Optimal Capital Flows in a Model with Financial Frictions and Imperfectly Competitive Banking Sector

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Abstract

The extent of foreign monetary policy spillovers can vary across countries. This paper studies one potential source of this heterogeneity — different degrees of banking sector competition — and the relevant optimal policy. I build a model with imperfect banking sector competition and financial frictions, which generate inefficient pecuniary externalities. A more competitive banking sector implies larger foreign monetary policy spillovers and higher optimal tax on inflows, conditional on the cost of accessing foreign interbank markets not being too large. However, if this cost is fairly large, larger spillovers need not imply an optimally higher capital inflow tax. Furthermore, there exists an "optimal" level of banking sector competition for which the overinvestment due to the pecuniary externalities cancels off the underinvestment due to the monopolistic competition and no capital controls are required. Finally, I test the comparative statics of the model using individual bank-level data and show that there is support for the predictions of the model in emerging markets.

1 Introduction

Cross-country monetary policy spillovers have been at the forefront of the recent research agenda in international finance. This paper attempts to tackle the issue of the size and efficiency of the spillovers in a small open economy (SOE) model with financial frictions and imperfectly competitive banking sector. The questions addressed include do countries with more or less competitive banking sectors experience larger foreign monetary policy spillovers? Are the model predictions supported in the data? What are the externalities present and are larger foreign monetary policy spillovers associated with higher optimal capital controls?

There is a growing literature emphasizing the importance of financial frictions for explaining financial crises and severe recessions (see for example the classic papers Bernanke and Gertler (1989) and Kiyotaki and Moore (1997) and the ensuing literature). The type of financial friction present in this paper is firm default due to a standard debt contract (see for example Bernanke, Gertler and Gilchrist (1999))

The fact that the banking sector in the majority of countries is far from the perfectly competitive benchmark is a well documented fact in the IO and empirical banking literature (see, for example, Bikker, Shaffer and Spierdijk (2012) and Claessens and Laeven (2004)). In this model, the banking sector is monopolistically competitive, where banks compete over the contractual loan rate. However, in cases of firm default, the return on banks' loans is below this contractual rate and is a function of aggregate loans in the economy. In this set up with firm default, the standard result emerges that the more competitive the banking sector is, the higher the aggregate level of loans is. There are a number of theoretical papers which feature imperfectly competitive banking sectors. The focus of these papers tends to be on a different set of questions such as studying the importance of imperfect competition for the transmission of real and financial shocks in closed economies (Dib (2010), Gerali, Neri, Sessa and Signoretti (2010) and Hafstead and Smith (2012)) and for the determination of credit/financial spreads (Blas and Russ (2013), Drechsler, Savov and Schnabl (2016)).

The foreign monetary policy spillovers to the domestic economy in the model developed in this paper are solely due to their effect on the domestic banking sector. The cost of bank financing is a function of both domestic and foreign monetary policy, conditional on the banking sector facing adjustment costs related to the level of home and foreign debt. These adjustment costs capture in a reduced form way the infrastructure costs related to borrowing from domestic and foreign interbank markets but also financial constraints such as leverage or "Value-at-Risk" constraints not formally introduced in the model. Conditional on non-zero foreign adjustment costs, an exogenous increase in foreign monetary policy leads to fewer domestic loans and, hence, to lower output.

In the framework of this model the size of foreign monetary policy spillovers depends importantly on the degree of imperfect competition of the banking sector. Conditional on the adjustment cost of accessing foreign interbank markets being small, the more competitive the banking sector is, the larger the decrease of domestic loans is in response to an increase of the foreign monetary policy rate. If the adjustment cost of accessing foreign interbank markets is large, the cross partial derivative cannot be clearly signed.

A number of studies have emphasized the cross country heterogeneity in monetary policy spillovers (examples include Rey (forthcoming) and Aizenman, Chinn and Ito (2015)). This paper contributes to this literature by bringing the testable implications of the model to the data. More precisely, I test whether it is indeed the case that more competitive banking sectors imply higher level of loans and whether a positive US monetary policy shock is associated with a contraction of loans in other countries. Finally, I test whether the contraction of loans is smaller for less competitive banks if the sample is restricted to banks facing lower adjustment costs of borrowing at foreign interbank markets. Using BankScope data and focusing on large banks as a proxy for banks that face relatively smaller adjustment costs of foreign interbank borrowing, I show that the model-implied comparative statics are supported by the data for emerging markets. However, the results are not statistically significant for advanced economies.

Finally, I study the optimal policy in this framework. There are two sources of inefficiencies — pecuniary externalities which lead to overinvestment and a standard imperfect competition force which leads to underinvestment. The pecuniary externalities are due to the fact that since banks are small, they don't internalize the fact that the more they lend, the lower the return they and other banks will receive if there is firm default due to the concavity of the production function. A good analogy would be real estate booms financed by bank borrowing where the bank does not internalize the fact that the more it lends, the lower the return will be if the real estate bubble bursts since the re-sale value of the collateral will be a function of total loans to the real estate market. The monopolistic competition leads to underinvestment due to the fact that banks internalize the fact that the more they lend, the lower the return that they will receive and they don't internalize the welfare of firms. The total welfare effect will be a function of the relative size of the two inefficiencies, where there exists a level of imperfect banking sector competition for which the two externalities cancel each other off.

While domestic monetary policy is sufficient to eliminate the externalities, if using domestic monetary policy to address financial sector imperfections is not an option, the policy maker can also use capital account controls in the form of tax on foreign inflows. The more competitive the banking sector is, the higher the optimal tax on inflows is as the size of the underinvestment decreases, while the strength of the pecuniary externalities is fixed. If the underinvestment force dominates, the optimal policy is to impose negative tax on inflows, i.e. a subsidy. Combining this last result with the result on how foreign monetary policy spillovers vary with the degree of banking sector competition implies that higher optimal capital controls will be associated with larger monetary policy spillovers only if it is relatively cheap for banks to access foreign interbank markets. If accessing foreign interbank markets is fairly costly, higher optimal tax on inflows need not be associated with larger monetary policy spillovers.

This paper is related to a recent theoretical literature addressing foreign monetary policy spillovers in models of SOEs with a banking sector. Some of these papers include Akinci and Queralto (2014), Cespedes, Chang and Velasco (2015) Aoki, Benigno and Kiyotaki (2016). Furthermore, given that one of the main frictions is pecuniary externalities, it also builds on models with pecuniary externalities and SOEs. Examples include Bianchi (2011) and Korineka and Sandri (2016) among many others.

The contribution relative to both of these literatures is that, to my knowledge, this is the first paper to study the effect of imperfect banking sector competition on the size of foreign monetary policy spillovers and the associated optimal policy.

The paper is structured as follows. Section 2 presents the model set-up and derives key comparative statics. Section 5 tests whether the predictions of the model are supported by the data. Section 6 explores the presence of over/underinvestment in the model and derives the optimal policy and Section 7 provides a numerical example. The final section concludes.

2 Model Set-Up

There are two periods, $t = 0, 1$ and three types of agents — bankers, entrepreneurs and consumers. There is a continuum of measure one of each type. Everyone is risk neutral and there is no discounting between the two periods. The financial frictions is captured by a standard debt contract between the banker and the entrepreneur in the spirit of Bernanke and Gertler (1989) and Bernanke, Gertler and Gilchrist (1999). The banking sector is monopolistically competitive. Monetary policy will be conducted by the Central Bank which will set an interest rate at which the banks can borrow/lend at from the Central Bank. The model is real.

3 The Problem of the Entrepreneur

First, consider the problem of the entrepreneur. Without loss of generality, for simplicity I assume that the entrepreneur consumes only in the last period and has no net worth. The entrepreneur maximizes his welfare by choosing how much to consume, borrow from the bankers and invest. The contract between the banker and the entrepreneur is exogenously assumed to be a standard debt contract (SDC). The optimization problem is given by

$$\max_{C_1,K_1,L_1} E_0\left(C_1\right) \tag{1}$$

$$\text{s.t. } L_1 \geq K_1 \tag{2}$$

$$A_1K_1^{\alpha} - R_1^l L_1 \geq C_1 \tag{3}$$

where the period one and two budget constraints are given by equations 2 and 3. C_1 is the consumption of the entrepreneur in $t = 1$. In $t = 0$, the entrepreneur can transform the consumption good into capital one-to-one, where K_1 is the invested capital. Capital produces in the second period $A_1K_1^{\alpha}$ units of the consumption good, and upon production, it depreciates one hundred percent. A_1 is the TFP shock with support $[\underline{A}, \bar{A}]$.

L_1 is the amount of aggregate loans taken in $t = 0$ and to be repaid in $t = 1$. I assume that the loans across banks are imperfect substitutes, which allows me to model the banking sector as monopolistically competitive. Such an approach to modelling imperfect competition in the banking sector has been explored by Hafstead and Smith (2012) and Dib (2010), among others. R_1^l is the aggregate realized return on the loan portfolio. The CES aggregator over loans is given by

$$(4) \qquad L_t = \left[\int_0^1 (L_{i,t})^{\frac{(\rho-1)}{\rho}} \, di \right]^{\frac{\rho}{\rho-1}}$$

where $L_{i,t}$ is the amount of loans the entrepreneur takes from bank i and $\rho \in (1, \infty)$ is the elasticity of substitution between loans. If $\rho \to \infty$, all the loans are perfect substitutes and if $\rho \to 1$ the functional form approaches Cobb-Douglas which has an elasticity of substitution of one.

The ex-post return on the loan taken from banker i is equal to $R^l_{i,1} = \min \left\{ \frac{1}{\hat{L}_1} A_1 K_1^\alpha, \bar{R}_{i,0} \right\}$ where $\hat{L}_1 = \int_0^1 L_{i,1} di$. The firm defaults if it does not have enough money to service all of its loan obligations. Upon default, its assets are distributed among bankers proportionally to the size of the loan from the respective bank, which is captured by $R^l_{i,1} L_{i,t} = \frac{L_{i,t}}{\hat{L}_1} A_1 K_1^\alpha$. If there is no default, the ex-post return is equal to the interest rate specified in the SDC, $\bar{R}_{i,0}$. Finally, $R^l_1 L_1 = \int_0^1 R^l_{i,1} L_{i,1} di$ and $\bar{R}_0 L_1 = \int_0^1 \bar{R}_{i,0} L_{i,1} di$. Due to limited liability, there will be default if

$$A_1 K_1^\alpha < \bar{R}_0 L_1$$

One can re-write the optimization problem of the entrepreneur as

$$\max_{L_1} \int_{\bar{R}_0 L_1^{1-\alpha}}^{\bar{A}} \left(A_1 (L_1)^\alpha - \bar{R}_0 L_1 \right) f(A_1) \, dA_1$$

The first order condition of the entrepreneur determines L_1 as a function of $\bar{R}_0$ and is given by

$$(5) \qquad \alpha L_1^{\alpha-1} \int_{\bar{R}_0 L_1^{1-\alpha}}^{\bar{A}} A_1 f(A_1) \, dA_1 = \bar{R}_0 \left(1 - F\left(\bar{R}_0 L_1^{1-\alpha} \right) \right)$$

I assume a distribution of the TFP shock such that equation 5 implies an unique solution to $\bar{R}_0 L_1^{1-\alpha}$. This would be the case if the TFP shock is uniformly distributed, for example. Then, higher amount of loans will be associated with a lower lending rate. The first order condition with respect to $L_{i,1}$is given by

$$L_{i,1} = L_1 \left[\frac{\bar{R}_{i,0}}{\bar{R}_0} \right]^{-\rho} \tag{6}$$

Equation 6 determines the demand for bank specific loans and is standard in models with monopolistic competition. The interest rate on aggregate loans is given by

$$\bar{R}_0 = \left[\int_0^1 \left(\bar{R}_{i,0} \right)^{(1-\rho)} di \right]^{\frac{1}{(1-\rho)}} \tag{7}$$

4 Consumer's Problem

The consumer's problem is trivial. I assume that the Central Bank can collect taxes or subsidies from the consumers and that the consumers have no investment instruments. The consumer's optimization problem is given by

$$U_0^c = \sum_{t=0}^{1} C_t^c = \sum_{t=0}^{1} (W_t^c - T_t)$$

where C_t^c is the consumption of the consumers, W_t^c is their exogenous endowment which is assumed to be always greater than or equal to the lump sum taxes collected T_t.

4.1 Banker $i's$ Optimization Problem

In this section I solve the optimization problem of banker i, who, similarly, to the entrepreneur consumes only in the last period. I assume parametrization such that there is no bank default and only the entrepreneurs default in equilibrium.

$$\max_{\bar{R}_{i,0},D_{i,0}} E_0 R^l_{i,1} L_{i,1} - R_0^{PR} D_{i,0} - R_0^* \left[L_{i,1}\left(\bar{R}_{i,0}\right) - D_{i,0} - N_{i,0} \right] E_0 \frac{e_1}{e_0} \tag{8}$$

$$-\frac{\gamma^f}{2}\left(L_{i,1}\left(\bar{R}_{i,0}\right) - D_{i,0} - N_{i,0}\right)^2 - \frac{\gamma^h}{2}\left(D_{i,0}\right)^2 \tag{9}$$

In $t = 0$, banker i borrows (lends if negative) the amount $D_{i,0}$ from the Central Bank which is, in turn, financed by the Central Bank taxing or subsidizing consumers. In $t = 1$ the banker repays back $R_0^{PR} D_{i,0}$ where R_0^{PR} is the domestic policy rate set in $t = 0$.

The Central Bank determines R^{PR}. It finances the operation by taxing and subsidizing the consumers where $T_0 = \int_0^1 D_{i,0} di$ and $T_1 = -\int_0^1 R_0^{PR} D_{i,0} di$. $D_{i,0} < 0$ can be interpreted as reserves the banker deposits with the Central Bank while $D_{i,0} > 0$ can be interpreted as borrowing from the Central Bank's discount window, where in this model the two rates are set to be the same. e_t is the exchange rate, which is exogenous, and defined as units of the home good per one unit of the foreign good. In $t = 0$ the banker borrows from abroad the amount $L_{i,1} - D_{i,0} - N_{i,0}$ denominated in the home good ($\frac{L_{i,1}-D_{i,0}-N_{i,0}}{e_0}$ in the foreign good) and repays in expectation next period $R_0^* \left[L_{i,1}\left(\bar{R}_{i,0}\right) - D_{i,0} - N_{i,0} \right] E_0 \frac{e_1}{e_0}$ denominated in the home good, where R_0^* is the foreign interbank market interest rate, which is closely linked to foreign monetary policy.

I assume that borrowing either from the domestic Central Bank or in foreign interbank markets is costly, which is captured by a quadratic cost of borrowing. The cost of borrowing can be interpreted literally as the infrastructure required in order to borrow domestically or from abroad (for example various types of brick and mortar costs and exchange rate hedging costs). Alternatively, it can capture in a reduced form way various types of financial constraints which imply that the bank dislikes large amounts of home and foreign debt where the costs on both can differ since the foreign debt also comes with foreign currency exposure. The latter interpretation is more pertinent for parametrization where domestic and foreign debt are positive. The extra cost from borrowing from the domestic Central Bank and from foreign interbank markets are parametrized by γ^h and γ^f, respectively.

I assume that larger banks tend to have lower γ^h and, in particular, lower γ^f, which seems to be supported in the data since larger banks are more levered. This could be due to economies of scale which allow larger banks cheaper access to interbank markets. Also if home and foreign debt are positive in equilibrium and one takes into account the broader interpretation that γ^h and γ^f capture the desire of banks to lever and take risk, larger banks could be more risk loving due to too big to fail moral hazard, for example.

The total amount of period zero borrowing is given by $L_{i,1} - N_{i,0}$ and the banker's net worth is $N_{i,0}$. There is no ex-ante heterogeneity between banks and $N_{i,0} = N_0$ for all bankers. I assume that banker i sets the interest rate of the SDC, taking into account the demand schedule of the entrepreneur $L_{i,1}\left(\bar{R}_{i,0}\right) = L_1 \left[\frac{\bar{R}_{i,0}}{\bar{R}_0}\right]^{-\rho}$, as is standard in the monopolistic competition literature. While the banking sector here is monopolistic with respect to loans, banks are price takers with respect to the liability side. Given that the bank borrowing costs here are tightly linked to monetary policy, this assumption seems realistic.

One can re-write banker i's optimization problem as

$$
\begin{aligned}
&\max_{\bar{R}_{i,0}} \left(1 - F\left(\bar{R}_0 L_1^{1-\alpha}\right)\right) \bar{R}_{i,0} L_{i,1}\left(\bar{R}_{i,0}\right) + \frac{L_{i,1}\left(\bar{R}_{i,0}\right)}{\hat{L}_1} \int_{\underline{A}}^{\bar{R}_0 L_1^{1-\alpha}} A_1 K_1^{\alpha} f\left(A_1\right) dA_1 \\
&-R_0^{PR} D_{i,0} - R_0^{*}\left[L_{i,1}\left(\bar{R}_{i,0}\right) - D_{i,0} - N_{i,0}\right] E_0 \frac{e_1}{e_0} \\
&-\frac{\gamma^f}{2}\left(L_{i,1}\left(\bar{R}_{i,0}\right) - D_{i,0} - N_{i,0}\right)^2 - \frac{\gamma^h}{2}\left(D_{i,0}\right)^2
\end{aligned}
$$

where all the variables without an i subscript are aggregate variables that the banker takes as given. The first order conditions are given by

$$\bar{R}_{i,0} : \left(1 - F\left(\bar{R}_0 L_1^{1-\alpha}\right)\right)\left(L_{i,1} + \bar{R}_{i,0} L'_{i,1}\left(\bar{R}_{i,0}\right)\right) + \frac{L'_{i,1}\left(\bar{R}_{i,0}\right)}{\hat{L}_1} \int_{\underline{A}}^{\bar{R}_0 L_1^{1-\alpha}} A_1 K_1^{\alpha} f\left(A_1\right) dA_1 = L'_{i,1}\left(\bar{R}_{i,0}\right)\left(E_0 \frac{e_1}{e_0} R_0^* + \gamma^h \left(L_{i,1} - D_{i,0} - N_{i,0}\right)\right) \tag{10}$$

$$D_{i,0} : R_0^* E_0 \frac{e_1}{e_0} + \gamma^f \left(L_{i,1} - D_{i,0} - N_{i,0}\right) = R_0^{PR} + \gamma^h D_{i,0} \tag{11}$$

where $L'_{i,1}\left(\bar{R}_{i,0}\right) = -\rho L_1 \frac{\left(\bar{R}_{i,0}\right)^{-\rho-1}}{\left(\bar{R}_0\right)^{-\rho}} < 0$.

Equation 10 equates the marginal benefit and the marginal cost of increasing the lending rate, $\bar{R}_{i,0}$, by an extra unit. Equation 11 equates the marginal cost of borrowing domestically and abroad. $\gamma^h > 0$ and/or $\gamma^f > 0$ introduce a deviation from UIRP.

Imposing a symmetric equilibrium and combining equations 10 and 11 implies

$$D_0 = \frac{R_0^* E_0 \frac{e_1}{e_0} - R_0^{PR}}{\left(\gamma^h + \gamma^f\right)} + \frac{\gamma^f}{\left(\gamma^h + \gamma^f\right)}\left(L_1 - N_0\right) \tag{12}$$

$$MB_L = \left(1 - F\left(\bar{R}_0 L_1^{1-\alpha}\right)\right) \bar{R}_0 \left(1 - \frac{1}{\rho}\right) + L_1^{\alpha-1} \int_{\underline{A}}^{\bar{R}_0 L_1^{1-\alpha}} A_1 f\left(A_1\right) dA_1 = R_0^{PR} \frac{\gamma^f}{\left(\gamma^f + \gamma^h\right)} + \frac{\gamma^h \gamma^f}{\left(\gamma^f + \gamma^h\right)}\left(L_1 - N_0\right) + \frac{\gamma^h}{\left(\gamma^f + \gamma^h\right)} R_0^* E_0 \frac{e_1}{e_0} = MC_L \tag{13}$$

$D_0, \bar{R}_0$ and L_1 are determined jointly by equations 13, 12 and 5. Equation 13 equates the marginal benefit of an extra unit of the consumption good lent, MB_L, to the marginal cost, MC_L. As long as both $\gamma^f > 0$ and $\gamma^h > 0$, the marginal cost depends both on the domestic and foreign monetary policy rates. The larger $\frac{\gamma^h}{\left(\gamma^f + \gamma^h\right)}$ is, the larger the impact of a change of the foreign policy rate on the marginal cost is. Similarly, the larger $\frac{\gamma^f}{\left(\gamma^f + \gamma^h\right)}$ is, the larger the impact of a change of the domestic policy rate on the marginal cost is. Another variable which affects the marginal cost of an extra unit lent is the total amount of debt $(L_1 - N_0)$, where the marginal cost is more sensitive to the total amount of debt, the larger $\frac{\gamma^h \gamma^f}{(\gamma^f + \gamma^h)}$ is. The marginal benefit of an extra unit lent is captured by the return in the states of nature where the firm does not default and the return when it defaults. Note that the perceived no default return is higher, the more competitive the banking sector is — the larger ρ is. This is due to the standard monopolistic force which implies that when there is imperfect competition, banks internalize the fact that an extra unit lent is associated with a lower lending rate. Equation 12 expresses the amount of domestic bank borrowing as a function of the scaled expected interest rate differential and the amount of total debt scaled by the relative cost of foreign borrowing. The higher the expected foreign interest rate is relative to the domestic one, the larger the domestic debt is.

Proposition 1. *Assume a distribution of A_1 such that equation 5 determines a unique solution for $\bar{R}_0 L_1^{1-\alpha}$ as a function of exogenous variables. Then the equilibrium exists and is unique. The following comparative statics hold*

$$\frac{\partial L_1^*}{\partial \rho} > 0$$

$$\frac{\partial L_1^*}{\partial R_0^*} \begin{cases} = 0 \ \textit{if} \ \gamma^h = 0 \ \textit{and} \ \gamma^f > 0 \\ < 0 \ \textit{if} \ \gamma^h > 0 \end{cases}$$

$$\frac{\partial L_1^*}{\partial R_0^* \partial \rho} \begin{cases} = 0 \ \textit{if} \ \gamma^h = 0 \ \textit{and} \ \gamma^f > 0 \\ < 0 \ \textit{if} \ \gamma^h > 0 \ \textit{and} \ \gamma^f \to 0 \end{cases}$$

where L_1^* is the decentralized equilibrium loan allocation.

Proof of Proposition 1: See Appendix.

The condition on the TFP distribution will be satisfied if A_1 has an uniform distribution, for example (see the Proof of Proposition 1 for this special case.) Proposition 1 implies that conditional on there being some adjustment cost of bank borrowing from the Central Bank, $\gamma^h > 0$, then there will be spillover effects from foreign monetary policy to domestic loans to entrepreneurs and, as a result, to total output. If the domestic borrowing adjustment cost is zero, then the foreign interest rate becomes irrelevant. The reason why that is the case is because then the marginal cost of borrowing of banks will be always equal to R_0^{PR} as can be seen from equation 13.

The intuition why a more competitive banking sector implies more loans is due to the fact that the more competitive banks perceive the marginal benefit of an extra loan to be higher than the less competitive banks. The reason why if $\gamma^h > 0$, then a higher foreign policy rate implies fewer domestic loans, $\frac{\partial L_1^*}{\partial R_0^*} < 0$, is due to the fact that the marginal cost of borrowing for the banks is higher. Finally, the cross-partial derivative $\frac{\partial L_1^*}{\partial R_0^* \partial \rho}$ is negative as long as γ^f is fairly small and γ^h is positive. In the case of low enough adjustment cost of accessing foreign interbank markets, a more competitive banking sector implies an even more negative effect of high R_0^* on domestic loans (i.e. larger spillover effects of foreign monetary policy). For large γ^f the sign of the cross partial derivative is unclear.

5 Testable Implications — Empirics

In this section I test the comparative statics derived in Proposition 1. For that purpose, I rely on individual bank level data from BankScope and I assume that the foreign country is the US.[1] The main challenge is due to the difficulty of identifying exogenous monetary policy shocks. For example, proxying R_0^* using the Fed Funds rate – the interbank overnight interest rate targeted by US monetary policy – would be incorrect due to an endogeneity problem. For example, the Fed Funds rate could be increasing in response to a positive output gap

[1] In order to clean the data and to avoid double counting I use the instructions in Thibaut and Mathias (2015) . I keep unconsolidated balance sheets first ($U1/U2 > U* > C1/C2 > C^*$) since the focus is on domestic lending and consolidated balance sheets might contain information on the bank foreign operations.

in the US, which, in turn, could have positive spillover effects to other countries via trade for example. In this model, this would be captured by R_0^* not being fully exogenous but responding to the US TFP shock, which, in turn, is correlated with the domestic TFP shock making R_0^* correlated with the domestic TFP shock. Since economic growth expectations are hard to control for, this can lead to the error term being positively correlated with the Fed Funds rate. In that case, higher foreign policy rate is likely to lead to higher, not lower, loans.

In order to address this identification issue I use the Fed Funds futures data to calculate monetary policy surprises as daily changes of the Fed Funds futures on FOMC days. These changes are summed over the whole year. I also check the robustness of the results using the narrative based measure of monetary policy shocks of Romer and Romer (2004). I use the quarterly series updated by Miranda-Agrippino and Rey (2015), which are, once again, summed in order to obtain the annual series.

However, even these instruments are not completely deprived from the endogeneity problem, especially given that the BankScope data is annual. Therefore, I use lagged monetary policy surprises which further reduces the endogeneity issue. Moreover, it might be the case that loans granted react with a lag to monetary policy changes, depending on the length of the contract of domestic banks with foreign lenders. The regression specification is given by

$$\begin{aligned}\triangle \ln L_{ijt} = \alpha + \delta_c C_{ij} + \delta_{MP}^{US} MPsurp_{us,t-1} + \delta_{MP}^{j} \triangle MP\ rate_{j,t-1} + \\ \delta_{c,MP}^{US} C_{ij} * MPsurp_{us,t-1} + \beta_L \triangle \ln L_{ijt-1} + \beta_E \frac{E_{ijt-1}}{TA_{ijt-1}} + \varepsilon_{ijt}\end{aligned}$$

where i stands for bank, j for country and t for time. As a dependent variable I use the growth rate of loans, $\triangle \ln L_{ijt}$, given that loans are a trending variable. This is an approach widely used in the banking literature (see Kashyap and Stein (2000) among many others).

C_{ij} is the measure of competitiveness which is bank-specific. It rangers from zero to one and the larger it is, the *less* competitive the bank is. It is constructed in the following way. First, I construct the cumulative distribution of total dollar bank assets for a given country for a given year. The least competitive bank will take a value of one while the most competitive bank a value of zero. A bank with 10 billion dollars worth of assets in a country with many larger banks will be considered more competitive and will have smaller C_{ij} than a bank with the same amount of assets in a country with fewer larger banks, even if the total amount of all bank assets in both countries is the same.[2] If two banks in a given year and country have the exact same amount of assets they are given the same competitiveness rank. For each bank, I average its rank over time and this is the measure of bank specific competitiveness. The reason why I do not use the time varying competitiveness rank is because the rank for a given year is a function of loans granted since loans are part of total assets. So if a firm provides more loans, then the competitiveness rank of the bank might increase (i.e. the bank is less competitive) which will lead to an endogeneity problem and to a positive δ_c while the theory predicts that δ_c should be negative.

$MPsurp_{us,t-1}$ stands for the US monetary policy surprise while $C_{ij} * MPsurp_{us,t-1}$ is a continuos interaction variable. According to Proposition 1, $\delta_{MP}^{US} < 0$ and $\delta_{c,MP}^{US} > 0$.[3] The lag of the change of the domestic policy rate, $\triangle\ MP\ rate_{j,t-1}$, is included for completeness given that the model implies that we should control for it. However, given that I do not have available measures of monetary policy surprises for non-US countries there will be a problem of omitted variable bias regarding identifying δ_{MP}^{j}. Even though the model predicts that $\delta_{MP}^{j} < 0$, the omitted variable bias will push δ_{MP}^{j} to be positive rather than negative. In order to alleviate the omitted variable bias to an extent, in one of the specifications I include

[2]This is an important difference between the C measure of bank competitiveness and an alternative measure such as the the size of bank's assets as a fraction of the total assets of the banking sector in a given country.

[3]Notice that larger C implies lower degree of competition while higher ρ stands for more competitive markets.

lagged inflation and lagged industrial production growth as controls which will partially absorb the systematic response of domestic monetary policy.

Finally, I use the lagged equity to asset ratio and lagged loan growth as controls. The former captures how close the bank is to the regulatory constraint which would affect its lending behavior independent of the forces discussed in this model. Using lagged loan growth controls further for trends in loan growth, if any.

To test Proposition 1, the sample needs to be restricted to banks with fairly small γ^f. Smaller banks tend to face tighter financial constraints and find it more costly to access foreign interbank markets. Therefore, I focus on large banks with total asset value of more than 7 billion USD.[4] I restrict the sample period to prior to 2009 in order to exclude the binding US zero lower bound period. The countries in the sample are chosen based on the MSCI index classification for advanced economies and emerging market countries (see Data Appendix for details). I report separate pooled regressions for advanced economies and emerging markets. Given the restriction that only banks with assets above 7 billion USD are included, in the sample used, C ranges from 0.196 to 1 for the emerging economy sample and from 0.31 to 1 for advanced economies.

Finally, I include country dummies as well and cluster at the bank level. I consider three specifications: (I) US monetary policy surprises calculated using Fed Funds futures data (II) Romer and Romer (2004) monetary policy shocks and (III) changes of the Fed Funds rate.

The sample is restricted to be the same across specifications (1988-2008). [5] The table below reports the results for emerging economies and the one for advanced countries is

[4] A bank's γ^f fluctuates over time. The dollar value of assets can suddenly drop below 7 billion dollars either due to significant losses during times of financial crises or due to exchange rate depreciation/devaluation. These would be also episodes when financial constraints will be tighter which will be correctly captured by a higher $\gamma^{f\cdot}$.

[5] While using micro data increases the power of the empirical test, the model derived in the previous section assumes symmetric equilibrium implying that all banks within a country are equally competitive. One way to bring the model closer to the empirical test is to assume that lending markets are segmented and larger banks service one type of firms – for example larger firms which need more sophisticated monitoring and more complex contracts – while small banks service primarily small firms. Allowing for heterogeneous banks would increase the complexity of the model significantly.

delegated to the Appendix.

Specification	$MPsupr$ (FF futures) (I)	$MPsupr(RR)$ (II)	$\triangle$FF Rate (III)
δ_c	$-11.96^{***}(3.41)$	$-12.8^{***}(3.51)$	$-13.3^{***}(3.41)$
δ_{MP}^{US}	$-19.6^{***}(5.66)$	$-3.56^{**}(1.8)$	$-2.22^{*}(1.18)$
δ_{MP}^{j}	$0.003^{***}(0.001)$	$0.003^{***}(0.001)$	$0.003^{***}(0.001)$
$\delta_{c,MP}^{US}$	$23.18^{***}(6.76)$	$4.69^{**}(2.21)$	$2.73^{*}(1.44)$
β_L	$0.13^{***}(0.048)$	$0.13^{**}(0.048)$	$0.13^{***}(0.048)$
β_E	$0.99^{**}(0.43)$	$0.99^{**}(0.44)$	$0.98^{**}(0.43)$
$adj\ R^2$	0.112	0.11	0.11
N	$1,849$	$1,849$	$1,849$
country dummies	YES	YES	YES

Emerging markets; Standard errors are reported in brackets; cluster by bank;

All variables besides competitiveness are in percentage terms

***/**/* – significant at 1%, 5% and 10%

Consider the results for emerging economies. The fact that $\delta_c < 0$ implies that the less competition the bank faces (the higher C is), the lower the growth rate of loans is. δ_c is statistically different from zero in all three specifications. δ_{MP}^{US} is negative and statistically significant in all specifications as well. $\delta_{c,MP}^{US} > 0$ and is significantly different from zero in all three specifications as the theory would predict. In specification (I), one cannot reject the null hypothesis that for the least competitive banks ($C = 1$) the effect of US monetary policy on loan growth is equal to zero. Notice that if γ^h is close to zero, which could be the case for banks with $C = 1$, then the theory predicts that $\delta_{c,MP}^{US} + \delta_{MP}^{US}$ is close to zero. For banks with lower C the effect of a positive US monetary policy shock leads to a decrease in loan growth, where the decrease is larger the more competitive the bank is.

δ^j_{MP} is positive rather than negative and statistically significant but also economically insignificant. Including inflation and industrial production growth as controls makes δ^j_{MP} negative and statistically significant. However, the result seems to be due to the different sample considered given the data availability of inflation and industrial production rather than due to including the additional controls. The rest of the results remain qualitatively unchanged and statistically significant. [6]

$\beta_L > 0$ implies that high loan growth rate the previous year is associated with a high loan growth rate during the following year. Similarly, the better capitalized the banks are, the higher the growth rate of loans is the next year ($\beta_E > 0$) potentially because the bank is less concerned about binding regulatory constraints. Finally, the results do not appear to be driven by the financial crisis period.

The results are not statistically significant for advanced economies with the exception of δ_c which is negative and statistically significant in all three specifications.

6 Optimal Policy

The heterogeneity of foreign monetary policy spillovers across banks with different degree of monopolistic competition appears to have some support in the data in emerging markets. It is important to understand how optimal policy, such as capital account controls, should vary with the degree of monopolistic competition of the banking sector. For example, do larger spillovers imply lower or higher capital account controls and why?

First, I solve the problem of the constrained Central Planner and study the presence of externalities. The constrained Central Planner chooses the actions of the bankers and takes into account the best response functions of the other agents in the economy. She also faces

[6] The results with industrial production growth and inflation as independent variables are available upon request.

the adjustment costs of borrowing/lending that the banker faces.

The constrained Central Planner puts equal weight on all agents. Summing up the ex-ante welfare of bankers, entrepreneurs and consumers and simplifying, the objective function of the constrained Central Planner becomes

$$\begin{aligned}
&\max_{L_1, D_0} (L_1)^{\alpha} E_0 A_1 - R_0^* \left[L_1 - D_0 - N_0\right] E_0 \frac{e_1}{e_0} \\
&- \frac{\gamma^f}{2} (L_1 - D_0 - N_0)^2 - \frac{\gamma^h}{2} (D_0)^2 \\
&+ (W_0^c - D_0) + W_1^c
\end{aligned}$$

The Central Planner is indifferent what value she chooses for the domestic policy rate since all agents are risk neutral and hence they have the same marginal rate of substitution equal to one. Combining the two first order conditions implies

$$\begin{aligned}
MB_L^{CP} = \alpha (L_1)^{\alpha-1} E_0 A_1 = \frac{\gamma^f}{(\gamma^f + \gamma^h)} \\
+ \frac{\gamma^h \gamma^f}{(\gamma^f + \gamma^h)} (L_1 - N_0) + \frac{\gamma^h}{(\gamma^f + \gamma^h)} R_0^* E_0 \frac{e_1}{e_0} = MC_L^{CP}
\end{aligned} \tag{15}$$

Proposition 2 examines the externalities present in the model.

Proposition 2. *Over/underinvestment: Assume a distribution of A_1 such that equation 5 determines a unique solution for $\bar{R}_0 L_1^{1-\alpha}$ as a function of exogenous variables. If $R_0^{PR} = 1$ in the decentralized equilibrium, then there will be overinvestment if the pecuniary externality is stronger than the monopolistic competition externality (Externality>0) and there will be underinvestment if it's the other way round (Externality<0). If $\rho^* = \frac{\alpha \int_{\bar{R}_0 L_1^{1-\alpha}}^{\bar{A}} A_1 f(A_1) dA_1}{(1-\alpha) \int_{\underline{A}}^{\bar{R}_0 L_1^{1-\alpha}} A_1 f(A_1) dA_1}$ there is no inefficiency and the two externalities cancel each other off (Externality=0).*

$$
\begin{aligned}
Externality &= \underbrace{-\alpha\frac{1}{\rho}L_1^{\alpha-1}\int_{\bar{R}_0 L_1^{1-\alpha}}^{\bar{A}} A_1 f\left(A_1\right) dA_1}_{monopolistic\ competition\ externality} \\
&\quad \underbrace{+\left(1-\alpha\right) L_1^{\alpha-1}\int_{A}^{\bar{R}_0 L_1^{1-\alpha}} A_1 f\left(A_1\right) dA_1}_{pecuniary\ externality}
\end{aligned}
$$

Proof of Proposition 2: See Appendix.

In Proposition 2, in the decentralized equilibrium, I set the Central Bank's policy rate equal to the marginal inter-temporal rate of substitution of consumers which will be the interest rate that prevails if consumers are allowed to deposit money in/borrow from the bank instead of the Central Bank taking that role. Setting it to something different from one introduces another distortion in the model. The intuition behind the proof of proposition 2 is the following.

The pecuniary externalities, which lead to overinvestment, are due to the fact that banks are small and they don't internalize the fact that the more they lend, the lower the return that they and other banks will receive in case of firm default due to the concavity of the production technology. The monopolistic underinvestment force is standard. The banker internalizes the fact that more loans he supplies, the lower the rate of return on each loan is and he does not take into account the welfare of the firm. This leads to underinvestment relative to what the constrained Central Planner will choose. Finally, there exists a degree of imperfect banking sector competition, ρ^*, for which the two externalities perfectly cancel each other off.

The next proposition considers the optimal policy required to decentralize the constrained Central Planner's allocation. In this framework, the domestic policy rate in the decentralized equilibrium is an instrument that is sufficient to eliminate the externalities. Alternatively, if, for reasons exogenous to this model, the policy maker does not want to distort the marginal inter-temporal rate of substitution or wants to use domestic monetary policy to eliminate externalities due to sticky prices, as in the New Keynesian model, the policy maker can impose a tax on capital, instead. Such a tax would imply that the effective foreign policy rate is $(1+\tau) R_0^*$ and will be sufficient to replicate the constrained Central Planner's allocation. I consider using either one of these instruments.

Proposition 3. *The decentralized equilibrium will replicate the constrained Central Planner's allocation in one of two ways*
I) $\tau = 0$ *and*

$$\left(R_0^{PR} - 1\right) = Externality \frac{\left(\gamma^f + \gamma^h\right)}{\gamma^f}$$

where $L_1 = L_1^{CP}$ *(the Central Planner's loan allocation) and* $R_0^{PR\prime}(\rho) > 0$.
II) $R_0^{PR} = \tilde{R}$ *and*

$$\tau = Externality \frac{\left(\gamma^f + \gamma^h\right)}{\gamma^h R_0^* E_0 \frac{e_1}{e_0}} - \frac{\gamma^f}{\gamma^h} \frac{\left(\tilde{R} - 1\right)}{R_0^* E_0 \frac{e_1}{e_0}}$$

where $L_1 = L_1^{CP}$ *and* $\tau'(\rho) > 0$ *and* $\tilde{R}$ *is exogenous.*

Proof of Proposition 3: See Appendix.

Consider the case of $\tilde{R} = 1$, then it is optimal to impose a tax on capital inflows if the pecuniary externality is larger than the monopolistic competition externality and a it is optimal to impose a subsidy on capital inflows if the opposite is true. If $R_0^{PR} = \tilde{R} \neq 1$ then the optimal capital tax will be also a function of how much the policy rate deviates from the consumers' marginal intertemporal rate of substitution.

Furthermore the higher the degree of monopolistic competition is, the larger the tax on inflows is if $\tau > 0$ (the smaller the subsidy is if $\tau < 0$).

The intuition regarding the optimal R_0^{PR} (case I) if the policy rate is used instead is similar. This is not surprising given that both instruments are price instruments, i.e. they affect the effective cost of borrowing of bankers.

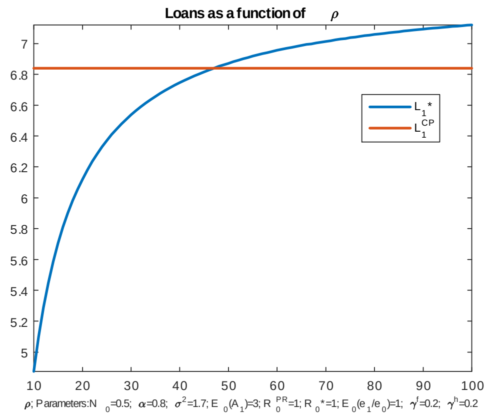

Figure 1: Figure 1

Combining the results in Proposition 1 and 3, then it is clear that larger spillovers (more negative $\frac{\partial L_1^*}{\partial R_0^*}$) does not always imply larger tax on capital inflows (larger $\tau'(\rho)$). This will be the case only if the additional costs of accessing foreign markets is fairly small ($\gamma^f \to 0$). The opposite can be true if γ^f and γ^h are large. In order to provide more intuition on this last point, the next section presents a numerical example.

7 Numerical Example

Consider the special case of an uniform distribution $A_1 \tilde{} U \left[\underbrace{E_0 A_1 - \frac{\sigma^2}{2}}_{\underline{A}}, \underbrace{E_0 A_1 + \frac{\sigma^2}{2}}_{\bar{A}}\right]$. $E_0 A_1$ is the conditional expectation of the domestic TFP shock which can be potentially a function of the period zero productivity of home and also of the foreign economy, if one wants to allow for exogenous spillovers to output. The variance of A_1 is a function of σ^2. Figure 1 plots L_t^* and L_t^{CP}. One can clearly see that for less competitive banking sectors, the monopolistic force dominates the pecuniary externality while the result flips after certain threshold for ρ. As emphasized in Proposition 2 there exists ρ^* for which the two externalities offset each other.

The following two Figures represent the optima τ and also $\frac{\partial L_1^*}{\partial R_0^*}$ as a function of ρ for two sets of values for γ^h and γ^f

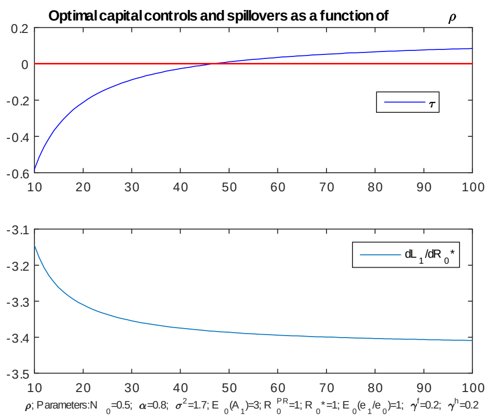

Figure 2

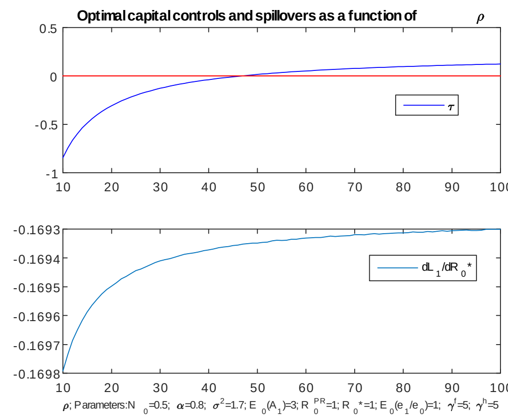

Figure 3

Figure 2 plots the case $\gamma^h = \gamma^f = 0.2$ which implies lower adjustment cost of foreign borrowing. In that case, the optimal tax on capital inflows increases with ρ and so do the spillover effects of an increase of foreign monetary policy on domestic loans in the decentralized equilibrium ($\frac{\partial L_1^*}{\partial R_0^*}$ becomes more negative). In Figure 3 $\gamma^h = \gamma^f = 5$ which implies we are in the case with high adjustment cost of foreign borrowing. In that case higher tax on inflows is associated with smaller foreign monetary policy spillovers.

8 Conclusion

In this paper I argue that the degree of banking sector competition is a key country-specific characteristic which governs the exposure of the banking sector and, therefore, of lending and GDP, to foreign monetary policy shocks. While higher degree of banking sector competition implies optimally higher capital controls (or higher optimal domestic policy rate), it is not always associated with larger foreign monetary policy spillovers. That will be the case only if accessing foreign interbank markets is fairly cheap, where these costs in reality can be a function of both the size of the bank but also of bank constraints not explicitly modelled here. This last comparative static seems to also find support in the data when one considers the sample of larger banks in emerging markets. The loans of less competitive banks in emerging markets seem to be less sensitive to US monetary policy shocks.

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A Appendix

A.1 Derivations:

A.1.1 Proof of Proposition 1:

Consider a distribution of A_1 such that equation 5 determines a unique solution for $\bar{R}_0 L_1^{1-\alpha}$ as a function of exogenous variables. This will be the case if the TFP shock has a uniform distribution, for example, as I show below.

Consider equation 13 which, jointly with equation 5, determines L_1^*, which is the equilibrium loan allocation in the decentralized equilibrium. Given that $\bar{R}_0 L_1^{1-\alpha}$ is equal to a constant, then $\frac{\partial \bar{R}_0(L_1) L_1^{1-\alpha}}{\partial L_1} = 0$ which implies that

(16)
$$\frac{\partial MB_L}{\partial L_1} = -(1-\alpha) L_1^{\alpha-2}\left[\left(1-F\left(\bar{R}_0 L_1^{1-\alpha}\right)\right)\bar{R}_0 L_1^{1-\alpha}\left(1-\frac{1}{\rho}\right)+\int_{\underline{A}}^{\bar{R}_0 L_1^{1-\alpha}} A_1 f\left(A_1\right) dA_1\right] < 0$$

and also $\frac{\partial MC_L}{\partial L_1} > 0$. Furthermore, $\lim_{L_1\to\infty} MB_L = 0, \lim_{L_1\to 0} MB_L = \infty, \lim_{L_1\to\infty} MC_L = \infty$ and $\lim_{L_1\to 0} MC_L < \infty$. This guarantees the existence of a unique decentralized equilibrium for a general distribution function of the TFP shock such that $\bar{R}_0 L_1^{1-\alpha}$ is equal to constant. Totally differentiate equation 13 to derive the following comparative statics

$$(17) \qquad \frac{\partial L_1^*}{\partial R_0^*} = -\frac{\frac{\gamma^h}{\left(\gamma^f+\gamma^h\right)} E_0 \frac{e_1}{e_0}}{\left[(1-\alpha) L_1^{\alpha-2}\tilde{\Theta} + \frac{\gamma^h \gamma^f}{\left(\gamma^f+\gamma^h\right)}\right]} \begin{cases} = 0 \text{ if } \gamma^h = 0 \text{ and } \gamma^f > 0 \\ < 0 \text{ if } \gamma^h > 0 \end{cases}$$

$$(18) \qquad \text{where } \tilde{\Theta} = \left[\left(1-F\left(\bar{R}_0 L_1^{1-\alpha}\right)\right)\bar{R}_0 L_1^{1-\alpha}\left(1-\frac{1}{\rho}\right)+\int_{\underline{A}}^{\bar{R}_0 L_1^{1-\alpha}} A_1 f\left(A_1\right) dA_1\right]$$

$$\frac{\partial L_1^*}{\partial \rho} = \frac{\left(1 - F\left(\bar{R}_0 L_1^{1-\alpha}\right)\right) \bar{R}_0 \frac{1}{\rho^2}}{\left(\frac{\gamma^h \gamma^f}{\left(\gamma^f + \gamma^h\right)} + (1-\alpha) L_1^{\alpha-2} \tilde{\Theta}\right)} > 0 \tag{19}$$

$$\frac{\partial L_1^*}{\partial R_0^* \partial \rho} = -\frac{\left[-L_1^{\alpha-3}\tilde{\Theta} + \frac{\gamma^h \gamma^f}{\left(\gamma^f + \gamma^h\right)} L_1^{-1}\right] (1-\alpha) \frac{\partial L_1}{\partial R_0^*} \frac{1}{\rho^2} \left(1 - F\left(\bar{R}_0 L_1^{1-\alpha}\right)\right) \bar{R}_0}{\left[(1-\alpha) L_1^{\alpha-2}\tilde{\Theta} + \frac{\gamma^h \gamma^f}{\left(\gamma^f + \gamma^h\right)}\right]^2}$$

$$\frac{\partial L_1^*}{\partial R_0^* \partial \rho} = 0 \text{ if } \gamma^h = 0 \text{ and } \gamma^f > 0$$

$$\frac{\partial L_1^*}{\partial R_0^* \partial \rho} = \frac{\frac{\partial L_1}{\partial R_0^*} \frac{1}{\rho^2} \left(1 - F\left(\bar{R}_0 L_1^{1-\alpha}\right)\right) \bar{R}_0 L_1^{1-\alpha}}{(1-\alpha)\tilde{\Theta}} < 0 \text{ if } \gamma^h > 0 \text{ and } \gamma^f \to 0$$

Consider the special case of an uniform distribution $A_1 \tilde{} U \left[\underbrace{E_0 A_1 - \frac{\sigma^2}{2}}_{\underline{A}}, \underbrace{E_0 A_1 + \frac{\sigma^2}{2}}_{\bar{A}}\right]$, which will be used later on for a numerical example. Equation 5 implies

$$\bar{R}_0 \left(L_1\right)^{1-\alpha} = \frac{\alpha \left(E_0 A_1 + \frac{\sigma^2}{2}\right)}{(2-\alpha)} \tag{20}$$

and $\bar{R}_0' \left(L_1\right) < 0$. Combining equations 13, 12 and 5, L_1 is determined by the following equation

$$MB_L = \Theta(\rho) L_1^{\alpha-1} = MC_L$$

$$\text{where } \Theta(\rho) = \left[-\alpha \frac{1}{\rho}\left(1 - \left(\frac{\alpha}{2-\alpha}\right)^2\right) + (1-\alpha)\left(\frac{\alpha}{(2-\alpha)}\right)^2\right]\left(E_0 A_1 + \frac{\sigma^2}{2}\right)^2 \frac{1}{2\sigma^2}$$
$$+\alpha E_0 A_1 - (1-\alpha)\frac{\left(E_0 A_1 - \frac{\sigma^2}{2}\right)^2}{2\sigma^2} > 0$$

$$\frac{\partial L_1^*}{\partial R_0^*} = -\frac{\frac{\gamma^h}{\left(\gamma^f+\gamma^h\right)} E_0 \frac{e_1}{e_0}}{(1-\alpha)\Theta(\rho) L_1^{\alpha-2} + \frac{\gamma^h \gamma^f}{\left(\gamma^f+\gamma^h\right)}} \begin{cases} = 0 \text{ if } \gamma^h = 0 \text{ and } \gamma^f > 0 \\ < 0 \text{ if } \gamma^h > 0 \end{cases}$$

$$\begin{aligned} \frac{\partial L_1^*}{\partial \rho} &= \frac{\Theta'(\rho) L_1^{\alpha-1}}{(1-\alpha)\Theta(\rho) L_1^{\alpha-2} + \frac{\gamma^h \gamma^f}{\left(\gamma^f+\gamma^h\right)}} > 0 \\ \text{where } \Theta'(\rho) &= \alpha \frac{1}{\rho^2}\left(1 - \left(\frac{\alpha}{(2-\alpha)}\right)^2\right)\left(E_0 A_1 + \frac{\sigma^2}{2}\right)^2 \frac{1}{2\sigma^2} > 0 \end{aligned}$$

$$\frac{\partial L_1^*}{\partial \rho \partial R_0^*} = -\frac{-\Theta(\rho) L_1^{\alpha-2} + \frac{\gamma^h \gamma^f}{\left(\gamma^f+\gamma^h\right)}}{\left((1-\alpha)\Theta(\rho) L_1^{\alpha-2} + \frac{\gamma^h \gamma^f}{\left(\gamma^f+\gamma^h\right)}\right)^2} (1-\alpha)\Theta'(\rho) L_1^{\alpha-2} \frac{\partial L_1}{\partial R_0^*}$$

$$\frac{\partial L_1^*}{\partial \rho \partial R_0^*} = 0 \text{ if } \gamma^h = 0 \text{ and } \gamma^f > 0$$

$$\frac{\partial L_1^*}{\partial \rho \partial R_0^*} = \frac{\Theta'(\rho) \frac{\partial L_1}{\partial R_0^*}}{(1-\alpha)\Theta(\rho)} < 0 \text{ if } \gamma^h > 0 \text{ and } \gamma^f \to 0$$

□

A.1.2 Proof of Proposition 2:

First consider the Central Planner's equilibrium where L_1^{CP}, which is the optimal amount of loans chosen by the Central Planner, is determined by equation 15. $\frac{\partial MC_L^{CP}}{\partial L_1} > 0$ and $\frac{\partial MB_L^{CP}}{\partial L_1} < 0$. Also $\lim_{L_1\to\infty} MB_L^{CP} = 0$, $\lim_{L_1\to 0} MB_L^{CP} = \infty, \lim_{L_1\to\infty} MC_L^{CP} = \infty$ and $\lim_{L_1\to 0} MC_L^{CP} < \infty$. This implies that there is an unique solution for L_1^{CP}. In Proposition 1, I proved that the decentralized equilibrium has an unique solution as well. One can re-write equation 13 as

$$MB_L = -\alpha\frac{1}{\rho}L_1^{\alpha-1}\int_{\bar{R}_0 L_1^{1-\alpha}}^{\bar{A}} A_1 f\left(A_1\right)dA_1 + \tag{21}$$

$$\left(1-\alpha\right)\left(L_1\right)^{\alpha-1}\int_{A}^{\bar{R}_0 L_1^{1-\alpha}} A_1 f\left(A_1\right)dA_1 + \alpha\left(L_1\right)^{\alpha-1}E_0 A_1 \tag{22}$$

$$= \frac{\gamma^f}{\left(\gamma^f+\gamma^h\right)}R_0^{PR} + \frac{\gamma^h\gamma^f}{\left(\gamma^f+\gamma^h\right)}\left(L_1 - N_0\right) + \frac{\gamma^h}{\left(\gamma^f+\gamma^h\right)}\left(1+\tau\right)R_0^* E_0\frac{e_1}{e_0} = MC_L$$

If $R_0^{PR} = 1$ in the decentralized equilibrium $MC_L^{CP} = MC_L$ for any L_1 and they are both increasing functions of L_1. MB_L^{CP} and MB_L are both decreasing functions of L_1. If $Externality > 0$ then $MB_L > MB_L^{CP}$ and $L_1^* > L_1^{CP}$. If $Externality < 0$ then $MB_L < MB_L^{CP}$ and $L_1^* < L_1^{CP}$. Finally if $Externality = 0$ then $MB_L = MB_L^{CP}$ and $L_1^* = L_1^{CP}$.$\square$

A.1.3 Proof of Proposition 3:

Equation 5 determines $\bar{R}_0$ as a function of L_1 both in the decentralized and the Central Planner's equilibria.

I) First consider the case where $\tau = 0$ and the instrument used is the domestic policy rate. Combining equations 15 and 21

$$\left(R_0^{PR} - 1\right) = Externality\frac{\left(\gamma^f+\gamma^h\right)}{\gamma^f}$$

where $L_1 = L_1^{CP}$.

$$R_0^{PR\prime}(\rho) = \alpha \frac{1}{\rho^2} \int_{\bar{R}_0 L_1^{1-\alpha}}^{\bar{A}} A_1 f(A_1)\, dA_1 (L_1)^{\alpha-1} \frac{\left(\gamma^f + \gamma^h\right)}{\gamma^f} > 0$$

II) Next consider the case where $R_0^{PR} = \tilde{R}$. Then the optimal τ is given by

$$\tau = \frac{\left(\gamma^f + \gamma^h\right)}{\gamma^h R_0^* E_0 \frac{e_1}{e_0}} Externality - \frac{\gamma^f}{\gamma^h} \frac{\left(\tilde{R} - 1\right)}{R_0^* E_0 \frac{e_1}{e_0}}$$

where $L_1 = L_1^{CP}$.

$$\tau'(\rho) = \frac{\left(\gamma^f + \gamma^h\right)}{\gamma^h R_0^* E_0 \frac{e_1}{e_0}} L_1^{CP,\alpha-1} \alpha \frac{1}{\rho^2} \int_{\bar{R}_0 L_1^{1-\alpha}}^{\bar{A}} A_1 f(A_1)\, dA_1 > 0$$

where given the uniform distribution specified in the proof of Proposition 1

$$\begin{aligned} Externality &= -\alpha \frac{1}{\rho} L_1^{CP,\alpha-1} \left(E_0 A_1 + \frac{\sigma^2}{2}\right)^2 \left(\frac{1 - \left(\frac{\alpha}{(2-\alpha)}\right)^2}{2}\right) \frac{1}{\sigma^2} \\ &\quad + (1-\alpha) \frac{\left(\frac{\alpha\left(E_0 A_1 + \frac{\sigma^2}{2}\right)}{(2-\alpha)}\right)^2 - \left(E_0 A_1 - \frac{\sigma^2}{2}\right)^2}{2} \frac{1}{\sigma^2} L_1^{CP,\alpha-1} \end{aligned}$$

□

A.2 Data Appendix

Data source:

Policy Rate (end of year): IFS (IMF), Global Financial Data and DataStream

Inflation and Industrial Production: IFS

Fed Funds Futures data: Bloomberg (1988-2008)

Romer and Romer surprises (1985-2008): Miranda-Agrippino and Rey (2015)

Fed Funds Rate (end of year): FRED

Bank Level variables: BankScope

Emerging markets include Brazil, Chile, Colombia, Mexico, Peru, Czech Republic, Egypt, Greece, Hungary, Poland, Russia, South Africa, Turkey, China, Indonesia, South Korea, Malaysia, Philippines, Taiwan and Thailand

Advanced economies include Canada, United States, Austria, Australia, Belgium, Finland, France, Germany, Ireland, Israel, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, Hong Kong, Japan, New Zealand and Singapore.

Appendix Tables:

Specification	$MPsupr$ (FF futures)	$MPsupr(RR)$	$\triangle$FF Rate
δ_c	$-19.8^{**}(8.21)$	$-23.2^{***}(7.5)$	$-22.7^{***}(7.7)$
δ_{MP}^{US}	$-17.2(12.68)$	$-1.84(4.5)$	$3.32(3.98)$
δ_{MP}^{j}	$0.19(0.22)$	$0.07(0.2)$	$0.12(0.2)$
$\delta_{c,MP}^{US}$	$22.44(14.6)$	$3.55(5.1)$	$-3.05(4.5)$
β_L	$-0.01(0.03)$	$-0.01(0.03)$	$-0.01(0.03)$
β_E	$0.45(0.49)$	$0.47(0.49)$	$0.45(0.49)$
$adj\ R^2$	0.016	0.016	0.016
N	$4,198$	$4,198$	$4,198$
country dummies	YES	YES	YES

Advanced Economies; Standard erros are reported in brackets; cluster by bank

All variables besides competitiveness are in percentage terms

***/**/* – significant at 1%, 5% and 10%