Macroprudential Policies in Low-Income Countries*

Margarita Rubio† D. Filiz Unsal‡
University of Nottingham International Monetary Fund

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Abstract

In this paper, we develop a DSGE model to study the implementation of macroprudential policy in low-income countries (LICs). The model features an economy with two agents; households and entrepreneurs. Entrepreneurs are the borrowers in this economy and need capital as collateral to obtain loans. The macroprudential regulator uses the collateral requirement as the policy instrument. We compare two different ways of implementing the macroprudential policy: permanently increasing the collateral requirement (passive policy) versus an active time-varying rule responding to deviations of credit from its steady state. Results show that with perfect information, an active approach is more effective in increasing financial stability, without incurring in a long-run output cost. However, if the regulator is not able to observe the economic conditions perfectly, which is usually the case in LICs, a passive approach may be preferred.

Keywords: Macroprudential policy, low-income countries, developing countries, collateral requirements, credit

JEL Classification: E44; E32; G18

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†University of Nottingham, School of Economics. Sir Clive Granger Building, University Park, Nottingham, NG7 2RD, UK. E-mail: margarita.rubio@nottingham.ac.uk.

‡International Monetary Fund. Strategy, Policy and Review Department. 700 19th Street, N.W., Washington DC, 20431. E-mail: DUnsal@imf.org.

1 Introduction

The financial crisis has made it very clear that there is the need for policies that enhance the stability in the financial system, namely macroprudential policies. However, there is scarce evidence on the implementation of these policies around the globe, and particularly in low-income and developing countries (LICs).[1] The literature has focused on studying these policies in developed countries, but the research to effectively design these measures for LICs is nonexistent.

A plausible approximation of macroprudential policy is time-varying rules. An advantage of a rule-based approach that ties policy settings to a pre-defined indicator is that it can overcome political economy challenges. In theory, it is useful to vary macroprudential instruments over the cycle. In fact, for developed countries, there is consensus that time-varying rule on instruments such as loan-to-values or capital requirement ratios would be a desirable option.

Furthermore, macroprudential policy has both benefits as well as costs. The benefits, when tools are used effectively, include a more stable financial system which therefore reduces the probability of a crisis. However, this policy could lead to other distortions since financial services reduce and this may have a long-run output cost.[2] A passive policy in which instruments tighten borrowing availability permanently may emphasize the long-run negative effects on output.

However, things might change when we talk about LICs. Although LICs are a diverse group of countries, they in general in a process of financial and institutional development with implications both for the nature of financial stability risks and the conduct of macroprudential policies. For LICs, the combination of limited data availability, volatile economic conditions, and weak supervisory capacity can mean that a passive policy can be preferred, an active and time-varying use of macroprudential policy may be inadvisable. Maintaining permanently high capital or collateral requirements could be a more effective approach under these circumstances.[3]

In this paper, we aim at developing a model that contains features that are specific for low-income countries and that can serve as a benchmark for macroprudential policy evaluation in these regions. Specifically, we focus on how macroprudential policy design should take into account data and capacity limitations (not timely/noisy data and weak supervisory capacity). The model features two types of agents; households and entrepreneurs. Entrepreneurs can access financial markets as long as they own

[1] See IMF (2014) (a), Table 1, for a list of countries that are included in the low-income developing countries.
[2] See Arregui (2013).
[3] See IMF (2014) (b).

capital collateral. Macroprudential policy is represented by changes in the collateral requirement. We compare a passive macroprudential policy, in which collateral requirements are increased permanently, with an active policy, in which there is a countercyclical rule so that the collateral requirement responds to deviations of credit with respect to its steady state. For our comparison, we consider two scenarios; one in which there is perfect information and an second one in which the macroprudential regulator is not able to observe the relevant financial indicators with accuracy.

In order to evaluate policies we adopt a positive approach. The model does not allow to perform a rigorous normative welfare-based approach since macroprudential policies are not microfounded here, we take the regulation as given.[4] This implies that the benefits and costs in terms of general equilibrium effects of having macroprudential policies are not fully captured in the utility functions of agents.[5] Thus, as in other papers studying macroprudential policies, we take the presence of the macroprudential regulator as given and study its effects on the macroeconomy and on financial markets. As in Angelini et al. (2014) we assume that the macroprudential authority cares about the variability of borrowing and output.

This paper relates to different strands of the literature. On the one hand, it is builds from DSGE models with collateral constraints such as Kiyotaki and Moore (1997), Iacoviello (2005) or Iacoviello and Minetti (2006). However, in our paper, unlike the others, the main source of collateral is capital, which better reflects the features of low-income countries. This paper is also related with the literature that studies macroprudential policies in a DSGE model, introducing such policies as a rule on financial regulation. Examples of these papers are Kannan et al. (2012), Angelini et al. (2014) and Rubio and Carrasco-Gallego (2014). However, all these papers refer to advanced economies, there is no mention to low-income or developing countries. Those papers use capital requirements or loan-to-values as macroprudential instruments. In our paper, the instrument is the collateral requirement, which has a great importance on those countries. On the other hand, our study adds imperfect information in the specification of the macroprudential rule, as in the literature on monetary policy rules with imperfect information. For instance, we can find Aoki (2003) or Orphanides (2003) who analyze optimal monetary policy with noisy indicators. Nevertheless, these studies focus on monetary policy, not on macroprudential policies. Finally, the paper is related to DSGE models that characterize specific features of

[4] For an example of study in which macroprudential policies are microfounded, see Angeloni and Faia (2013). In this paper financial regulation is microfounded through fragile banks. This allows the authors to discuss welfare properly.

[5] Angelini et al. (2014) find that even when policy makers achieve a lower volatility of output compared to the efficient equilibrium when making use of macroprudential policies, this need not be necessarily welfare improving.

low-income and developing countries, such as Dabla-Norris et al. (2015) or Baldini et al. (2015). These papers are however silent on how macroprudential policies should be implemented in such countries.

To our knowledge, our paper is the first one that studies the implementation of macroprudential policies specifically for low-income and developing countries into a DSGE model framework. It provides a theoretical counterpart to empirical studies and policy papers that point out that the particular features of low-income countries may alter the optimal way to implement macroprudential policy. This paper permits to analyze different policy options within a rigorous micro-founded model, suitable for policy evaluation.

Results show that macroprudential policies are effective to reduce financial instability, since they lower the volatility of credit. We find that if the macroprudential regulator is able to observe economic indicators without an error, active time-varying policies are preferred to passive approaches. Active policies, being countercyclical, are more effective to achieve financial stability without incurring in a long-run output cost. Passive policies, although they also manage to enhance a more stable financial system, they are not as effective and they imply a permanently lower steady-state output. However, under imperfect information and inability of policy makers to observe financial indicators without noise, this may not be the case. Under these circumstances, a passive approach may be more advisable even though entailing an output cost. The policy implications of these results are clear; there should be an effort in these countries to reduce problems of regulatory and supervisory capacity in order to enable authorities to better monitor financial systems and be able to use time-varying approaches which do not imply a long-run output loss.

The rest of the paper continues as follows. Section 2 presents the basic model. Section 3 describes macroprudential policies. Section 4 makes a comparison between the different macroprudential policy options. Section 5 concludes.

2 The Model

We consider an infinite-horizon economy. The economy is populated by infinitely lived agents, entrepreneurs and households, of measure ω and $(1-\omega)$ respectively. There are capital producers that sell the capital goods output to entrepreneurs. Households rent labor to entrepreneurs and consume the final good; they also trade non-contingent one-period bonds issued by entrepreneurs. Entrepreneurs consume and use labor and capital to produce the final good; Entrepreneurs use capital as collateral to access financial markets. The macroprudential instrument is the collateral requirement.

2.1 Entrepreneurs/Firms

Entrepreneurs produce the final consumption good according to a Cobb-Douglas production function in domestically located labor l_t and capital k_t, which depreciates at rate δ over time:

$$Y_t = k_t^{\mu} l_t^{1-\mu} \tag{1}$$

Entrepreneurs maximize their lifetime utility from the consumption flow c_t. We denote with E_t the expectation operator conditional on time t information and with γ the entrepreneurs' discount factor. Entrepreneurs solve the following problem:

$$\max_{c_t, b_t, l_t, , k_{t+1}} E_0 \sum_{t=0}^{\infty} \gamma^t \ln c_t$$

subject to the flow of funds:

$$k_t^{\mu} l_t^{1-\mu} + b_t + q_t (1-\delta) k_t = c_t + q_t k_{t+1} + R_{t-1} b_{t-1} + w_t l_t. \tag{2}$$

where γ is the entrepreneurial discount factor, b_t represents borrowing from the entrepreneur, R_t is the interest rate, q_t is the price of capital and w_t is the real wage.

Assuming that k is collateralizable, we denote z the value of capital collateral required to obtain a loan. Then, the entrepreneur faces the following borrowing constraint:

$$b_t \leq \frac{1}{z} \frac{q_t k_t}{R_t} \tag{3}$$

This collateral constraint is analogous to the ones used in Kiyotaki and Moore (1997) or Iacoviello (2005) but using capital instead of land and housing as collateral. We consider that collateralizing debt with capital reflects better the features of low-income countries.

Entrepreneurs choose labor and capital and how much to borrow from households; The first-order conditions are as follows:

$$\frac{1}{c_t} = E_t \left(\frac{\gamma R_t}{c_{t+1}} \right) + \lambda_t R_t \tag{4}$$

$$w_t l_t = (1-\mu)\, y_t \tag{5}$$

$$\frac{1}{c_t} q_t = E_t \frac{\gamma}{c_{t+1}} \left(\mu \frac{y_{t+1}}{k_t} + q_{t+1}(1-\delta) \right) + \lambda_t q_t \frac{1}{z} \tag{6}$$

where λ_t is the Lagrange multiplier of the borrowing constraint. The first-order conditions are the consumption Euler equation (4), labor demand (5), and capital demand (6). The consumption Euler equation and the capital demand differ from the usual formulations because of the presence of the Lagrange multiplier on the borrowing constraint.

2.2 Households

Let us denote households variables with a prime. Households enter each period with assets and a bond coming to maturity. They derive utility from consumption and leisure. They rent labor to the entrepreneur, lend b_t to firms, while receiving back the amount lent in the previous period times the agreed gross interest rate R.

Preferences are given by:

$$\max_{c'_t, b'_t, l_t} E_0 \sum_{t=0}^{\infty} \beta^t \left(\ln c'_t - \frac{1}{\eta} l_t^{\eta} \right) \tag{7}$$

where β is the discount factor, which is assumed to be greater than γ, the discount factor for entrepreneurs.[6]

Households maximize (7) subject to the flow of funds:

$$c'_t + b'_t = R_{t-1} b'_{t-1} + w_t l_t \tag{8}$$

Solution of this problem yields the following first-order conditions:

$$\frac{1}{c'_t} = \beta E_t \left(\frac{R_t}{c'_{t+1}} \right) \tag{9}$$

[6] In a neighborhood of the steady state equilibrium, the multiplier associated with the entrepreneurs collateral constraint will be positive, so long as the entrepreneurial discount factor γ is lower than the households'discount factor β, which in turn prices bonds.

$$w_t = c_t' l_t^{\eta-1} \tag{10}$$

where equation (9) represents the Euler equation for consumption. Equation (10) is the labor supply schedule.

2.3 Capital Producers

Competitive capital producers use investment as materials input i_t and produce new capital goods sold at price q_t. We assume that the marginal return to investment in terms of capital goods is decreasing in the amount of investment undertaken due to the presence of adjustment costs.

The representative firm solves:

$$\max_{i_t} q_t \left[\left(\frac{i_t}{k_t} \right) - \frac{\phi}{2} \left(\frac{i_t}{k_t} - \delta \right)^2 \right] k_t - i_t \tag{11}$$

The first order condition for i_t is as follows:

$$q_t = \left[1 - \phi \left(\frac{i_t}{k_t} - \delta \right) \right]^{-1} \tag{12}$$

Equation (12) captures the price of a unit of capital and it represents the optimality condition for the capital-producing firms with respect to the choice of i_t yields the following nominal.[7]

2.4 Equilibrium

Goods markets clear:

$$Y_t = \omega c_t + (1 - \omega) c_t' + i_t \tag{13}$$

Capital markets clear, so that the stock of capital used by the firms in the economy evolves according to the following:

$$k_{t+1} = \left[\left(\frac{i_t}{k_t} \right) - \frac{\phi}{2} \left(\frac{i_t}{k_t} - \delta \right)^2 \right] k_t + (1 - \delta) k_t \tag{14}$$

[7] This specification of capital production is standard in the literature. See for instance Bernanke et al. (1999) or Unsal (2013).

2.5 Parameter Values

Table 1 presents a summary of the parameter values used for the benchmark calibration. The discount factor for households takes the usual value of 0.99 to reflect an annualized interest rate of approximately 4%. The discount factor for entrepreneurs is slightly lower so that they are impatient agents.[8] As a benchmark collateral requirement, we use data from the World Bank Enterprise Survey Data. In Sub-Saharan Africa, the value of collateral needed for a loan is 183.2%. The capital depreciation takes a standard value of 3%. The capital share is about one third, consistent with the data. The labor supply value, reflects a labor supply elasticity of one third, in line with the literature.[9] The proportion of entrepreneurs (borrowers) is set to 0.8.[10] For our analysis, we will consider demand shocks, that is, an additive shock ε_t in the log-linearized version of the Euler equation for households (equation 9). We assume that $\log(\varepsilon_t)$ follows an exogenous stochastic stationary AR (1) process around a constant mean. As in the standard framework, this type of shock may reflect changes in tastes or components of demand that do not react to the real interest rate, such as government expenditures.[11] As in Rabanal (2004), the persistence of the demand shock is set to 0.80.

Table 1: Benchmark Calibration

β	Discount Factor Households	0.99
γ	Discount Factor Entrepreneurs	0.98
z	Collateral Requirement	183.2
δ	Capital depreciation	0.03
μ	Capital Share	0.35
η	Labor supply	3
ω	Entrepreneur proportion	0.8
ρ	Shock persistence	0.8

[8] The value of this parameter is not crucial for the results, as long as there is a difference between households and entrepreneurs discount factors that makes the collateral constraint to be binding. We take this value in line with Iacoviello and Minetti (2006), in which it implies a steady state in which the retrun on entrepreneurial investment is 8%.

[9] These values are consistent with Iacoviello and Minetti (2006).

[10] According to the World Bank Enterprise Survey Data, in Sub-Saharan Africa, the proportion of loans requiring collateral is about 80%

[11] We have also experimented with technology shocks and have found that demand shocks emphasize our results and strengthen the positive effects of macroprudential policies on financial stability.

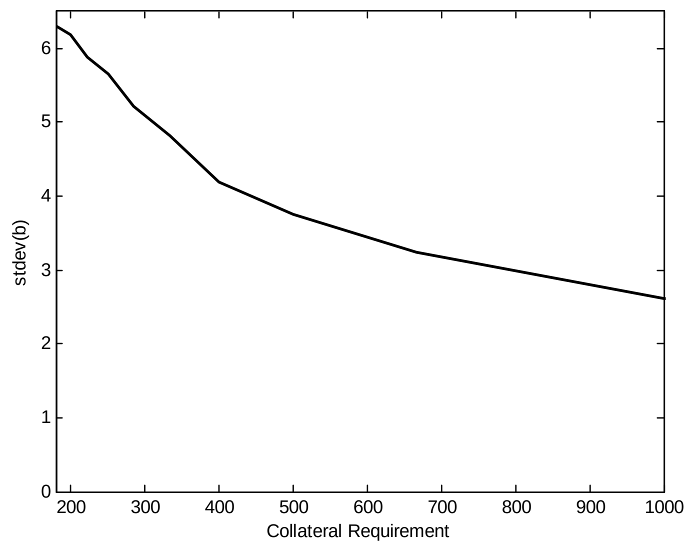

Figure 1: Financial stability implied by increasing collateral requirements

3 Macroprudential Policy

3.1 Passive Policy

For passive macroprudential policy we consider a permanent change in the collateral requirement, the macroprudential instrument, as opposed to varying it depending on economic or financial conditions.[12] Increasing collateral requirements means restricting credit permanently and it is thus an example of a passive macroprudential policy. This action may have implications for financial stability since now, the collateral constraint is tighter once and for all. This would benefit the economy, since now the financial system is more stable. However, this passive policy also affects steady states in the economy. Increasing permanently the collateral requirements implies reducing the steady state of credit and output. Therefore, even though this policy represents a benefit in terms of financial stability, it may also entail a long-term cost in terms of output that has to be taken into account.

Figure 1 displays the standard deviation of borrowing when collateral requirements are increased with respect to the benchmark initial point (183.2%). We take the standard deviation of borrowing as a proxy for financial stability. As we can see in the graph, when collateral requirements increase the standard deviation decreases. Therefore, a passive macroprudential policy that increases collateral requirements permanently is able to achieve a higher financial stability, as implied by the figure. This

[12] A number of LICs already set the minimum regulatory capital ratio higher than international standards. For example, a higher regulatory ratio is imposed in Moldova, Uganda and Tanzania (See IMF, 2014,b).

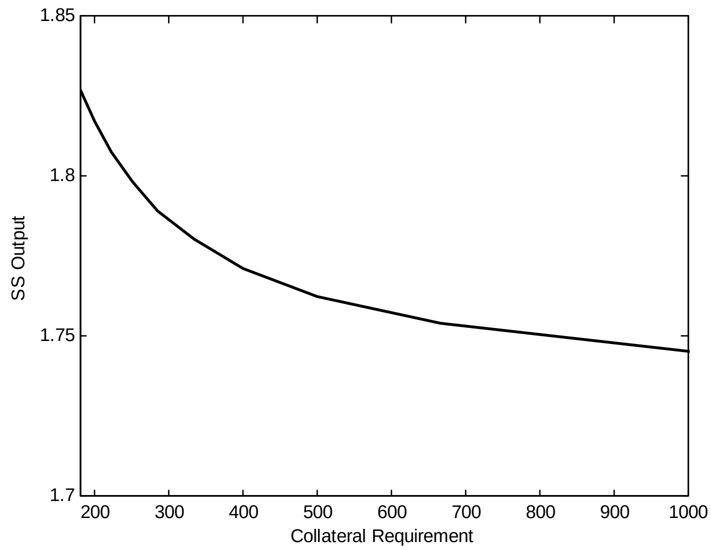

Figure 2: Steady state output implied by increasing collateral requirements

represents a benefit when implementing this macroprudential policy.

However, as figure 2 shows, this policy also implies a lower steady-state level of output. Here, we show the output in the steady state that is obtained when increasing the collateral requirement permanently, that is, making the collateral constraint tighter for entrepreneurs. This policy, even enhancing financial stability, would limit the ability of entrepreneurs to access financial markets and therefore to borrow and produce. This means that the economy has permanently less resources for production and therefore the steady-state output decreases.[13] This represents a cost that is associated with the implementation of this policy.

3.2 Active Policy: A Macroprudential Rule

As an approximation for a realistic active macroprudential policy, that is, one that is time-varying, we consider a Taylor-type rule for collateral requirements. We can think of regulations on the required collateral as a way to moderate credit booms. Increasing collateral requirements when observing a credit boom makes the collateral constraint tighter and therefore restricts the loans that borrowers can obtain. However, a macroprudential rule is implicitly assuming that the macroprudential regulators observes the current state of the economy promptly and accurately and can therefore adjust policy based on this information. In LICs, this may not be the case. An issue in the implementation of a macroprudential

[13] Note that results are in line with the literature on advanced and emerging markets that has found that the long-run cost of increases in capital requirements or buffers on credit and output are generally small (See IMF 2014,b).

rule would be the availability of relevant data. As in the monetary policy literature, failing to account for the correct level of information may provide an inefficient policy rule.[14] The availability of relevant data is certainly an issue for the correct implementation of rules.[15] Therefore, we consider the rule both when there is perfect information and when there is noisy and inaccurate data. Recognition of the difficulties that arise with presence of noise is important for the study of macroprudential policies. Under imperfect information, macroprudential policies would be based on distorted data. The evaluation of alternative policy strategies would be misleading if it is based on the assumption that policy reacts to data that is not available when policy must be set or it is available with substantial noise.

3.2.1 The rule with perfect information

Here, we propose the following rule:

$$z_t = z_{SS} \left(\frac{E_t b_{t+1}}{b_{SS}} \right)^{\phi_b}, \tag{B1}$$

where z_{SS} is the steady-state value for the collateral requirement. $\phi_b \geq 0$ measures the response of the collateral requirement to expected deviations of credit from its steady state. This kind of rule would be countercyclical, delivering higher requirements during credit booms, therefore restricting the credit in the economy and increasing financial stability.[16] Here we assume that the regulator can perfectly observe the state of the economy.

Figure 3 displays the financial stability implied by the rule for different parameters of ϕ_b. We can observe from the graph that the more aggressive the rule is in reacting to deviations of credit from its steady state, the more effective it is to deliver financial stability, in the sense of achieving a lower volatility of credit. We see however that the marginal gains in terms of financial stability are decreasing. In fact, for very large values of the reaction parameter, financial stability is still improving but at a very small rate. Given this feature, it is not possible to find a value of the reaction parameter for which the variability of credit is minimized and we could take as optimal. This finding goes in line with monetary policy studies that try to find an optimal parameter for the inflation coefficient. For instance, in Schmitt-Grohé and Uribe (2007), they find that deviating from the optimal policy rule by setting the inflation

[14] See Orphanides (2003).
[15] See Aoki (2003).

[16] We have experimented with other rules. The collateral requirement responding to the credit-to-GDP delivers very similar results. When it responds to credit growth we encounter indeterminacy issues.

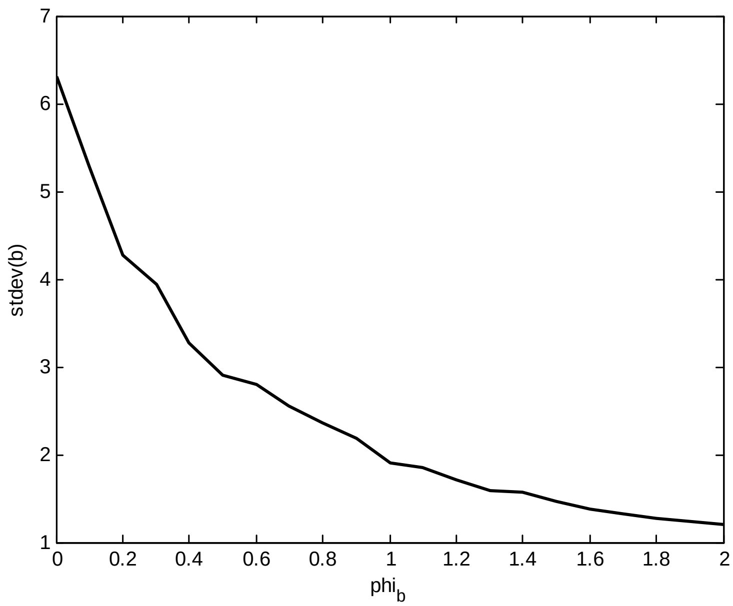

Figure 3: Standard deviation of borrowing for different values of the reaction parameter

coefficient anywhere above unity yields virtually the same level of welfare as the optimal rule. Here, we also find that up to a certain level of the parameter, the improvement in financial stability associated to increasing the aggressiveness of the rule is negligible.[17] For our analysis, we take a value of 0.5 for this parameter, in order to take a conservative value that is in line with the monetary policy literature on Taylor rules.[18]

3.2.2 The Rule with imperfect information

The macroprudential rule with perfect information is implicitly assuming that the macroprudential regulators observe the current state of the economy promptly and accurately and can therefore adjust policy based on this information. In LICs, this may not be the case. An issue in the implementation of a macroprudential rule would be the availability of relevant data. As in the monetary policy literature, failing to account for the correct level of information may provide an inefficient policy rule.[19] The availability of relevant data is certainly an issue for the correct implementation of rules.[20] Another way

[17] Schmitt-Grohé and Uribe (2007) find that removing the upper bound on policy parameters optimal policy calls for a much larger inflation coefficient (namely 332), but yields a negligible improvement in welfare. If we check the volatility of borrowing associated with extreme values, we also find negligible improvements. For instance, a coefficient of 100 implies a standard deviation of borrowing of 0.423537 and a coefficient of 1000 a standard deviation of 0.421284.

[18] 0.5 corresponds to the original parameter for inflation and output proposed by Taylor for its Taylor rule for monetary policy.

[19] See Orphanides (2003).

[20] See Aoki (2003).

to see the problem of data availability is to assume that accurate measures of these variables, which are required for the implementation of an optimal rule, are not known until much later. Here, we consider that the relevant rule is one that responds to lagged values of borrowing.

We assume that variables are observed both with a lag and with an error. We consider that accurate measures of these variables, which are required for the implementation of an optimal rule, are not known until much later and with noise. We consider that the regulator observes credit corresponding to four quarters back and with an error.

Then, the macroprudential regulator, instead of observing $E_t b_{t+1}$, observes b_{t-4} but with an error. Thus, $b_{t-4} = \widetilde{b}_{t-4} + x_t$. Where x_t is the noise. The true rule then becomes:

$$z_t = z_{SS} \left(\frac{b_{t-4} - x_t}{b_{SS}} \right)^{\phi_b}, \tag{15}$$

As pointed out by Orphanides (2003), the information problem makes that the policy authority is also reacting to the noise processes. This may introduce undesirable movements in the macroprudential tool. Thus, unless there is perfect information and $x_t = 0$, equation (15) may be less effective.

We assume that the noise follows an AR(1) process:

$$x_{t=} \varphi x_{t-1} + v_t \tag{16}$$

where v_t is drawn from an independent zero mean normal distribution with variance σ_v^2.

Figure 4 shows the volatility of credit implied for different parameters of ϕ_b, the reaction parameter of the macroprudential rule, both when there is perfect and imperfect information. For our experiments, we have considered a 1% shock with 0.8 persistence.[21] For imperfect information, we present three cases: when lagged variables are observed, when there is noisy data and when variables are both observed with a lag and noise. In this way, we can disentangle where results are coming from. We see that for very low values of the reaction parameter, the rule is delivering similar results with perfect and imperfect information, albeit in this case, the effectiveness of the rule to enhance financial stability is limited. However, for larger ones, which are effective for the rule with perfect information, with imperfect information the volatility of credit increases. This makes the rule not only not effective but counterproductive.

[21] Orphanides (2003) estimates the standard error and persistence of the noise in the data used for US monetary policy. He finds that the standard error is close to 1% and with high persistence. Given the difficulties of an analogous estimation for low-income countries, we take these values as a benchmark.

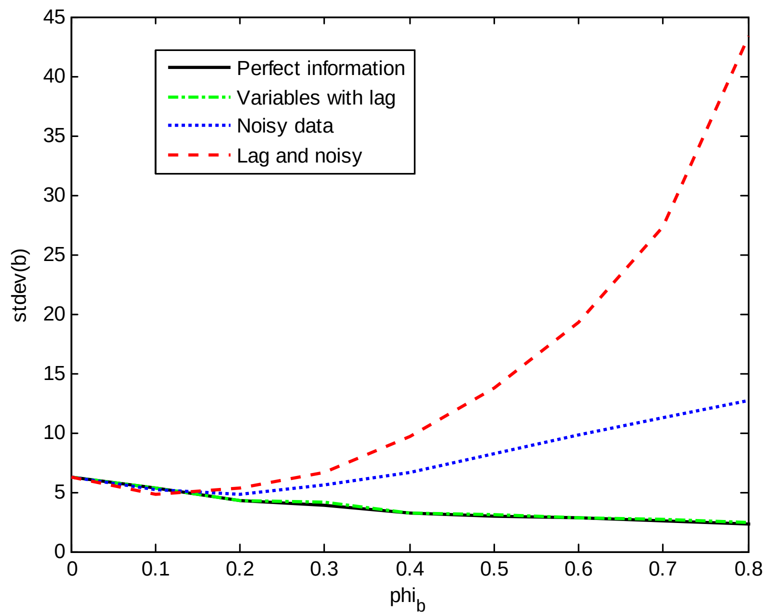

Figure 4: Standard deviation of borrowing for different values of the rule reaction parameter

If variables are observed with a lag, the rule performs only marginally worse than with perfect information. When variables are observed with noise, the rule is less effective than with perfect information and worsens in fact the stability of the financial system. A combination of lagged values of the variables and error term exacerbates the results. In this case, unless using the rule in a very cautious way, with a low value of the reaction parameter, the macroprudential regulator generates more instability than without the macroprudential policy. However, if the macroprudential regulator takes the option of being very conservative, with a reaction parameter of around 0.1, to avoid the potential problem of imperfect information, the effects of the policy are more limited.[22]

This graph suggests that if there is imperfect information and an active rule is applied, financial stability might get worse than without macroprudential policies, especially when increasing the aggressiveness of the rule. Results are in line with the literature on monetary policies with noisy and imperfect information. As in this literature, straight adoption of policies which are effective when information is perfect may result in economic performance which is worse than the initial situation. An activist policy which does not take into account the noise in the data can increase rather than decrease instability.

[22] In subsequent sections, we will call this case "cautious rule with imperfect information."

4 Policy Comparison: Active versus Passive

In this section we compare the different macroprudential policies that we have proposed to assess whether an active or a passive policy is preferred and under which circumstances. We first present impulse responses for the three most paradigmatic cases: The benchmark, with no macroprudential policies, the active rule with perfect information and the passive policy corresponding to increasing collateral requirements to the average increase with the active rule, in order for the two cases to be comparable. Then, we show how the different policies affect financial stability and steady-state values of output and borrowing, including also the cases of imperfect information.

As in Angelini et al. (2014) and other studies in which the existence of macroprudential regulator is not microfounded, we take a positive approach instead of a welfare-based evaluation, since the costs and benefits of macroprudential policies may not be fully captured by the utility of the agents. We take the existence of the collateral constraint and the financial policy as given and compare policies in terms of the financial and macroeconomic volatility they generate. We assume that the objective of the macroprudential regulator is to minimize the volatility in financial markets without compromising macroeconomic stability and long-term output. We will rank policies using this criterion.[23]

4.1 Impulse Responses

Figure 5 displays the dynamics of the level of the collateral requirement, the instrument of the macroprudential regulator, when there is a demand shock. We compare the benchmark case, in which there are no macroprudential policies in place, with the case in which the regulator applies the policy (both passive and active). For the active rule, we consider a reaction parameter of 0.5 and perfect information.[24] For the passive rule, to make it comparable to the active one, we take the average increase of the collateral requirement implied the macroprudential rule for the first 20 periods of the impulse responses and approximate a permanent equivalent increase as a passive macroprudential policy.[25] For the benchmark, the collateral requirement remains at its steady-state level, which was calibrated to 183.2. However, in

[23]This analysis could be comparable to using Taylor curves to rank monetary policies. Taylor curve, or policy frontiers, display the trade-off between inflation and output stabilization, so that a policy is preferred when it mananges to reduce further the volatilities of these two variables. See for instance Iacoviello (2005) for an example of monetary policy evaluation using Taylor curves.

[24]For presentation purposes, we do not include impulse responses for the imperfect information case, since they are very unstable and make it difficult the comparison. They are available upon request.

[25]For this passive policy we consider an increase collateral requirement once and for all which is equivalent to the average increase produced by the active rule for the first 20 periods. In this case, it would be an increase in the requirement requirement from 183.2 to 250, approximately.

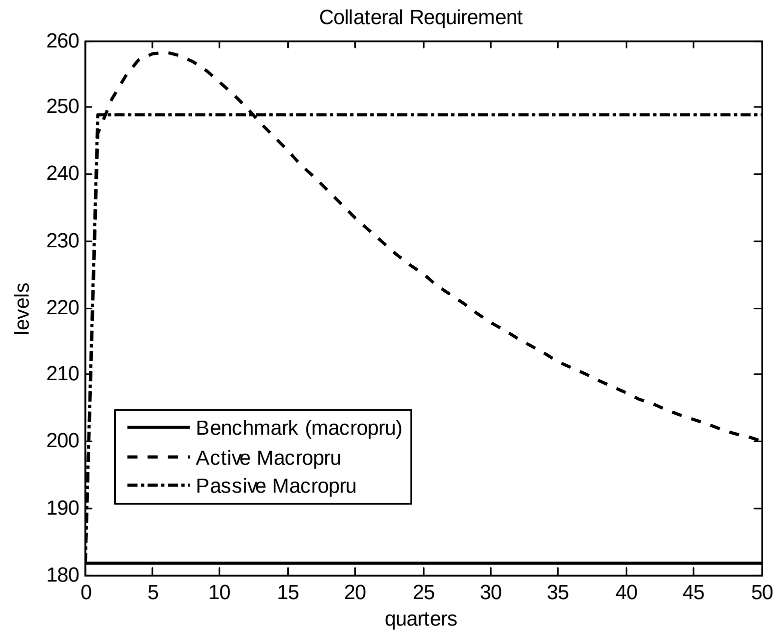

Figure 5: Collateral Requirement response (in levels)

the case of the active rule, collateral requirements increase, to go back to the steady state after a certain amount of periods. This is because, when there is an expansionary shock in the economy, credit increases and this activates the macroprudential rule, which reacts to deviations of credit from its steady state. When there is a positive demand shock, this generates an extra amount of income in the economy that pushes investment, consumption, output and borrowing. In order to avoid credit to increase in excess, the macroprudential regulator, uses the countercyclical rule and increases collateral requirements in order to limit credit growth. However, this increase in temporary and, gradually, collateral requirements return to their initial value. If we consider a passive rule, collateral requirements increase permanently. This policy also achieves the goal of cutting credit but not in a countercyclical and temporary way. Increasing collateral requirements once and for all does not only decrease short-term dynamics of credit but also its steady state, which will be lower. Output in the steady state also decreases permanently with a passive measure. Therefore, there is a long-run output cost associated with this passive policy.

Figure 6 displays impulse responses for a demand shock, for the variables of interest in the model.[26] We can observe from the graph that macroprudential policies mitigate the effects of the shock for aggregate output, especially if the policy is an active one, because of the countercyclicality of the rule.

[26] Note that impulse responses show percent deviations of variables from their steady states. For the case of the active policy the steady state is not changing with respect to the benchmark, however, for the passive policy, there is a change to a new lower steady state.

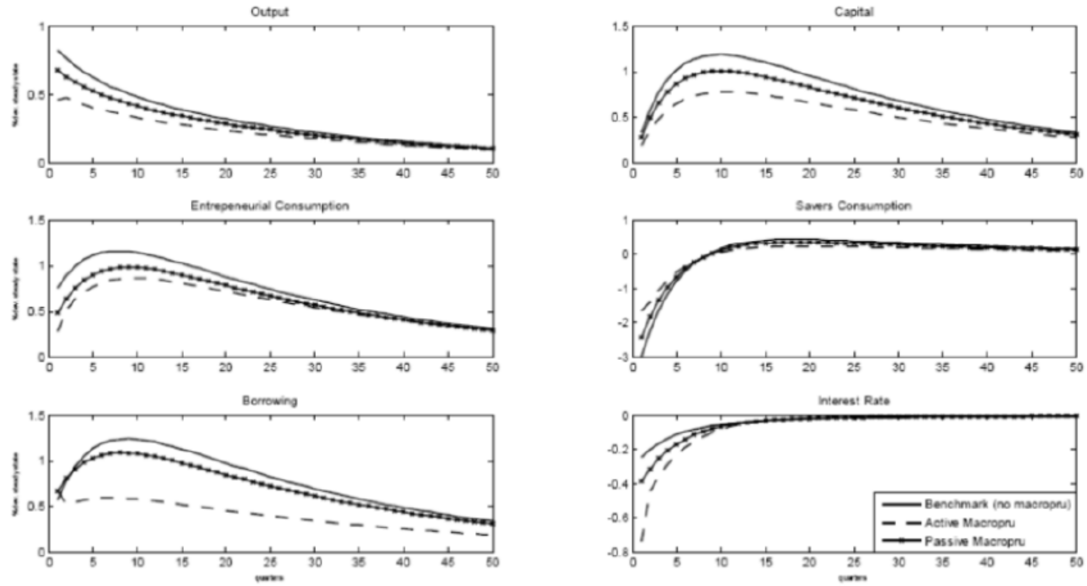

Figure 6: Impulse Responses to a Demand Shock. Benchmark (No macropru), Active Macropru, Passive Macropru

The increases in the collateral requirement that we observed in figure 5 cut down borrowing in both macroprudential cases, more strongly though for the active rule. This dampening in credit makes entrepreneurial consumption not to increase as much as in the benchmark case, softening the effects of the initial expansionary shock. Household consumption is the mirror image of entrepreneurial consumption since they now save less, responding to the cut in credit. The interest rate decreases more strongly with macroprudential policies. In models without collateral constraints, the interest rate matches the marginal product of capital. However, with collateral constraints, the interest rate is also determined by the collateral requirement. When the requirements increase, the demand for credit decreases and that makes its price decrease as well.[27] Overall, we see from the dynamics of the model that the increase in the collateral requirement that macroprudential policies imply have an effective impact on credit, the goal of the macroprudential regulator. The effect is stronger for the active policy and, although it mitigates further the effects of the shock than the passive policy, it does not have a long-run cost because it does not affect the steady state.

[27] From equations (4) and (6) , one can see that the interest rate is inversely related to collateral requirement.

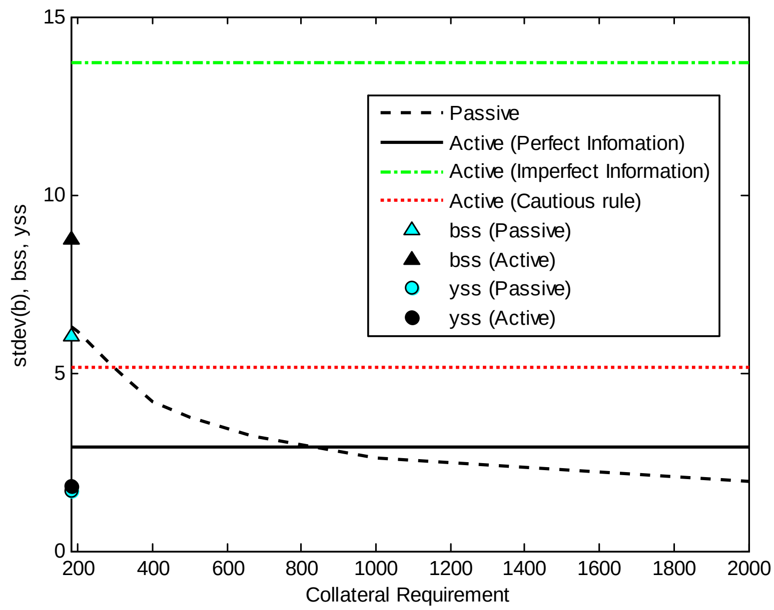

Figure 7: Collateral Requirements and Financial Stability. Active versus Passive.

4.2 Financial and Macroeconomic Stability

In this subsection we study the implications of the different policies for financial and macroeconomic stability, as well as for the steady state of the economy. Since we are assuming that the objective of the macroprudential regulator is to achieve a more stable financial scenario, without compromising macroeconomic stability, we will consider that a policy will be preferable when it implies higher financial stability without a macroeconomic stability cost. We will also consider that a policy that, as a by-product, generates a lower steady state of output and borrowing has an associated cost and will be therefore less desirable.

In figure 7 we can see how financial stability changes with the collateral requirement for passive policies (the black dashed line). For active policies we consider both the cases of perfect and imperfect information. The active rule with perfect information corresponds to the black solid horizontal line. The active rule with imperfect information is represented by the green dashed-dotted horizontal line. For both rules we present the standard deviation of credit implied by a reaction parameter of 0.5. The lines are horizontal because financial stability does not depend on the collateral requirement, since at the steady state, it remains constant at the initial calibrated value. We also present in the graph, what we have called the "cautious rule," that is, the rule with imperfect information with a reaction parameter of 0.1, for which financial stability is not increasing with the policy but its effectiveness is limited. This "cautious rule" corresponds to the red dotted line.

Furthermore, figure 7 also displays the steady-state values of borrowing and output for both the passive and the active rules. The black and blue triangles represent the steady state of borrowing of the active and the passive rule, respectively. In turn, the black and blue circles correspond to the respective steady states of output.

From the graph we can see that the active rule with perfect information is preferred to the passive rule, in the sense that it implies a lower variability of borrowing, for plausible parameters of the collateral requirement. Furthermore, apart from the active rule being preferable from the point of view of financial stability, it does not have associated a long-term steady-state cost in terms of borrowing and output. In order for the passive rule to achieve the same financial stability as the active rule, the collateral requirement would have to go permanently as high as 833, which would imply a steady-state output of 1.74 and a steady-state borrowing of 1.64.[28] However, if there is imperfect information and noisy data, as it is usually the case in low-income and developing countries, things change. The active rule with imperfect information always delivers higher variability of borrowing than a passive approach, even though it entails a long-run output cost. For the "cautious rule," the active rule is preferred than the passive rule up to a value of the collateral requirement of approximately 312. The "cautious rule" with imperfect information is able to deliver higher financial stability than the initial situation with no macroprudential policies but its effectiveness is limited with respect to a more aggressive rule with perfect information.[29]

In Table 2 we convey these results:

Table 2: Policy Comparison

	Benchmark	**Active (Perfect Inf)**	**Active (Imperfect Inf)**	**Passive**
σ_b	6.30528	2.91223	13.71666	5.15497
σ_y	2.68960	1.71788	3.561224	2.16968
b_{SS}	8.74839	8.74839	8.74839	6.03170
y_{SS}	1.82683	1.82683	1.82683	1.79848

[28] These results are in line with the literature on macroprudential policies in advanced economies, in which rules are preferred to passive policies.

[29] Results do not have to be taken from a quantitative point of view, since the rule is not optimally implemented and the value of the noise is not calibrated. We make the point that with a plausible parameter of the reaction parameter and a large enough shock, results with respect to the perfect information case may be reversed.

Table 2 shows the standard deviations of borrowing and output, as a proxy for financial and macroeconomic stability, for the benchmark (with no macroprudential policies) and for the passive and active rules (both perfect and imperfect information). It also presents the steady-state values of borrowing and output, in order to have a sense of the long-run cost that each policy has associated. As can be seen, with perfect information, an active rule is preferred to a passive rule in terms of both macroeconomic and financial stability, since the standard deviation of borrowing and output decreases with respect to the benchmark of no macroprudential policies. Furthermore, the rule does not imply a long-run cost for the economy, since the steady-state values of these two variables remain the same. However, if data is observed imperfectly, a passive approach would be more advisable for the objective of attaining a low variability of credit and output, even though it generates a long-run steady-state cost in terms of output and borrowing.[30]

5 Concluding Remarks

In this paper we develop a DSGE model to analyze the implementation of macroprudential policies in low-income developing countries. The economy features households and entrepreneurs. Entrepreneurs use capital and labor to produce. Capital is also used as collateral for loans. We assume that there exists a macroprudential regulator that takes collateral requirements as a policy instrument. Macroprudential policies can be passive or active. Passive policies imply increasing collateral requirements permanently. An active policy is represented by a countercyclical rule on collateral requirements that respond to expected deviations of credit from its steady state. However, for low-income developing countries, we consider that this indicator may be observed imperfectly.

Results show that macroprudential policies are effective to reduce financial instability, since they lower the volatility of credit. We find that if the macroprudential regulator is able to observe economic indicators without an error, active time-varying policies are preferred to passive approaches. Active policies, being countercyclical, are more effective to achieve financial stability without incurring in a long-run output cost. Passive policies, although they also manage to enhance a more stable financial system, they are not as effective and they imply a permanently lower steady-state output. However, under imperfect information and inability of policy makers to observe financial indicators without noise,

[30] This result is analogous to the monetary policy literature with noisy data. In this literature, those who believe that the knowledge of the economy is seriously lacking suggest adopting passive rules that forego short-run stabilization (See Orphanides, 2003).

this may not be the case. Under these circumstances, a non-aggressive policy or a passive approach may be more advisable, even though the latter one entails a long-run output cost.

The policy implications of these results are clear; there should be an effort in these countries to reduce problems of regulatory and supervisory capacity in order to enable authorities to better monitor financial systems and be able to use time-varying effective approaches which do not imply a long-run output loss.

Appendix

Steady State Relationships

From equation 9 we have that $R = 1/\beta$. From equation 4 we obtain $\lambda = \frac{\beta-\gamma}{c}$, which implies that the collateral constraint binds with equality in the steady state. From equation 3 we find the ratio of borrowing to capital: $\frac{b}{k} = z\beta$. From the definition of investment, we obtain: $i = \delta k$. From equation 6 we can find the output to capital ratio: $\frac{Y}{k} = \frac{1-\gamma(1-\delta)-z(\beta-\gamma)}{\gamma\mu}$. And from equation 2 the consumption to capital ratio: $\frac{c}{k} = \frac{1+z\beta(\gamma-1)+\gamma(z-1)}{\gamma}$. From 12 we have that $q = 1$.

If we normalize labor at the steady state to be 1, then we obtain from equation 1 that $Y = k^{\mu}$. Then, we can solve for the value of capital in the steady state:

$$k = \left(\frac{1-\gamma\left(1-\delta\right)-z\left(\beta-\gamma\right)}{\gamma\mu}\right)^{\frac{1}{\mu-1}}$$

In the same way, for bonds, consumption, and output:

$$b = z\beta\left(\frac{1-\gamma\left(1-\delta\right)-z\left(\beta-\gamma\right)}{\gamma\mu}\right)^{\frac{1}{\mu-1}}$$

$$c = \left(\frac{1+z\beta\left(\gamma-1\right)+\gamma\left(z-1\right)}{\gamma}\right)\left(\frac{1-\gamma\left(1-\delta\right)-z\left(\beta-\gamma\right)}{\gamma\mu}\right)^{\frac{1}{\mu-1}}$$

$$Y = \left(\frac{1-\gamma\left(1-\delta\right)-z\left(\beta-\gamma\right)}{\gamma\mu}\right)^{\frac{\mu}{\mu-1}}$$

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