (cheaper) demand deposits. The problem of the bank can thus be written as:

$$\max_{q \in [0,1], R \in [r, A/\beta]} \Pi = \left(q(R - r) - \frac{cq^2}{2} \right) (A - \beta R).$$

The necessary and sufficient first-order conditions for a maximum are:

$$\frac{\partial \Pi}{\partial q} = (A - \beta R)(R - r - cq) = 0, \quad (1)$$

$$\frac{\partial \Pi}{\partial R} = Aq - 2\beta qR + \beta \left(qr + \frac{cq^2}{2} \right) = 0, \quad (2)$$

so that⁶

$$q^* = \frac{2(A - r\beta)}{3c\beta}, \quad (3)$$

⁵ As in Blum (1999), or Cordella and Levy-Yeyati (2003).

⁶ To avoid boring the reader with tedious assumptions, throughout the paper we implicitly assume that the bank's maximization problem has an internal solution, that is, $q^* \in (0, 1)$ and $R^* \in (r, A/\beta)$. In the Appendix, we provide the conditions that have to be satisfied for the existence of an internal solution in presence of prudential policies of which this solution is a special case.

$$R^* = \frac{2A + r\beta}{3\beta}. \quad (4)$$

Unsurprisingly, monitoring effort depends positively on the strength of the demand (and on the bank's market power) and negatively on its costs (both monitoring and funding costs). Having worked out the simplest model in which a bank strategically chooses risk and interest rates, the next step is to introduce macroprudential tools into the model to see how they affect the bank's behavior.

Notice that the analysis of this paper is purely positive. Our interest is that of highlighting some of the possible tradeoffs that may arise between micro- and macroprudential objectives without modeling the overborrowing externalities that call for macroprudential policies in the first place and thus, without explicitly solving for the optimal policy. This is why we decided to focus on a representative monopolistic competitive bank. In other words, we assume that a macroprudential regulator might want to smooth the credit cycle because of the negative externalities associated with lending booms and busts (which we do not model); and we ask how the different instruments the regulator uses affect the risk-taking incentives of a representative bank (which we do model). In addition, we also abstract from other (sound) prudential reasons why reserve requirements (or other measures targeting the banks' liability structure, such as the net stable funding ratio introduced in Basel III) may be put in place.

2.2. Prudential regulation

We now look at two prudential measures that have received particular attention in the recent literature: an unremunerated (or partially remunerated) reserve requirement, and a minimum risk-based capital requirement equal to a fraction $\phi \in [0, 1]$ of the volume of risk-adjusted loans. More precisely, we assume that capital requirements are equal to a fraction

$$\rho = \phi(1 - \alpha q) \quad (5)$$

of total loans, where ϕ denotes the capital adequacy ratio and $\alpha \in [0, 1]$ the risk adjustment factor. We also assume that a fraction λ of deposits should be held in an unremunerated account at the central bank, so that the deposit base is equal to $(1 - \rho)(1 + \lambda)L$. Under this regulatory framework, the bank's expected total cost of funding per unit of loans, $C(\cdot)$, can thus be written as

$$C(\lambda, \rho, r, \kappa) = q(1 - \rho)(1 + \lambda)r + \rho(r + \kappa).$$

For the sake of simplicity, in the remainder of the analysis, we assume that capital requirements are always binding regardless of the value of q , or equivalently that $\kappa + r > (1 + \lambda)r$.⁷ The bank's problem can now be written as

$$\max_{q \in [0, 1], R \in [r, A/\beta]} \pi_i = \left(q(R - \Theta) - \phi(r + \kappa) - \frac{\mu q^2}{2} \right) (A - \beta R), \quad (6)$$

where $\Theta \equiv ((1 + \lambda)(1 - \phi)r - \alpha\phi(r + \kappa))$; $\mu \equiv (c + 2\alpha(1 + \lambda)\phi r) > 0$. The first-order conditions of the problem are

$$\frac{\partial \pi}{\partial q} = (A - \beta R)(R - \Theta - \mu q) = 0, \quad (7)$$

$$\frac{\partial \pi}{\partial R} = q(A - \beta R) - \beta \left(q(R - \Theta) - \phi(r + \kappa) - \frac{\mu q^2}{2} \right) = 0, \quad (8)$$

so that

$$q^* = \frac{1}{3\mu} \left(\frac{A}{\beta} - \Theta + \sqrt{6\phi(r + \kappa)\mu + \left(\frac{A}{\beta} - \Theta \right)^2} \right), \quad (9)$$

$$R^* = \frac{1}{3} \left(\frac{A}{\beta} + 2\Theta + \sqrt{6\phi(r + \kappa)\mu + \left(\frac{A}{\beta} - \Theta \right)^2} \right). \quad (10)$$

Expressions (9) and (10) provide the equilibrium levels of risk and the interest rate (and thus lending volumes) as functions of the model's parameters. In the Appendix, we show that the second-order conditions of the problem are satisfied; we also show under which conditions an interior solution with non-negative profits for the bank exists.

We turn next to the analysis of the effects of the regulatory variables ϕ and λ on credit volumes and monitoring. Our main result is that:

Result 1. A tightening of macroprudential regulation, through an increase in either minimum capital requirements or reserve requirements, leads to a reduction in credit volumes. However, while an increase in capital requirements decreases the riskiness of the bank's loan portfolio, an increase in reserve requirements increases it.

Proof. In Appendix $\square$

⁷ This assumption is equivalent to imposing an upper bound on the level of unremunerated reserve requirements, $\bar{\lambda}$, such that $\bar{\lambda} < \kappa/r$.

This result suggests that, when incentives are taken into account, the equivalence between different macroprudential tools is broken. In particular, an increase in the bank's external cost of funds triggered, for instance, by a rise in reserve requirements increases individual banks' risk-taking incentives. The reason is that an increase in the cost of the bank's external liabilities, such as obligations to depositors, only matters for the bank when the loan portfolio is repaid and the bank does not fail. Given that the costs of monitoring are the same, with or without reserve requirements, their increase reduces the effective returns on monitoring and induces the bank to behave in a less prudent way: in other words increased reserve requirements exacerbate moral hazard. On the contrary, increasing the bank's skin with the introduction of capital requirements, makes it more liable in the case of failure and decreases risk-taking incentives by increasing the returns on monitoring.

As much as the argument may at first seem far-fetched, the idea that reserve requirements have a negative effect on banks' risk taking incentives is not strange to policymakers. Indeed, Aldo Mendes, formerly Brazil Central Bank's director responsible for monetary policy, stated that "lowering reserve requirements helps financial stability."⁸ The practical argument, highlighted in Nier et al. (2012), is that "Unlike an increase in capital requirements, an increase in RRs has no impact on the resilience of the banking system to loan losses [...] When RRs squeeze profitability, this can lead banks to shift into higher margin, but higher risk segments, in an effort to restore return on equity" (p. 15). As an example, the report mentioned the unwanted consequences of Turkey's aggressive reserve requirements increase in early 2011.

What we argue here is not that reserve requirements are bad instruments per se. They are powerful macrostabilization tools that help guide monetary policies in the presence of volatile capital flows. Also, reserve requirements together with other prudential measures targeting the banks' liability structure, such as the net stable funding ratio introduced in Basel III, could strengthen the resilience of financial systems to liquidity shocks. Instead, what we stress is that there can be trade-offs between instruments, and what stabilizes liquidity or reduces aggregate risk may have negative consequences on individual banks' risk-taking incentives. This is what we discuss next.

3. Discussion

In our previous analysis, we discussed how some of the instruments proposed for the implementation of macroprudential policies affect credit volumes and risk-taking incentives, abstracting from where the economy's position in the business cycle. However, the *raison d'être* of macroprudential policies is to put sand in the wheels of the financial sector in good times and grease in bad times because of the negative externalities associated with their procyclicality. It is thus important to know how capital requirements and reserve requirements bite differently in different moments of the business cycle.

Looking at the trade-offs along the business cycle, our view is that the cyclical use of reserve requirements to dampen the credit cycle may exacerbate the tensions between micro- and macroprudential objectives, especially if the cycle is defined by the cost of capital. When capital is cheap, banks already have an incentive to move to riskier projects and incentives are strengthened if liabilities are heavily taxed. When the cycle is driven by a great abundance of good projects instead (as can be the case during technological revolutions), banks tend to be more prudent. The adverse effect of reserve requirements (or other form of "taxes") on banks' incentives is partially offset by the positive effect that a stronger credit demand has in fostering prudent behavior. If, instead of reserve requirements, capital requirements are used as the instruments to deal with the business cycle, there is no major structural conflict between micro- and macroprudential measures. A tightening of capital requirements reduces both aggregate risk and individual banks' risk-taking incentives. However, there can still be cyclical tensions between micro and macro objectives, when the cycle is driven by the quality of good projects. In this case, capital requirements have to be anticyclical for macroprudential but not for microprudential reasons.

This means that, depending on the drivers of the business cycles, the stance of macro- and microprudential policy may or may not be aligned. This is not as surprising a finding as one may think. It is quite well known that, in periods of economic boom (that is, when there is abundance of good projects, or at least of projects perceived as good), supervisors are usually satisfied with the levels of banks' capital and provisions, while in periods of downturns they become more worried and may ask for remedial actions which, from a macroprudential perspective, may make things worse.

So far, in a "*Hamlet* without the prince" vein, we discussed the effect of macroprudential instruments while neglecting monetary policy. This is a problem. As we all know, at least since Stiglitz and Weiss (1981), if monetary policy is an effective (to use today's jargon) macroprudential tool, it might not fare as well microprudentially. High interest rates exacerbate adverse selection problems and incentivize risk shifting, all the more so the higher reserve requirements (or other forms of taxation) are. This means that the use of monetary policy and reserve requirements to avoid the buildup of aggregate risk needs to be accompanied by very careful microprudential supervision.

When we look at the interaction between monetary policy and capital requirement, the picture is more nuanced. In particular, capital requirements may make monetary policy more microprudence friendly. Indeed, the effect of monetary policy tightening on banks' risk-taking may depend on the level of capital requirements. For low levels of capital requirements, an interest rate hike increases the riskiness of bank's loan portfolio, while the opposite is true if capital requirements are sufficiently high. The intuition is simple: monetary policy affects the incentives of the bank in two ways: (i) by decreasing the returns in the case of success (since the increase in the cost of funding is only partially passed on to borrowers), and (ii) by increasing the banks' skin in the game. When capital requirements are low, the first effect dominates, which leads risk-taking to follow the interest rate. Instead, when capital

⁸ Bloomberg, September 20, 2012.

requirements are sufficiently high, the skin in the game effect dominates, and interest rate hikes make banks behave more prudently. This is the same argument as in [Dell' Ariccia et al. \(2014\)](#), who show that if the capital structure of a bank is fixed, the effect of a monetary easing on risk-taking depends on its leverage.

While we focused our attention on reserve requirements and capital requirements, these are not the only macroprudential instruments available. For instance, different types of macroprudential taxes can be levied on bank loan activities. If we compare the reserve requirements and taxes on credit, it is easy to verify that in the absence of minimum capital requirements, taxes on deposit and taxes on credit are equivalent. Instead, in presence of capital requirements, an increase in the tax on credit will affect credit (negatively) and risk taking (positively) more than a tax on deposit. This follows from the fact that the presence of capital requirements reduces the base of the deposit tax.

Finally, the model presented in this paper is intentionally stylized, leaving out important regulatory design considerations. The first regards the impact that banking regulation can have on the behavior of nonbank financial intermediaries. For example, [International Monetary Fund \(2016\)](#) documents that in countries with stricter bank capital regulation, monetary policy tightening induces a reduction in banks' and an increase in financial companies' assets that are greater than in countries with less stringent regulation. Similarly, [Bengui and Bianchi \(2018\)](#) show that regulations that induce more prudent behavior from supervised institutions can have the unintended consequence of encouraging riskier behavior from institutions that are outside of the regulator's purview. Thus, the coexistence of banks and nonbank financial institutions calls for a unified regulatory framework that internalizes the potential for regulatory leakages.

A second consideration not covered in our paper is the fact that banks subject to the policies discussed here are part of a network, where each individual bank's action affects others directly, through interbank transactions, and indirectly ([Acemoglu et al., 2015](#)). The presence of financial networks not only introduces the potential for those uninternalized externalities that are typical in macroprudential models, but it also highlights the fact that prudential policies can disrupt the interbank network. For example, [Erol and Ordóñez \(2017\)](#) show that the interbank network may suddenly collapse once regulations are pushed above a critical level, with a discontinuous increase in systemic risk as banks' cross-insurance collapses.

4. Conclusions

According to the current wisdom, prudential regulation should be thought of as an additional instrument in the hands of policy-makers to avoid the buildup of excessive risk along the business cycle. Such a view is supported by many recent contributions that incorporate financial amplification effects in open macro models, which study how "macroprudential" taxes can help in coping with financial externalities.⁹

In this paper, we show that while different prudential instruments may help reduce lending incentives, their effect on banks' risk-taking incentives are uneven. While capital requirements always promote safer behavior, the same is not true for reserve requirements or, in general, for those kinds of instruments that are equivalent to taxes on banks' liabilities. This means that if it is important to look at the macro effects of microprudential measures, one should also look at the micro effects of macroprudential policies. Policies that aim at reducing risk associated with financial externalities may under certain circumstances increase banks' risk appetite so that micro- and macroprudential objectives may not always go hand in hand.

Declaration of Competing Interest

- All authors have participated in (a) conception and design, or analysis and interpretation of the data; (b) drafting the article or revising it critically for important intellectual content; and (c) approval of the final version.
- This manuscript has not been submitted to, nor is under review at, another
- Journal or other publishing venue. The authors have no affiliation with any organization with a direct or indirect financial interest in the subject matter discussed in the manuscript

Appendix A. Appendix

A1. Conditions for the existence of an interior solution

From (9), $q^* < 1$ if

$$\left(\frac{A}{\beta} - \Theta + \sqrt{6\phi(r + \kappa)\mu + \left(\frac{A}{\beta} - \Theta \right)^2} \right) < 3\mu,$$

which, after some manipulation, can be written as

$$\frac{A}{\beta} < \frac{3}{2}\mu - \phi(r + \kappa) + \Theta. \quad (11)$$

⁹ See, among others, ([Bianchi et al., 2012](#); [Korinek, 2011](#)), and [Benigno et al. \(2011\)](#)

From (10), $R^* < A/\beta$ if

$$\frac{1}{3} \left(\frac{A}{\beta} + 2\Theta + \sqrt{6\phi(r+\kappa)\mu + \left(\frac{A}{\beta} - \Theta \right)^2} \right) < \frac{A}{\beta},$$

which, after some manipulation, can be written as

$$\frac{A}{\beta} > \sqrt{2\phi(r+\kappa)\mu} + \Theta. \quad (12)$$

Finally, the bank's profits can be written in equilibrium as

$$\pi^* = \left(\frac{A}{\beta} - R^* \right) \left(q^*(R^* - \Theta) - \mu \frac{q^{*2}}{2} - \phi(r+\kappa) \right);$$

and, using (8),

$$\pi^* = q^* \left(\frac{A}{\beta} - R^* \right)^2 > 0.$$

Using (11) and (12) we obtain the following inequality for an interior solution: $\frac{3}{2}\mu - \phi(r+\kappa) + \Theta > \frac{A}{\beta} > \sqrt{2\phi(r+\kappa)\mu} + \Theta$. Notice that the set of values of $\frac{A}{\beta}$ that satisfies the inequality is non-empty as long as

$$\frac{3}{2}\mu - \phi(r+\kappa) > \sqrt{2\phi(r+\kappa)\mu}. \quad (13)$$

This condition is clearly satisfied for $\phi = 0$. Moreover, it is easy to verify that there exists a $\bar{\phi} \in [0, 1]$ such that $\frac{3}{2}\mu - \phi(r+\kappa) > \sqrt{2\phi(r+\kappa)\mu}$ for every $\phi < \bar{\phi}$. Throughout the paper we assume that $\phi < \bar{\phi}$ and $\frac{3}{2}\mu - \phi(r+\kappa) + \Theta > \frac{A}{\beta} > \sqrt{2\phi(r+\kappa)\mu} + \Theta$.

A2. Second-order conditions for a maximum

The second-order sufficient conditions for an interior maximum are that at (q^*, R^*) , $\Pi_{qq} < 0$, $\Pi_{RR} < 0$, and $\Pi_{qq}\Pi_{RR} > \Pi_{qR}^2$, where Π_{xy} denotes the cross partial derivative of Π with respect to x and y .

$$\Pi_{qq} = -\mu(A - \beta R^*) < 0, \quad (14)$$

$$\Pi_{RR} = -2\beta q^* < 0, \quad (15)$$

$$\Pi_{qR} = -\beta(R - \Theta - \mu q^*) + (A - \beta R^*),$$

which, using (7), becomes

$$\Pi_{qR} = (A - \beta R^*). \quad (16)$$

Using, (14), (15), and (16), we find that

$$\Pi_{qq}\Pi_{RR} > \Pi_{qR}^2 \iff R^* > \frac{A}{\beta} - 2q\mu. \quad (17)$$

Substituting the value of R^* from (10), one can immediately verify that (17) always holds true.

A3. Proof of Result 1.

Totally differentiating the first-order conditions of the bank and applying Cramer's rule, we find that

$$\frac{dq^*}{d\phi} = \frac{-\Pi_{q\phi}\Pi_{RR} + \Pi_{R\phi}\Pi_{qR}}{\Pi_{qq}\Pi_{RR} - \Pi_{Rq}^2}. \quad (18)$$

Since the denominator of (18) is negative because of (17),

$$\text{sign} \left| \frac{dq^*}{d\phi} \right| = \text{sign} \left| -\Pi_{q\phi}\Pi_{RR} + \Pi_{R\phi}\Pi_{qR} \right|$$

and

$$-\Pi_{q\phi}\Pi_{RR} + \Pi_{R\phi}\Pi_{qR} = b(A - bR)(\alpha\kappa q + \kappa + r(-3\alpha(\lambda + 1)q^2 + q(\alpha + \lambda + 1) + 1)) > 0, \quad (19)$$

where the inequality follows from the fact that $\alpha, q \in (0, 1)$ and the assumption that capital requirements are binding $\kappa > r\lambda$.

Similarly,

$$\text{sign} \left| \frac{dq^*}{d\lambda} \right| = \text{sign} \left| -\pi_{RR}\pi_{q\lambda} + \pi_{R\lambda}\pi_{qR} \right| \quad (20)$$

where

$$-\pi_{RR}\pi_{q\lambda} + \pi_{R\lambda}\pi_{qR} = -\beta q r(A - \beta R)(1 - \phi + 3\alpha q\phi) < 0. \quad (21)$$

Turning now to the interest rate,

$$\text{sign}\left|\frac{dR^*}{d\phi}\right| = \text{sign}\left|-\pi_{qq}\pi_{R\phi} + \pi_{q\phi}\pi_{qR}\right|, \quad (22)$$

and

$$\begin{aligned} & -\pi_{qq}\pi_{R\phi} + \pi_{q\phi}\pi_{qR} \\ & = (A - bR)((A - bR)(\alpha(k + r) + r(\lambda - 2\alpha(\lambda + 1)q) + r) + b(\alpha q - 1)(r(\lambda q + q - 1) - k)(c + 2\alpha(\lambda + 1)r\phi)) > 0 \end{aligned} \quad (23)$$

where the inequality follows from the fact that capital requirements are binding.

Similarly, we hold that

$$\text{sign}\left|\frac{dR^*}{d\lambda}\right| = \text{sign}\left|-\pi_{qq}\pi_{R\lambda} + \pi_{q\lambda}\pi_{qR}\right| \quad (24)$$

where

$$-\pi_{qq}\pi_{R\lambda} + \pi_{q\lambda}\pi_{qR} = r(A - bR)((bR - A)(\phi(2\alpha q - 1) + 1) + bq(\phi(\alpha q - 1) + 1)(c + 2\alpha(\lambda + 1)r\phi)) > 0. \quad (25)$$

A necessary and sufficient condition for (25) is that

$$\mu q - 2\left(\frac{A}{\beta} - R\right) = -\left(\frac{A}{\beta} - \theta\right) + \sqrt{6\phi(r + \kappa)\mu + \left(\frac{A}{\beta} - \Theta\right)^2} > 0.$$

Hence, $\frac{dq^*}{d\phi} > 0$, $\frac{dR^*}{d\phi} > 0$, and $\frac{dR^*}{d\lambda} < 0$. This, together with the fact that $\frac{\partial L}{\partial R} = -\beta < 0$, proves the result.

References

- Acemoglu, D., Ozdaglar, A., Tahbaz-Salehi, A., 2015. Systemic Risk in Endogenous Financial Networks. Columbia Business School Research Paper No 15-17.
- Altunba, Y., Banici, M., Gambacorta, L., 2017. Macroprudential Policy and Bank Risk. BIS Working Paper No 646.
- Bengui, J., Bianchi, J., 2018. Macroprudential Policy With Leakages (No. w25048). NBER Working Paper No 25048.
- Benigno, G., Chen, H., Otrok, C., Rebucci, A., Young, E., 2011. Financial Crises and Macro-Prudential Policies. IADB RES Working Papers No 4710.
- Bernanke, B.S., Gertler, M., 1986. Agency costs, collateral, and business fluctuations. NBER Working Paper No. 2015.
- Bianchi, J., 2011. Overborrowing and systemic externalities in the business cycle. *Am. Econ. Rev.* 101, 3400–3426.
- Bianchi, J., Boz, E., Mendoza, E., 2012. Macroprudential policy in a fisherian model of financial innovation. *IMF Econ. Rev.* 60, 223–269.
- Blum, J., 1999. Do capital requirements reduce risk taking in banking? *J. Bank. Financ.* 23, 755–771.
- Calomiris, C., Heider, F., Hoerova, M., 2015. A Theory of Bank Liquidity Requirements. Columbia Business School Research Paper, pp. 14–39.
- Cordella, T., Levy-Yeyati, E., 2003. Bank bailouts: Moral hazard vs. value effect. *J. Financ. Intermed.* 12, 300–330.
- Dell' Ariccia, G., Laeven, L., Marquez, R., 2014. Real interest rate, leverage and bank risk-taking. *J. Econ. Theory* 149, 65–99.
- Erol, S., Ordóñez, G., 2017. Network reactions to banking regulations. *J. Monet. Econ.* 89, 51–67.
- Forbes, K., 2019. Macroprudential policy: What we've learned, don't know, and need to know. *Am. Econ. Rev.* 109, 470–475.
- Freixas, X., Rochet, J.-C., 2008. *Microeconomics of Banking*. MIT Press.
- Galati, G., Moessner, R., 2011. Macroprudential Policies – a Literature Review. BIS Working Paper No. 337.
- Hanson, S.G., Kashyap, A.K., Stein, J.C., 2011. A macroprudential approach to financial regulation. *J. Econ. Perspect.* 25 (1), 3–28.
- International Monetary Fund, 2016. Monetary Policy and the Rise of Nonbank Finance. Global Financial Stability Report, Chapter 2, 2016. Washington, D.C.
- Jeanne, O., Korinek, A., 2010. Excessive volatility in capital flows: a pigouvian taxation approach. *Am. Econ. Rev.* 100, 403–407.
- Kiyotaki, N., Moore, J., 1997. Credit cycles. *J. Polit. Econ.* 105, 211–248.
- Korinek, A., 2011. Systemic Risk-Taking: Amplification Effects, Externalities, and Regulatory Responses. ECB Working Paper No. 1345.
- De Nicolò, G., Gamba, G., Lucchetta, M., 2012. Capital regulation, liquidity requirements and taxation in a dynamic model of banking. IMF Working Paper No 12/72.
- Nier, E., Kang, H., Mancini, T., Hesse, H., Columba, F., Tchaidze, R., Vandenbussche, J., 2012. The interaction of monetary and macroprudential policies—background paper. IMF Staff Paper.
- Stiglitz, J.E., Weiss, A., 1981. Credit rationing in markets with imperfect information. *Am. Econ. Rev.* 71, 393–410.