# Cross-Country Spillovers from Macroprudential Regulation: Reciprocity and Leakage

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**Abstract**

In a globally interconnected banking system, there can be spillovers from domestic macroprudential policies to foreign banks and vice versa, for example, through the presence of foreign branches in the domestic economy. The lack of reciprocity of some macroprudential instruments may result in an increase in bank flows to those banks with lower regulatory levels, a phenomenon known as "leakage." This may decrease the effectiveness of macroprudential policies in the pursuit of financial stability. To explore this topic, I consider a two-country DSGE model with housing and credit constraints. Borrowers can choose whether to borrow from domestic or foreign banks. Macroprudential policies are conducted at a national level and are represented by a countercyclical rule on the loan-to-value ratio. Results show that when there are some sort of reciprocity agreements on macroprudential policies across countries, financial stability and welfare gains are larger than in a situation of non reciprocity. An optimal policy analysis shows that, in order to enhance the effectiveness of macroprudential policies, reciprocity mechanisms are desirable although the foreign macroprudential rule does not need to be as aggressive as the domestic one.

Keywords: Macroprudential Policies, Spillovers, Banking Regulation, Foreign Branches, Leakage, Loan-to-value

JEL Classification: E44, F34, F41

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"*The current framework already effectively addresses a number of risks emerging at national level. Yet, it is biased in selecting instruments to counter vulnerabilities at the national level while having a tendency to disregard cross-border implications, such as leakages, which may weaken the overall macro-prudential stance.*". Speech by Vítor Constâncio, Vice-President of the ECB, at the joint conference organized by the European Commission and the European Central Bank "European Financial Integration and Stability," 27 April 2015.

# 1 Introduction

In the aftermath of the financial crisis, there is consensus on the need for macroprudential policies to smooth the level of leverage in the financial system and therefore enhance its resilience. However, in a globally interconnected banking system, countries have less control over their own financial stability. Macroprudential measures may have cross-border spillover effects, which can go in different directions; they can be outward, when macroprudential policy affects conditions abroad. Or they can be inward, when foreign financial institutions are able to circumvent the national macroprudential policy. In this case, reciprocity agreements may be desirable.

In this paper, I focus on inward (or "waterbed") spillovers from macroprudential policy. National policies to contain risks from a rapid build-up of domestic credit can lead to an increase in the share of credit that is provided across borders, a phenomenon that has come to be known as "leakage." Thus, foreign banks can "undo" the intended effects of the domestic regulatory action. One example of such spillovers is where branches of foreign banks increase lending as a result of tighter financial regulation on domestic banks, if they are not subject to the same regulation as domestic banks. Then, if there is no reciprocity in policies across countries, that is, different regulatory regimes, credit activities may move from the regulated system to the non-regulated one.[1]

This cross-border arbitrage can occur through direct lending by cross-border banks to domestic borrowers, lending locally by foreign branches, as well as a rebooking of loans, whereby credit is originated by subsidiaries, but then booked on the balance sheet of the parent institution. The distinction between branches and subsidiaries is relevant as only subsidiaries are subject to the regulatory conditions of their host country. Branches, in the absence of reciprocity arrangements, are not bound by domestic macroprudential policy measures. Although subsidiaries are subject to the regulatory conditions in the

[1] The same argument could apply to shadow banking within the country.

host country, a large share of subsidiaries in one country can indicate substantial potential for regulatory arbitrage when financial intermediation that previously took place via subsidiaries is shifted to branches, or if subsidiaries are converted into branches. In addition, these spillovers may occur if lending in the country is substituted with direct lending from the home country of the banking group. In either case, the financial intermediation would no longer fall within the realm of macroprudential policy in the host country.

There is evidence of inward geographical macroprudential spillovers in several countries. For instance, leakage effects seem to have complicated the response to national credit booms in a number of countries in Eastern Europe ahead of the crisis, e.g. in Bulgaria and Croatia (See Viñals and Nier, 2014). For the United Kingdom, Aiyar et al. (2012) estimate that just under a third of the reduction in credit growth that could have been achieved from increases in capital requirements on regulated banks was "undone" by an increase in lending by foreign branches that were not subject to the same requirements.

In light of this evidence, international spillovers through foreign banks' presence in a country matter for instrument effectiveness within a country's borders and are relevant for the broader issues of policy frameworks, reciprocity, and welfare. Leakage effects derived from foreign bank presence may call for cooperative action in the form of reciprocity in the conduct of macroprudential policy. The relevant policy question that arises then is how should reciprocity agreements be arranged so that macroprudential policies reach the highest levels of financial stability and welfare. The necessity of exploring these effects using a policy model is evident. This paper aims to fill this gap.

In this paper, I touch upon these issues, providing an analytical framework to disentangle the mechanisms behind the empirical evidence on the topic. I use a DSGE model with housing, and two types of agents; borrowers and lenders. Borrowers can borrow from domestic and foreign lenders and face collateral constraints when doing so. As in Iacoviello and Minetti (2006), I assume that foreign lenders have more difficulties in recovering domestic borrowers' assets and therefore, borrowers will have a preference for domestic lenders. Macroprudential regulators use the loan-to-value ratio (LTV) as a policy instrument. However, foreign lenders may not be subject to the same banking regulation as the host country, there may be lack of reciprocity. Within this setting, I study how domestic regulation affects the share of foreign borrowing, that is, if there are leakages coming from macroprudential policy. Then, I analyze how reciprocity agreements affect the dynamics of the model, financial stability and welfare. Finally, I perform an optimal policy analysis to assess the most effective macroprudential policy to maximize welfare, taking into account spillovers.

This paper is related to several strands of the literature. First, it is closely related to studies that analyze macroprudential rules in a DSGE setting, such as Kannan et al. (2012), Rubio and Carrasco-Gallego (2014), or Angelini et al. (2014), among others. Nevertheless, this literature has not touched upon inward spillovers of macroprudential policies. To my knowledge, this is the first DSGE framework that explicitly introduces this issue. In fact, leakages have been mainly studied from an empirical point of view, as for instance in the above mentioned studies from Aiyar et al. (2012, 2014ab) for the UK. Therefore, this paper represents the theoretical counterpart to the literature that finds evidence on leakages from domestic macroprudential policy. It contributes to this literature by being able to analytically disentangle the mechanisms behind this phenomenon through a DSGE model suitable for policy evaluation and welfare analysis. In terms of modelling, this paper is also related to models that study how the presence of foreign lenders affects the economy. On this front, the closest paper to this research is Iacoviello and Minetti (2006). However, the latter paper abstracts from macroprudential policies. To my knowledge, this is the first time that this question is explored using a DSGE framework, which is extremely useful for policy evaluation.

Results show that, in the presence of foreign lending, macroprudential policy does leak. The share of domestic borrowing is not only inversely related to stricter domestic regulation, but also to loose regulation in foreign lending. Therefore, when domestic macroprudential policies do not reciprocate, inward spillovers appear. This has implications for financial stability and welfare. Macroprudential policies represent a welfare gain and an improvement in financial stability with respect to a situation in which there are not such policies. However, gains in terms of welfare and financial stability are larger under reciprocity agreements. I find that it is optimal for policies to reciprocate. However, given the preference of borrowers for domestic lenders, macroprudential policies should be applied less aggressively to foreign lenders than to the domestic ones.

The rest of the paper continues as follows. Section 2 presents some evidence on cross-country spillovers. Section 3 sets up the model. Section 4 displays results from simulations. Section 5 introduces macroprudential policies. Section 6 concludes.

## 2 Evidence

There is evidence of cross-border spillovers in many European countries. The UK is a paradigmatic example that has been vastly studied (see for instance Aiyar et al., 2014, Danisewicz et al., 2015). There

is evidence of both spillovers from domestic macroprudential policies to foreign banks operating in the UK and also spillovers from foreign macroprudential policies to banks operating in the UK. Foreign bank branches in the UK are subject to home country regulatory policies only. Empirical work shows that when capital requirements are tightened for the UK banks, loan supply significantly diminishes. However, about a third of the effect is offset by foreign branches in the UK. Thus, any tightening in capital requirements would have to be coordinated with the home supervisor of the foreign branches, so that they tighten capital requirements for UK exposures as well (See Arregui et al., 2013). Aiyar et al. (2014ab) also find evidence of spillovers from domestic macroprudential policies to foreign banks operating in the UK, as well as leakage across UK financial sub-sectors. They also show that foreign bank branches increased their lending in the UK in response to tighter measures applied to local banks, a sign of cross-border competition and regulatory arbitrage. Their study concludes that leakages have weakened policy effectiveness in the UK.

This problem is also present in policy discussions, in fact, according to the European Systemic Risk Board, ESRB (2016), in some EU countries (Bulgaria, Italy, Poland, Slovakia, Spain) current LTV limits apply to domestic banks only, while in others they also apply to foreign branches (Cyprus, Lithuania, Romania, Sweden). The ESRB expresses a concern on this issue, due to the unintended effects that these policies may have in this context.

In Europe, cross-border flows are mostly from foreign parent banks into their subsidiaries, which take advantage of the growth opportunities and competed for market share with other foreign banks. Tightening of local regulatory policies often leads the parent banks to lend directly to the private sector. According to the 2015 edition of the ECB Financial Stability Review, in the EU countries, banking activity by foreign banks is predominantly conducted via subsidiaries. The ratio of foreign subsidiaries' assets to GDP greater than 50% in Ireland, Belgium, Luxembourg, Denmark, Finland, Estonia, Latvia, the Czech Republic, Slovakia, Croatia, Bulgaria and Cyprus. The same ratio for branches reveals that assets in foreign branches exceed 30% of GDP in Ireland, the United Kingdom, Belgium, Estonia and Cyprus.

## 3 Model Setup

I consider an infinite-horizon two-country economy. The economy is populated by the same measure of infinitely lived agents, lenders and borrowers. Both types of households work, consume the final good and

housing services; Borrowers can borrow and choose whether to borrow from domestic or foreign lenders. In borrowing, borrowers face credit constraints. Foreign lenders differ from domestic lenders in their ability to recover value from borrowers' assets and, therefore, to protect themselves against contractual non-enforceability. The two countries are symmetric and therefore, without loss of generality, and given that in this paper I just focus on the domestic economy, only the latter is described hereafter.

### 3.1 Borrowers

Borrowers maximize their lifetime utility from the consumption flow. I denote with $E_t$ the expectation operator conditional on time $t$ information and with $\gamma \in (0,1)$ the borrowers' discount factor. Borrowers solve the following problem:

$$\max_{b_t^H, b_t^F, l_t, \alpha_t} E_0 \sum_{t=0}^{\infty} \gamma^t \left( \ln c_t + j_t \ln h_t - \frac{(l_t)^\eta}{\eta} \right)$$

subject to the flow of funds:

$$c_t + q_t \left(h_t - h_{t-1}\right) + R_{t-1}^H b_{t-1}^H + R_{t-1}^F b_{t-1}^F = b_t^H + b_t^F + w_t l_t \tag{1}$$

where $c_t$ and $h_t$ denote consumption and housing by borrowers, respectively. $b_t^H$ and $b_t^F$ represent domestic and foreign bond holdings, with their respective associated interest rates $R_t^H$ and $R_t^F$. $w_t l_t$ is the borrower's labor income. $j_t$ represents the weight of housing in the utility function. I assume that $\log\left(j_t\right) = \log(j) + u_{Jt}$, where $u_{Jt}$ follows an autoregressive process and $j$ is the steady-state value of the weight of housing. A shock to $j_t$ represents a shock to the marginal utility of housing. These shocks directly affect housing demand and therefore can be interpreted as a proxy for exogenous disturbances to house prices.

Assuming that $h_t$ is collateralizable, I denote $m_H$ the domestic loan-to-value for housing and $\alpha_t$ the share of collateral which is pledged to domestic lenders. $m_F$ is the loan-to-value for foreign lenders. Then, the borrower faces the following borrowing constraints:

$$R_t^H b_t^H \leq m_H \alpha_t q_{t+1} h_t \tag{2}$$

$$R_t^F b_t^F \leq q_{t+1} \left(1 - \alpha_t\right) h_t \left( 1 - \left(1 - m_F\right) \frac{q_{t+1} \left(1 - \alpha_t\right) h_t}{qh} \right) \tag{3}$$

As in Iacoviello and Minetti (2006), the collateral constraints with respect to domestic and foreign lenders are different to capture the idea that foreign lenders are likely to have limited experience in recovering and liquidating the assets of the borrowers.[2] The main assumption of the model is the decreasing marginal ability of foreign lenders to extract value from borrowers' assets. This assumption is made to capture the idea that foreign lenders have limited local experience and knowledge, which can be put under more pressure than that of domestic lenders as the value of assets to be liquidated increases.[3] There is empirical evidence that this might be the case. For instance, Rajan and Zingales (1998) argue that foreign lenders were exposed to such a problem in East Asian countries, where accounting standards and disclosure and bankruptcy laws were poorly drafted and enforced. Ramey and Shapiro (2001) also stress the importance of search costs in the redeployment of assets. The ability of a lender to identify efficient users is at least in part a by-product of the information gathered in previous credit relationships. Since foreign lenders have generally a shorter history in lending to local firms, they will likely have limited ability. Hermalin and Rose (1999) argue that foreign lenders face higher marginal monitoring and debt recovery costs than domestic lenders. Thus, it is reasonable to assume that gathering additional information is more costly for foreign lenders than for domestic ones: that is, the monitoring technology of foreign lenders exhibits decreasing returns to scale.

Borrowers choose labor and assets, how much to borrow from domestic and foreign lenders, and how to allocate shares $\alpha_t$ of assets between domestic and foreign financiers. The first-order conditions are as follows:

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

$$\frac{1}{c_t} = E_t\left(\frac{\gamma R_t^F}{c_{t+1}}\right) + \lambda_t^F R_t^F \tag{5}$$

[2]The foreign lender expects to pay a convex cost $(1-m_F)E_t\left(\frac{1}{qh}\left(q_{t+1}h_t\right)^2\right)$ to dispose of the asset in case of debt repudiation, where $qh$ is just a steady-state normalization. Therefore, the value that the foreign lender can expect to recover from the sale of the asset is $E_t\left(q_{t+1}h_t - \frac{1-m_F}{qh}\left(q_{t+1}h_t\right)^2\right)$.

[3]The liquidation technologies imply that, for small values of assets, foreign lenders have a lower average liquidation cost than domestic ones. Otherwise, foreign lenders would be dominated by domestic ones and would never be chosen in equilibrium. However, for sufficiently high values of collateral, the advantage due to their organized offices is offset by the disadvantage due to their limited local experience.

$$\frac{j_t}{h_t} = E_t\left(\frac{1}{c_t}q_t - \frac{\gamma q_{t+1}}{c_{t+1}}\right) + \lambda_t^H m_H \alpha_t q_{t+1} + \lambda_t^F\left(1-\alpha_t\right) q_{t+1}\left(1 - \frac{2\left(1-m_F\right)\left(1-\alpha_t\right) q_{t+1}h_t}{qh}\right) \tag{6}$$

$$\lambda_t^H m_H = \lambda_t^F E_t\left(1 - \frac{2\left(1-m_F\right)\left(1-\alpha_t\right) q_{t+1}h_t}{qh}\right) \tag{7}$$

$$w_t = \left(l_t\right)^{\eta-1} c_t \tag{8}$$

where $\lambda_t^H$ and $\lambda_t^F$ are the Lagrange multipliers of the domestic and foreign borrowing constraint, respectively. The first-order conditions are the consumption Euler equations (4 and 5), asset demand (6), choice of $\alpha_t$ (7), and labor supply (8).

From equations (4), (5), and (7), we can solve for $\alpha_t$:

$$\alpha_t = 1 - \frac{1 - \left(\lambda_t^H/\lambda_t^F\right) m_H}{1-m_F}\frac{qh}{2q_{t+1}h_t} \tag{9}$$

If we find the value of $\alpha_t$ in the steady state, we obtain:

$$\alpha = 1 - \frac{1-m_H}{2\left(1-m_F\right)} \tag{10}$$

Therefore, in the steady state, the share of domestic collateral will be positively related to the average domestic loan-to-value ratio ($m_H$) and inversely related to average foreign loan-to-value ratio ($m_F$). In other words, credit will flow to the country with less strict regulation, that is, there are spillovers coming from LTV regulation.

### 3.2 Lenders

Let us denote lenders variables with a prime. Lenders enter each period with assets and a bond coming to maturity. They derive utility from consumption, leisure and from housing. They rent labor and lend $b_t^H$ to domestic borrowers, $b_t^{F*}$ to foreign borrowers, and lend $b_t$ to foreign lenders, while receiving back the amount lent in the previous period times the agreed gross interest rates, respectively $R^H$, $R^{F*}$ and $R$.

Preferences are given by:

$$\max_{b_t^H, b_t^{F*}, h_t', b_t, l_t} E_0 \sum_{t=0}^{\infty} \beta^t \left( \ln c_t' + j_t \ln h_t' - \frac{(l_t')^\eta}{\eta} \right) \tag{11}$$

where $\beta$ is the discount factor, which is assumed to be greater than $\gamma$, the discount factor for lenders.[4] These households maximize (11) subject to the flow of funds:

$$c_t' + q_t \left( h_t' - h_{t-1}' \right) + b_t^H + b_t^{F*} + b_t = R_{t-1}^H b_{t-1}^H + R_{t-1}^{F*} b_{t-1}^{F*} + R_{t-1} b_{t-1} + w_t' l_t' \tag{12}$$

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

$$\frac{1}{c_t'} = \beta E_t \left( \frac{R_t}{c_{t+1}'} \right) \tag{13}$$

$$R_t^H = R_t^{F*} \tag{14}$$

$$R_t^H = R_t \tag{15}$$

$$w_t' = c_t' \left( l_t' \right)^{\eta - 1} \tag{16}$$

$$\frac{q_t}{c_t'} = \frac{j_t}{h_t'} + \beta E_t \left( \frac{q_{t+1}}{c_{t+1}'} \right) \tag{17}$$

where equation (13) represents the Euler equation for consumption. Equations (14) and (15) are the no-arbitrage opportunities conditions that will yield a single world interest rate in equilibrium. Equations (16) and (17) are the labor supply schedule and the asset demand schedule, respectively.

### 3.3 Firms

Firms produce the final consumption good. The problem for the final good firms is standard and static. They maximize profits subject to the production function by using labor from both types of households:[5]

[4] In a neighborhood of the steady state equilibrium, the multipliers associated with the entrepreneurs collateral constraints will be positive, so long as the entrepreneurial discount factor $\gamma$ is lower than the households' discount factor $\beta$, which in turn prices bonds.

[5] Following the literature that starts with Kiyotaki and Moore (1997) and builds up with Iacoviello (2005) and Iacoviello (2015), I assume that output is produced with labor supplied from both agents. In this way I make this model comparable with the rest of the literature.

$$\max \Pi_t = y_t - w_t l_t - w'_t l'_t,$$

$$y_t = A_t l_t^{\nu} l_t'^{1-\nu}, \tag{18}$$

where $A_t$ represents a technology parameter. The problem delivers the standard first-order conditions, which represent the labor-demand equations:

$$w_t = \frac{\nu y_t}{l_t}, \tag{19}$$

$$w'_t = \frac{(1-\nu)\, y_t}{l'_t}. \tag{20}$$

### 3.4 Equilibrium

The total supply of housing is fixed and it is normalized to unity:

$$h_t + h'_t = 1. \tag{21}$$

The goods market clearing condition is as follows:

$$y_t = c_t + c'_t, \tag{22}$$

Labor supply (equations 8 and 16) and labor demand (equations 19 and 20) are equal to each other, so that labor markets also clear.

### 3.5 Welfare Measure

As discussed in Benigno and Woodford (2008), the two approaches that have recently been used for welfare analysis in DSGE models include either characterizing the optimal Ramsey policy, or solving the model using a second-order approximation to the structural equations for a given policy and then evaluating welfare using this solution. As in Mendicino and Pescatori (2007), and Rubio (2011), we take this latter approach to be able to evaluate the welfare of the two types of agents separately.[6] The

[6] I used the software Dynare to obtain a solution for the equilibrium implied by a given policy by solving a second-order approximation to the constraints, then evaluating welfare under the policy using this approximate solution, as in Schmitt-

individual welfare for domestic borrowers and lenders is defined, respectively, as follows:

$$V_t \equiv \; E_t \sum_{k=0}^{\infty} \gamma^k \left( \ln c_{t+k} + j \ln h_{t+k} - \frac{(l_{t+k})^{\eta}}{\eta} \right), \tag{23}$$

$$V_t' \equiv \; E_t \sum_{k=0}^{\infty} \beta^k \left( \ln c'_{t+k} + j \ln h'_{t+k} - \frac{(l'_{t+k})^{\eta}}{\eta} \right), \tag{24}$$

Following Mendicino and Pescatori (2007), we define social welfare as a weighted sum of the individual welfare for the different types of households:

$$W_t = (1-\gamma)\, V_t + (1-\beta)\, V_t'. \tag{25}$$

Borrowers' and lenders' welfare are weighted by $(1-\gamma)$ and $(1-\beta)$, respectively, so that the two groups receive the same level of utility from a constant consumption stream.

To make results more intuitive, I present welfare changes in terms of consumption equivalents. The consumption equivalent measure defines the fraction of consumption that needs to be given up to equate the welfare under the new policy to the welfare under the baseline case (the policy is not active). A positive value means a welfare gain, hence indicates that the new policy is more desirable from a welfare point of view. The derivation of the welfare benefits in terms of consumption equivalent units is as follows:

$$CE = \exp\left[(1-\gamma)\left(V^{MP} - V^{*}\right)\right] - 1, \tag{26}$$

$$CE' = \exp\left[(1-\beta)\left(V'^{MP} - V'^{*}\right)\right] - 1, \tag{27}$$

where the superscripts in the welfare values denote the benchmark case when policy is not active and the case in which it is, respectively.[7]

Grohe and Uribe (2004). See Monacelli (2006) for an example of the Ramsey approach in a model with heterogeneous consumers.

[7] I follow Ascari and Ropele (2009).

# 4 Simulations

In order to gain some insight about the model, in this section I first show how the steady state proportion of domestic credit changes with the value of the LTV. Then, I present some impulse responses to see the dynamics of selected variables in the model, including the share of domestic lending, when the domestic economy is hit by a technology and a housing demand shock. The next subsection describes the parameter values used for calibration.

## 4.1 Parameter Values

The model time period is a quarter. As in standard models, $\beta = 0.99$, implying an annual real interest rate of 4%; $\gamma = 0.98$, so that borrowers are more impatient than lenders.[8] The steady-state weight of housing in the utility function, $j$, is set to 0.1 in order for the ratio of housing wealth to GDP to be approximately 1.40 in the steady state, consistent with the US data. I set $\eta = 2$, implying a value of the labor supply elasticity of 1.[9] The labor-income share for lenders is set to 0.64, following the estimate in Iacoviello (2005). As in Iacoviello and Minetti (2006), the parameters describing the average liquidation ability (the LTVs) are set equal to $m_H = 0.9$ and $m_F = 0.8$ to reflect the fact that domestic lenders have a better liquidation technology than foreign ones. I assume that technology and housing demand follow an autoregressive process with 0.92 and 0.96 persistence, respectively, and a normally distributed shock with 0.01 and 0.04 standard deviation.[10] Table 1 presents a summary of the parameter values used:

[8] I have experimented with different discount rates and the leverage ratio, although it changes with the value of gamma, it does not show very large difference. For instance, the leverage ratio when gamma is 0.98 is 0.8764, while when gamma is 0.95 is 0.8491. Lawrance (1991) estimated discount factors for poor consumers at between 0.95 and 0.98 at quarterly frequency. I take the most conservative value.

[9] Microeconomic estimates usually suggest values in the range of 0 and 0.5 (for males). Domeij and Flodén (2006) show that in the presence of borrowing constraints these estimates could have a downward bias of 50%.

[10] I follow the estimates in Iacoviello and Neri (2010).

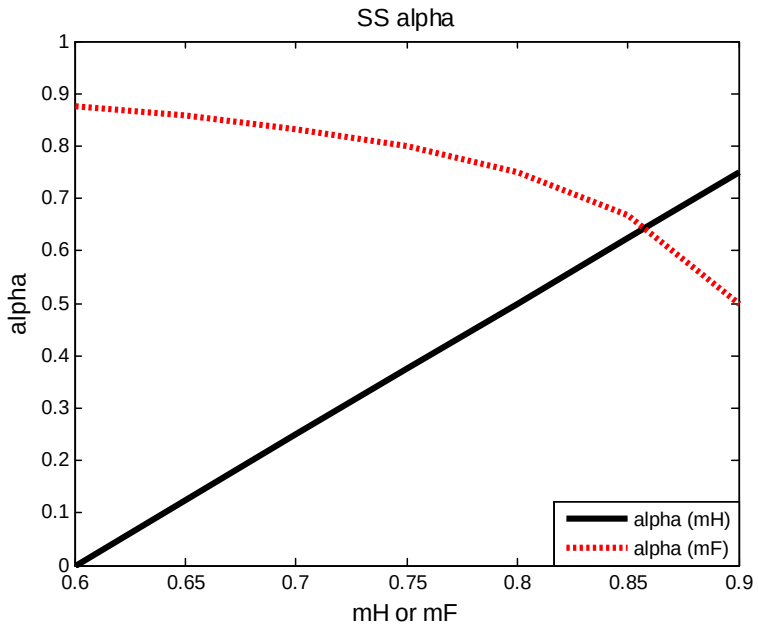


Figure 1: Steady state value of alpha for different domestic and foreign LTVs

| **Table 1: Parameter Values** | | |
|---|---|---|
| $\beta$ | .99 | Discount Factor for lenders |
| $\gamma$ | .98 | Discount Factor for Borrowers |
| $j$ | .1 | Weight of Housing in Utility Function |
| $\eta$ | 2 | Parameter associated with labor elasticity |
| $\nu$ | .64 | Labor-income share for lenders |
| $m_H$ | 0.9 | Domestic LTV |
| $m_F$ | 0.8 | Foreign LTV |
| $\rho$ | .9 | Shock persistence |

Note: Table 1 reports parameter values.

### 4.2 Steady-State alpha

Figure 1 displays how the share of domestic borrowing changes with regulation on the LTV.[11] The vertical axis reflects the value of $\alpha$ in the steady state, that is, the share devoted by borrowers to domestic borrowing. The horizontal axis displays the home and foreign LTV ($m_H$ and $m_F$, respectively). Moving

[11] For the benchmark calibration, the model generates a steady-state alpha of 60%, meaning that borrowers borrow around 40% from foreign sources. According to the World Bank, in Europe and Central Asia, this percentage was 49% in 2008, 46% in 2011, 39% in 2014, and 38% in 2015. Therefore, the model moment matches data pretty closely.

along the horizontal axis to the right would mean looser LTV regulation. The black line represents the change in the proportion of domestic borrowing when the domestic LTV changes, for given foreign LTV. This graph already gives us an idea on how domestic regulation affects this share, particularly if it is not accompanied by a change in regulation for foreign lenders in the same direction. These effects on the share would represent leakages from regulation. We see that when the domestic regulation becomes looser, that is, $m_H$ increases for a given $m_F$, credit from domestic lenders goes up in a linear way. There is a threshold at $m_H = 0.6$, at which the regulation in the host country is so strict that all credit would flow abroad. Up to this point, loosening up the regulation would linearly increase the value of $\alpha$. On the other hand, keeping fixed $m_H$, making foreign regulation looser, for instance, increasing the LTV in foreign branches, makes the proportion of domestic credit decrease, since now credit constraints are looser abroad (red dotted line). Nevertheless, notice that this decrease is non linear, reflecting the decreasing marginal ability of foreign lenders to extract value from borrowers' assets. In other words, this could be interpreted as domestic borrowers having an intrinsic preference for domestic lenders. The punchline that can be extracted from the graph is that financial regulation does leak, that is, there are cross-border spillovers coming from regulation and credit will flow to the country in which the regulation is less strict.

### 4.3 Impulse Responses

In this subsection, I present impulse responses to a productivity and a housing demand shock, in order to understand how the dynamics of the model work. Both shocks are expansionary and make output and borrowing increase. Consumers are wealthier due to the shock and they are able to borrow more. However, the question that arises is whether this increase in borrowing is evenly distributed between domestic and foreign bonds. The choice of these two shocks intends to give a complete picture of the situation, given that they represent exogenous disturbances coming from both the supply and the demand side of the economy, as well as from the real and housing sector.

Figure 2 presents impulse responses to a technology shock. We see that, given a positive productivity shock, output increases, as expected. This shock makes domestic borrowing increase because of its expansionary nature. Keeping fixed regulation and given the preference of borrowers for domestic lenders, $\alpha$, the share of domestic borrowing over total borrowing, increases, meaning that the expansion in credit is mainly domestic. Thus, there is a redistribution between domestic and foreign borrowing. Foreign borrowing also increases, but much less than the domestic one. The increase in credit makes the demand

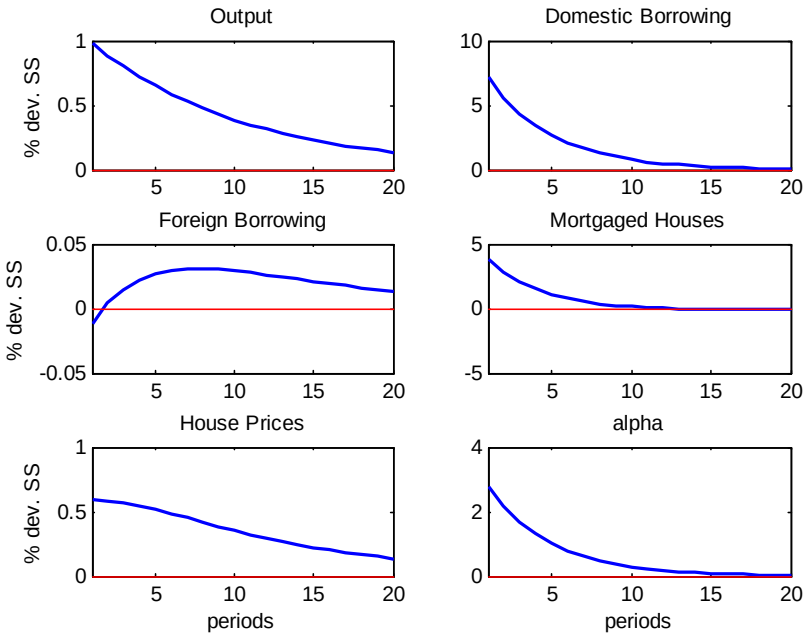


Figure 2: Impulse Responses to a Technology Shock

for mortgaged houses go up, also boosting up house prices. The increase in house prices acts as a feedback loop through collateral constraints and pushes up credit and output even further, representing the financial accelerator that is present in this model.

Figure 3 displays the impulse responses of the model to a housing demand shock. Housing demand shocks are translated directly to house prices, which is why in these type of models are usually interpreted as exogenous disturbances to house prices. A house price shock is transmitted to the macroeconomy through the collateral constraint. Higher house prices mean that the value of the collateral is higher for borrowers and thus can borrow more. Since future house prices enter in the collateral constraint, there is an initial slight drop in output, which is compensated by the increase in the collateral value in future periods. As in the previous case, we see that credit increases due to the shock but that borrowers mainly increase domestic borrowing, slightly decreasing the borrowing from abroad, as a substitution effect. This is reflected in the increase in $\alpha$, the share of borrowing that comes from domestic lenders. This is a mechanism that can be explained by the optimal value of alpha (equation 9). The share of domestic borrowing rises with house prices. That is, increases in house prices involve a switch from foreign to domestic lenders. Thus, following a house price shock, transaction costs become relatively higher at the margin for the foreign lender. Hence, the amount of foreign borrowing rises in percentage less than

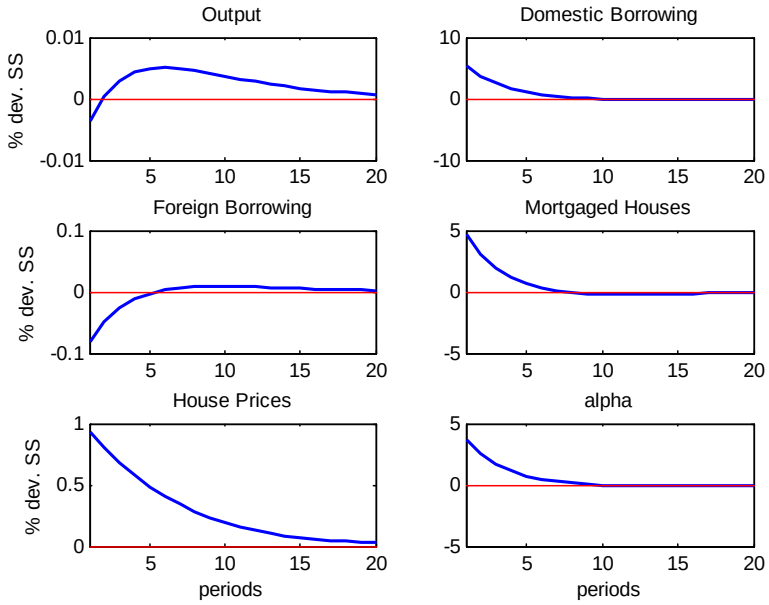


Figure 3: Impulse Responses to a House Price Shock

the amount of domestic borrowing ($\alpha$ rises).[12] The increase in borrowing then pushes up mortgaged housing and consumption goods, bringing up in turn output and making this shock expansionary for the macroeconomy.

From these impulse responses we can see that expansionary shocks in the model trigger an increase in output and borrowing, but that this borrowing mainly comes from domestic sources.

# 5 Macroprudential Policy

In this section, I introduce macroprudential policies into the model, to assess the implementation of these kind of policies in the presence of foreign banks in the domestic economy. First, I present a countercyclical macroprudential rule on the LTV as a plausible approximation for macroprudential policy. Then, I analyze the effects of the lack of reciprocity in macroprudential rules for the dynamics of the model, financial stability and welfare. Finally, I present the optimal macroprudential policy to maximize welfare.

[12] Iacoviello and Minetti (2003), using US time-series data, show that real estate values positively affect the importance of domestic versus foreign business loans.

### 5.1 Macroprudential rule

As an approximation for a realistic macroprudential policy, the literature has considered Taylor-type rules on the LTV.[13] In standard models, the LTV ratio is a fixed parameter, which is not affected by economic conditions. However, we can think of regulations of LTVs as a way to moderate credit booms. When the LTV is high, the collateral constraint is less tight. And, since the constraint is binding, borrowers will borrow as much as they are allowed to. Lowering the LTV tightens the constraint and therefore restricts the loans that borrowers can obtain. As stated in the introduction, the ESRB has identified the LTV as one of the potential macroprudential policies that in some cases is applied just domestically, while foreign banks may escape its jurisdiction.

Recent research on macroprudential policies has proposed Taylor-type rules for the LTV so that it reacts inversely to credit variables such as credit, the credit-to-GDP ratio or house prices. These rules can be a simple illustration of how a macroprudential policy could work in practice. In this model, I propose a rule in which the LTV responds to domestic house prices, as an indicator of credit conditions:[14]

$$m_{Ht} = m_H \left(q_t\right)^{-\phi_H}, \tag{28}$$

$$m_{Ft} = m_F \left(q_t\right)^{-\phi_F}, \tag{29}$$

where $m_H, m_F$ are the steady-state values for the LTV for domestic and foreign lending, respectively. $\phi_H \geq 0, \phi_F \geq 0$ measure the response of the two LTVs to house prices. This kind of rule would be countercyclical, delivering a lower LTV ratio in housing booms, therefore restricting credit in the economy.

#### 5.1.1 Reciprocity vs. Lack of Reciprocity

Within this macroprudential setting, we can consider two cases: the case in which there is no reciprocity in policies between the two countries versus the case in which there is.

We can think of the first case, that is, non reciprocity, as for example, foreign branches of banks not following the regulation of the host country. Then, if there is a boom in housing markets in the

[13] See for instance Kannan et al. (2012) or Angelini et al. (2014).

[14] An alternative would be letting the LTV respond to credit, which gives similar results. However, given that in this model there is domestic and foreign lending, it is not clear to which credit variable to respond. To make the modelling of the rule cleaner, I choose house prices as the relevant variable to respond. In any case, through collateral constraints, house prices and credit are directly related.

host country, which makes credit conditions stricter in the domestic country, foreign branches do not necessarily follow this regulation. In this case, the above mentioned leakage phenomenon may appear; funds could flee to the less regulated sector, in this case foreign lenders. In terms of the model, I approximate this case to $\phi_H > 0, \phi_F = 0$. This means that the domestic country is actively using macroprudential policies to respond to developments in domestic housing markets but foreign lenders are not responding.

However, the two countries could reach some sort of reciprocity agreement, in which case, foreign branches will also have to follow regulations in the host country and thus $\phi_H > 0, \phi_F > 0$. In the case of reciprocity, I assume that $\phi_H$ and $\phi_F$ do not necessarily have to equal each other, given that liquidation technology of domestic and foreign lenders is different. As we have seen, in the model, borrowers have a preference for domestic lenders. Thus, to avoid corner solutions, I consider reciprocity as a situation in which, even though foreign branches are applying the macroprudential policy of the host country, it does not need to be as strict as for domestic lenders.

### 5.2 Effects of Macroprudential Policies on Welfare and Financial Stability

The lack of empirical evidence on macroprudential rules, makes it very difficult to calibrate the parameters of the macroprudential rule. Therefore, I find the optimal combination of parameters, both for domestic and foreign lenders, that maximizes welfare. Results are presented in Table 2:[15]

**Table 2: Optimal Macroprudential Policy**

| $\phi_H^{OPT}$ | $\phi_F^{OPT}$ | $\sigma_{b^T}$ | **Welfare Gain** |
|---|---|---|---|
| 8.5 | 0.2 | 0.102 | 1.32 |

Note: Table 2 reports the values of the parameters in the macroprudential rule that maximize welfare.

We can observe from Table 2 that it is optimal, with the presence of foreign lenders in the domestic country, to have reciprocity in macroprudential policies. However, given that foreign lenders have more difficulties in extracting value from borrowers' collateral, the optimal macroprudential rule needs to be less aggressive for foreign lenders. In particular, the first column of the table presents the optimized parameter for the domestic macroprudential rule. We see that the domestic rule needs to be aggressive in responding to housing market developments in order to achieve financial stability and maximize welfare gains. The optimized coefficient in the foreign macroprudential rule is positive, meaning that

[15] Welfare gains are presented in consumption equivalent units.

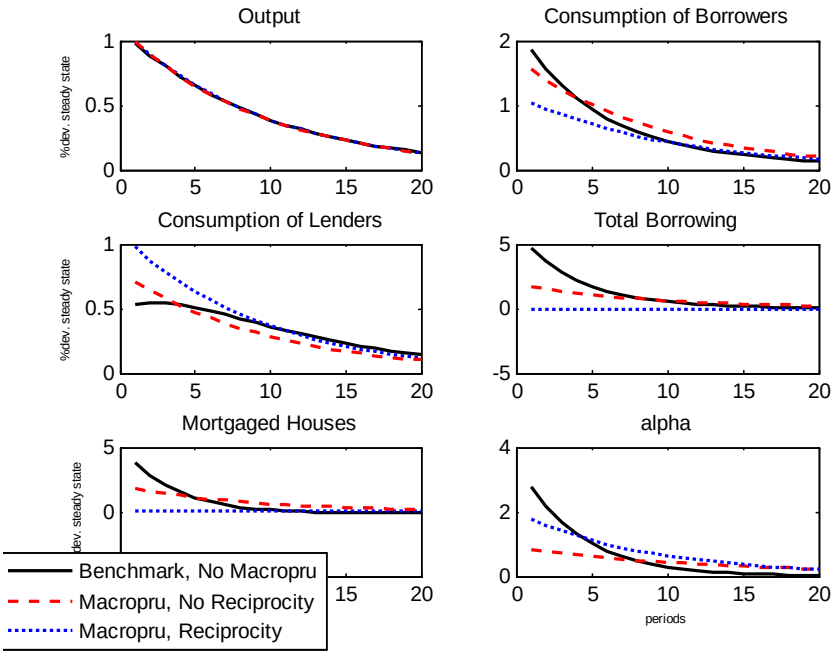


Figure 4: Impulse Responses to a Technology Shock

it is beneficial for welfare to reach some sort of reciprocity agreement between both countries, so that leakages are not as strong as in the non reciprocity case. However, the optimized coefficient for foreign lenders is smaller than the domestic one. This means that the macroprudential rule for foreign lenders, though it needs to be activated, does not have to be as aggressive as the domestic one. A very aggressive foreign macroprudential rule could imply no funds at all going to foreign lenders.

### 5.2.1 Dynamics

Here, I present impulse responses to illustrate how the dynamics of the model change when there are macroprudential policies, using the optimal values presented above. However, for completeness, I also consider a case of non reciprocity, that is, I also check what would happen if the macroprudential policy channel were shut down for foreign branches. The interpretations of non reciprocity is the following: the domestic country has macroprudential policies activated in the form of a countercyclical rule and responds to domestic housing conditions. When there is an increase in domestic house prices, LTVs decrease, making the regulation stricter. However, the LTV applied to foreign branches in the host country stays constant and does not vary with housing cycles. This situation would be, by definition, suboptimal but serves to quantify the welfare gains of reciprocity within the model. I perform these experiments for both a technology and a housing demand shock.

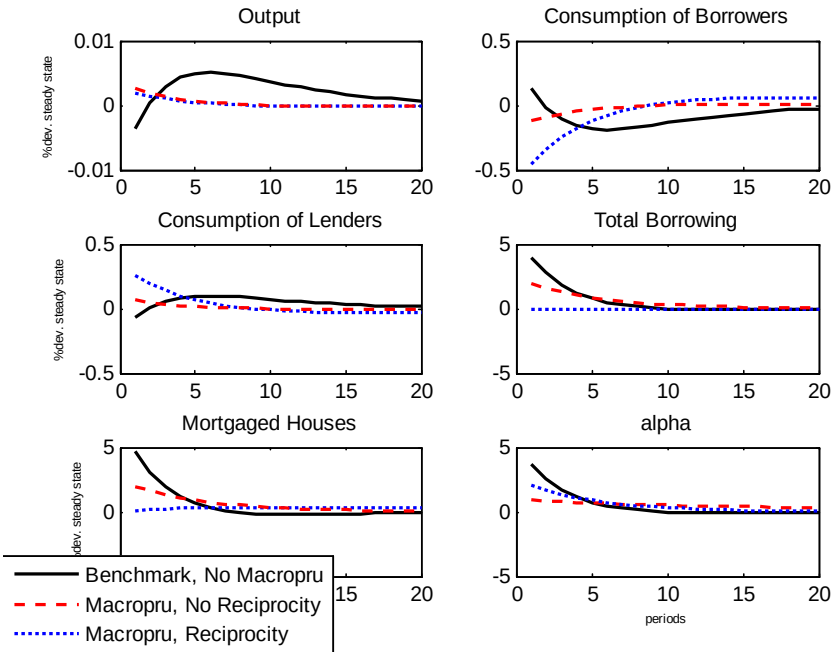


Figure 5: Impulse Responses to a House Price Shock

Figure 4 shows impulse responses for a technology shock. The black solid line represents the benchmark case, already displayed in the previous section, in which there are no macroprudential policies in place. I compare the benchmark with the case in which macroprudential policies are introduced. The blue dotted line corresponds to the optimal values, in which there is reciprocity in macroprudential policies, that is, given developments in housing markets in the domestic country, both domestic and foreign lenders apply a stricter macroprudential policy on their respective LTVs following a boom. We see that the overall effects of macroprudential policies on the aggregate macroeconomy, regardless of reciprocity, are very similar. This is is coming because the effects are compensating in the aggregate between borrowers and lenders, there is a redistribution among agents. However, there seems to be implications for financial markets. Total debt is increasing by less when there is reciprocity, meaning that the macroprudential policy is more effective in this case and more financial stability is achieved. There is also a difference in the distribution of debt between domestic and foreign among the three cases. We can see this if we look at the response of the share of domestic borrowing. With macroprudential policies, if there is no reciprocity, since the regulation at home becomes stricter, $\alpha$ increases much less than for the benchmark, representing leakages from macroprudential policies. Therefore, when there is reciprocity in policies, there is not so much redistribution in debt, meaning that then, macroprudential policy does not leak as much as in the non reciprocity situation.

Figure 5 displays the dynamics of the model for a house price shock. The arguments for this type of shock are similar to the ones in the previous figure, since it is also an expansionary shock. An increase in house prices increases the demand for borrowing through the collateral constraint. However, if there are macroprudential policies, the collateral constraint becomes tighter. If there is no reciprocity, this happens just for the domestic constraint and thus we can observe leakages from macroprudential policies. There is a redistribution of debt between domestic and foreign. Although domestic borrowing increases relatively less compared to the benchmark with the introduction of a stricter regulation, if foreign lenders do not reciprocate the policy, their lending is less affected than for the case of reciprocity. Overall, the effects of the shock for the macroeconomy, although mitigated by macroprudential policies, do not depend as much on reciprocity. However, as in the previous case, financial markets behave differently depending on whether macroprudential policies are reciprocal or not.

As a robustness check, Table A1 in the Appendix shows the impact response of $\alpha$ for different arbitrary combinations of the reaction parameters, subject to determinacy, as a sensitivity check. We can see that qualitatively, results are mantained for the differentt values of these parameters. On impact, the stricter the regulation in the home country, the more effect macroprudential policies have on domestic debt. However, it is still the case that, as regulation in the foreign economy also becomes stricter, foreign lending also gets affected.

### 5.2.2 Financial Stability and Welfare

In light of the results on dynamics, Table 2 displays the effects of macroprudential policies on welfare and financial stability for the same value of the parameters as above:

**Table 3: Financial Stability and Welfare**

| | $\sigma_{b^H}$ | $\sigma_{b^F}$ | $\sigma_{b^T}$ | $\sigma_R$ | **Welfare Gain** |
|---|---|---|---|---|---|
| **No Macropru** | 6.90 | 0.101 | 5.16 | 0.223 | - |
| **Macropru-No Reciprocity** | 5.48 | 0.106 | 3.818 | 0.16 | 0.97 |
| **Optimal Macropru** | 1.45 | 0.011 | 0.104 | 0.106 | 1.32 |

Note: Table 3 reports measures of financial stability and welfare gains for the benchmark case, the no reciprocity case and the reciprocal optimal case.

The first row of the table constitutes the benchmark case, when there are no macroprudential policies in place. The columns show the standard deviations of borrowing and the standard deviations of the

interest rate, as a proxy of financial stability. That is, the lower the standard deviations the more stable financial markets are. The first column corresponds to the standard deviation of borrowing from domestic lenders, the second one is borrowing from foreign lenders, the third one is total borrowing, and the fourth one is the interest rate, which in equilibrium is equal to the domestic and foreign interest rates.[16]

Results shown in this table confirm the case that macroprudential policies have an impact on financial markets and that the effects are different depending on whether there is reciprocity in policies or not. As we can observe, when there are macroprudential policies, the standard deviation of borrowing and the interest rate, no matter the source, decrease. However, gains in terms of financial stability are larger if there is some sort of reciprocity among policies. In terms of welfare gains, it is also desirable that macroprudential policies are reciprocal. In other words, non reciprocity in macroprudential policies can partly "undo" their purpose of achieving financial stability and high welfare.[17]

## 6 Concluding Remarks

In this paper, I use a DSGE model to study the effects of macroprudential policy leakages when there are foreign banks operating in the domestic economy and regulation is not reciprocal. The model features patient and impatient agents, namely lenders and borrowers, respectively. Borrowers face collateral constraints and can borrow from domestic and foreign lenders. Macroprudential policies are represented by a rule on the LTV. Macroprudential policies can be applied just to domestic lenders or to both types of lenders, if there are some sort of reciprocity agreements.

Within this framework, I explore how the share of domestic borrowing, financial stability and welfare are affected by the lack of reciprocity in macroprudential policies, a phenomenon known as leakage. I find that, when financial regulation is stricter for domestic lenders than for foreign ones, funds tend to go to the less regulated sector. However, if policies are reciprocal, that is, foreign lenders also follow domestic regulation, leakages are less important. Results show that reciprocity in macroprudential policies delivers higher welfare gains than non reciprocity, with respect to a situation in which policies are not in place. A larger improvement in financial stability is also achieved.

[16] If we compare the standard deviations with the ones found in the data, we find that qualitatively the model is able to capture that the standard deviation of domestic loans is larger than the same for foreign loans (4.32 vs. 1.07, respectively). However, the ratio is larger in the model than in the data.

[17] It has to be acknowledged that the welfare gains from reciprocity within the macroprudential policy are relatively more limited than the gains from introducing the policy itself.

I find that, in order to maximize welfare, some sort of reciprocity agreements are desirable. However, the macroprudential rule for foreign lenders does not need to be as aggressive as the domestic one, reflecting the fact that borrowers have a preference for domestic lenders.

# Appendix

**Table A1: Rule parameters. Sensitivity analysis**

| $\phi_H$ | $\phi_F$ | $\alpha$ Response (% dev. SS) | |
|---|---|---|---|
| | | Technology Shock | House Price Shock |
| 0 | 0 | 2.7924 | 3.6455 |
| 0.3 | 0 | 1.0909 | 1.1966 |
| 0.3 | 0.1 | 1.4771 | 1.6309 |
| 0.3 | 0.2 | 1.9433 | 2.1640 |
| 0.5 | 0 | 0.8446 | 0.9217 |
| 0.5 | 0.1 | 1.1375 | 1.2312 |
| 0.5 | 0.3 | 1.8267 | 1.8363 |
| 0.6 | 0 | 0.7722 | 0.8473 |
| 0.6 | 0.1 | 1.0344 | 1.1215 |
| 0.6 | 0.3 | 1.7004 | 1.6915 |

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