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Monetary and Macroprudential Policies to Manage Capital Flows

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Abstract

We study interactions between monetary and macroprudential policies in a model with nominal and financial frictions. The latter derive from a financial sector that provides credit and liquidity services that lead to a financial accelerator-cum-fire-sales amplification mechanism. In response to fluctuations in world interest rates, inflation targeting dominates standard Taylor rules, but leads to increased volatility in credit and asset prices. The use of a countercyclical macroprudential instrument in addition to the policy rate improves welfare and has important implications for the conduct of monetary policy. "Leaning against the wind" or augmenting a standard Taylor rule with an argument on credit growth may not be an effective policy response.

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I. Introduction

One of the legacies of the recent financial crisis has been a shift toward a system-wide or macro-prudential approach to financial supervision and regulation (Bernanke, 2008, Blanchard et. al. 2010). By their own nature, macro-prudential policies that have a systemic and cyclical approach are bound to impact macroeconomic variables beyond the financial sector, and interact with other macro policies, especially monetary policy (Caruana, 2011, IMF, 2013). In this paper, we study these interactions, focusing on the distortions that these policies attempt to mitigate, especially in the management of swings in capital flows (Ostry et al, 2011).

A number of emerging market economies have recently used macroprudential instruments countercyclically to deal with swings in capital flows. Lim et al (2011) document this for a number of macro-prudential instruments, and Federico et al (2013) do it for reserve requirements.[1] Figure 1 shows the countercyclical use of reserve requirements for four EMs around Lehman's bankruptcy (see also IMF, 2012). All four countries slashed policy rates in the immediate aftermath of Lehman's bankruptcy, but Brazil and Peru reduced reserve requirements dramatically even before cutting rates. As capital inflows surged following the adoption of unconventional monetary policies in the major reserve-currency-issuing countries, all four countries raised reserve requirements to curb credit growth, and they increased policy rates—with the exception of Turkey.[2]

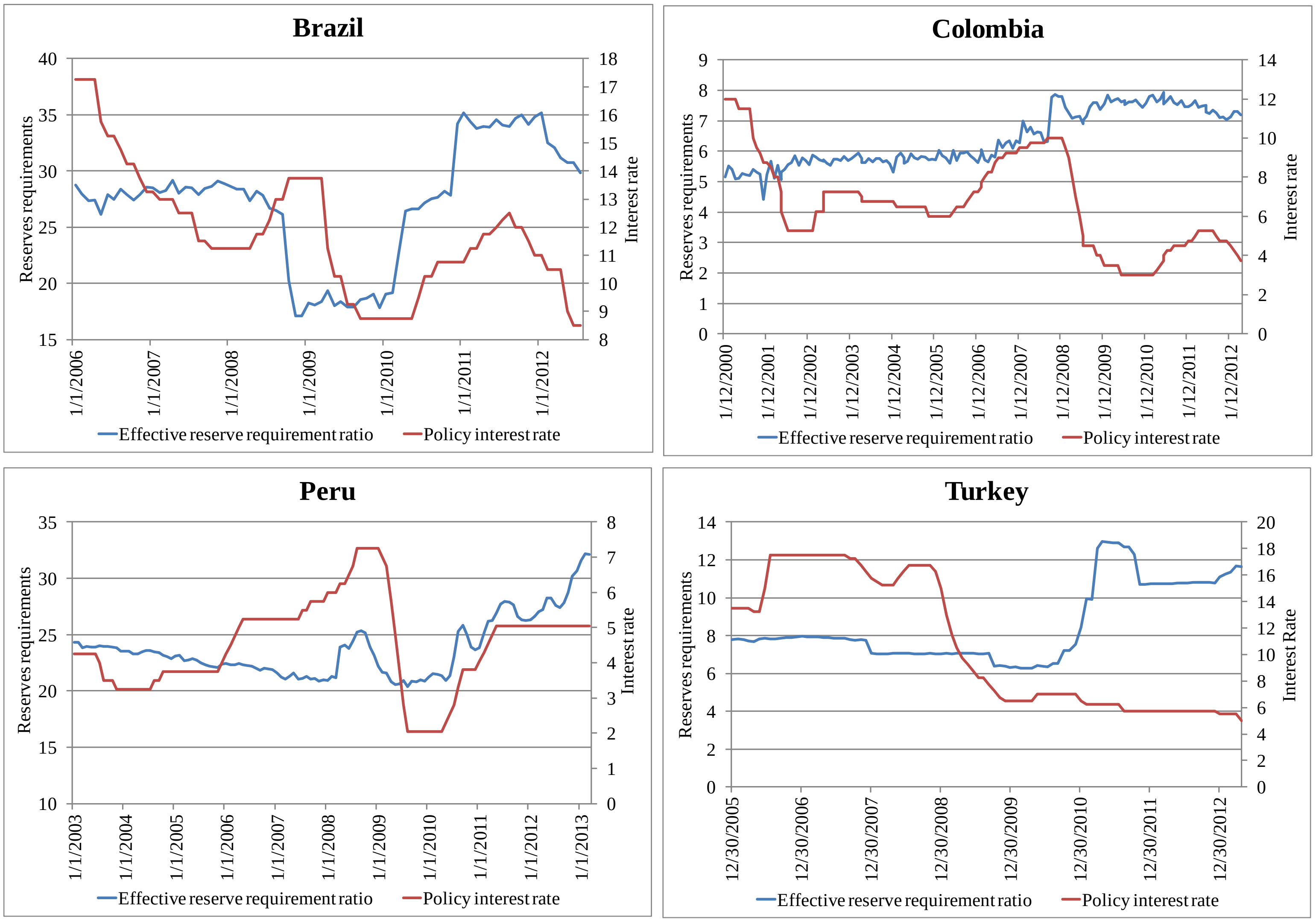
These policy responses and the crisis itself have opened an intense debate about objectives, targets and instruments of both monetary and macroprudential policies. Most papers addressing these issues assume that the government's objective is to minimize a loss function that adds credit growth volatility to that of output and inflation, and rank policies accordingly (for instance Glocker and Towbin, 2012, Mimic et al, 2013). They usually find that macroprudential instruments contribute to price and financial stability, especially when dealing with financial shocks, but that there are trade-offs between monetary and macroprudential instruments with respect to demand or productivity shocks. Kannan et al (2012) and Unsal (2013) also rank these policies according to the volatility of inflation and the output gap, and do not derive the impact of the macroprudential measures from financial frictions but rather postulate that the measures lead to an additional cost for financial intermediaries.

In this paper we study interactions between monetary and macroprudential policies and we innovate in three fronts. First, we model explicitly the nominal and financial frictions that monetary and macroprudential policies attempt to mitigate. In particular, we incorporate a financial sector that provides both credit and liquidity services with standard microfoundations. Second, we calculate model-based welfare measures for different policy arrangements and rank them accordingly. And third, focusing on a shock to world interest rates, that keeps rates low

[1] Elliot et al (2013) provide a comprehensive survey of the historical evidence on the use of cyclical macro-prudential instruments in the U.S., including underwriting standards, reserve requirements, credit growth limits, deposit rate ceilings and supervisory pressure.

[2] Changes in average reserve requirements in Colombia underestimate the actual impact because they don't capture changes in marginal rates and remuneration that increase the effectiveness of these measures (Vargas et al, 2010).

Figure 1. Interest Rates and Reserve Requirements in Selected Emerging Markets



for an extended period of time and that is later on undone. This induces a long period of inflows followed by a reversal that resembles the unwinding of unconventional monetary policies in advanced economies. Thus, we study the interactions of these two policies during an event that is relevant for many countries at this juncture and where the potential tensions between these two policies are least understood. [3]

The financial sector in our model features two types of representative intermediaries that operate in competitive markets: a lending and a liquidity intermediary, that interact with each other through an interbank market. The lending intermediary provides credit to entrepreneurs solving an agency-cost problem as in Bernanke, Gertler and Gilchrist (1999). For the liquidity intermediary, we extend the mechanism introduced by Choi and Cook (2012), and assume that liquidity services are produced with "excess reserves" and real resources. This assumption provides natural links with the lending intermediaries and with the monetary authority, and allows us to endogenize not just default but also recovery rates and the response to a countercyclical macroprudential instrument. Although the model does not deliver the type of systemic events (crises) that macroprudential policies aim to mitigate, the financial accelerator-cum-fire sales mechanism we introduce produces a fair amount of amplification and persistence that makes the financial friction relevant for macroeconomic policies—in particular, to study interactions between monetary and macroprudential policies.

This financial sector is embedded in an otherwise-standard small open economy New Keynesian model with Calvo-pricing nominal rigidities (as in Gali and Monacelli, 2005). We study the transitional dynamics to the world interest rate shock and also derive a welfare function consistent with the underlying model, where trade-offs between correcting both distortions may exist. As in Faia and Monacelli (2007), we study a restricted set of rules which we can rank according to that welfare metric. In particular, we consider Taylor-type rules, both standard and augmented with a credit growth argument (as in Christiano et al, 2010), and combine them with both a constant and a counter-cyclical reserve requirement—our simple macroprudential rule.

A large and protracted reduction in world interest rates produces large capital inflows, and increases in aggregate demand, activity, the real exchange rate and asset prices, in what we call the "natural" economy—i.e. the one without price or financial frictions. The introduction of these frictions magnifies the cyclical fluctuations of most macro and financial variables, in particular of asset prices and credit.

Our main results are the following. First, although a pure or strict inflation targeting (IT) regime dominates a standard Taylor-rule regime in most cases, it delivers too much asset price volatility and may (or may not) be dominated by an adjusted Taylor-rule that reacts to credit growth (as suggested by Christiano et al (2010)). However, all these regimes are dominated in welfare terms by one that utilizes a counter-cyclical reserve requirement (aimed at the financial friction) together with a pure IT rule for monetary policy (aimed at the nominal friction). We interpret this result as reflecting the Tinbergen principle of "one instrument for each objective" and

[3] The importance of shocks to world interest rates for emerging market business cycles has been emphasized in Neumeyer and Perri (2005).

Mundell's "principle of effective market classification," whereby instruments should be paired with the objectives on which they have the most influence (see Glocker and Towbin, 2012, and Beau et al, 2012).

Second, once we use a macroprudential instrument, the evolution of the policy rate deviates substantially from the Taylor rule, and suggests the need for close coordination of both instruments. In particular, while the "natural" interest rate of this economy declines with the world rate, the policy rate may indeed need to be increased to accommodate reserve requirements—in contrast to the Turkey experience.

The paper is organized as follows. The next section lays out the model economy, with special focus on the financial sector, and describes the four monetary and macroprudential policy frameworks. Section III discusses a baseline calibration and the welfare measure we use to rank these policy frameworks. Section IV studies the policy responses to the proposed world interest rate shocks, analyzing impulse responses and welfare rankings, followed by section V on the robustness of the results. Section VI concludes the paper.

II. Model Economy

The model is an extension of the financial accelerator framework developed by Bernanke et al. (BGG, 1999) to an open economy context. The presence of price rigidities induces a role for monetary policy to affect the real interest rate and correct the associated distortion. Similarly, the presence of a financial friction associated with the cost of monitoring defaulted borrowers suggests the potential role of a macro-prudential instrument to reduce this other distortion. In addition to the BGG credit friction, we extend the mechanism in Choi and Cook (2012) whereby fire sales further amplify the financial accelerator mechanism. In Choi and Cook (2012), when a loan is defaulted the capital seized by the lending intermediaries is sold at a discounted price due to the fact that the liquidation technology consumes resources. In this paper, we assume that in addition to the use of real resources the liquidation process also requires time and excess reserves in the financial sector, which produces a natural real-financial linkage and a role for reserve requirements to manage the intensity of the financial cycle.

In what follows we explain in more detail the different agents and their behavior in our model economy: households, capital and goods producers, entrepreneurs, and the financial sector.

A. Households

The intertemporal preferences of the households are characterized by

$$U_t = E_t\left[\sum_{i=0}^{\infty}\beta^i u(c_t, h_t, \frac{M_t}{P_t})\right]$$

where c_t is the consumption basket, h_t is labor supply and $\frac{M_t}{P_t}$ are real money balances.

The period t household budget constraint equals consumption plus savings with real income:

$$c_t + \frac{D_t}{P_t} - \frac{e_t B^*_{H,t}}{P_t} + \frac{M_t}{P_t} = \frac{W_t}{P_t} h_t + R^D_{t-1} \frac{D_{t-1}}{P_t} - R^*_{t-1} \Theta_{t-1} \frac{e_t B^*_{H,t-1}}{P_t} + \frac{M_{t-1}}{P_t} + \Pi_t - \tau_t$$

Household savings can be invested in three types of financial assets: deposits (D_t) with a return of R^D_t in t; foreign bonds ($B^*_{H,t}$) with a foreign-currency return $R^*_t \Theta_t$ in t; and money balances (M_t). The household's income in period t derives from labor, returns from previous period holding of financial assets, and profits from firms Π_t (net of lump-sum taxes, τ_t).
Foreign bonds are expressed in foreign currency and e_t is the nominal exchange rate (unit of domestic currency per unit of foreign currency). Θ_t is a risk premium for foreign bonds (liabilities), which is taken as given for the households, but it is a function of the total indebtedness of the economy, $\Theta_t = \Theta(B^*_t)$. The real exchange rate is defined as $rer_t = \frac{e_t P^*_t}{P_t}$.

The optimal holding of deposits satisfies the following households' *Euler* equation:

$$1 = \beta R^D_t E_t \left[\frac{u_{c,t+1}}{u_{c,t}} \frac{1}{(1+\pi_{t+1})} \right] \tag{1}$$

The optimal holding of foreign bonds (liabilities) satisfies the following households' *Euler* equation:

$$1 = \beta R^*_t \Theta(B^*_t) E_t \left[\frac{u_{c,t+1}}{u_{c,t}} \frac{rer_{t+1}}{rer_t} \frac{1}{(1+\pi^*_{t+1})} \right] \tag{2}$$

The money demand by households is given by:

$$u_{\frac{M}{P},t} = \frac{R^D_t - 1}{R^D_t} u_{c,t} \tag{3}$$

and households' labor supply is characterized by:

$$\frac{W_t}{P_t} = -\frac{u_{h,t}}{u_{c,t}} \tag{4}$$

In this economy, households save but they don't manage the allocation and financing of the physical capital stock.

B. Production and Capital Accumulation

Competitive firms in this economy produce domestic goods (that are sold to domestic and foreign wholesalers) and capital goods (that are sold to entrepreneurs). Aggregate production of domestic goods is given by:

$$y_t = a_t (k_t)^{\theta_y} (h_t)^{1-\theta_y}, \tag{5}$$

which is sold at price $P_{y,t}$. The demand for labor and capital services are given by:

$$\frac{W_t}{P_t} = \frac{P_{y,t}}{P_t}\frac{(1-\theta_y)y_t}{h_t}, \text{ and} \tag{6}$$

$$\frac{VMPK_t}{P_t} = rr_{K,t} = \frac{P_{y,t}}{P_t}\frac{\theta_y y_t}{k_t} \tag{7}$$

where $VMPK_t$ and $rr_{K,t}$ are the nominal marginal productivity of capital and the real rental rate of capital. Capital is produced by perfectly competitive capital producers that buy installed capital from successful entrepreneurs, new capital from goods producers, and liquidated or restructured capital from liquidity intermediaries.

In contrast to the standard financial accelerator model (BGG, 1999), we assume that defaulted capital requires time and resources to be liquidated and become productive again. Let $k_{D,t}$ and $k_{D,t}^{new}$ be, respectively, the stock of defaulted capital and the new defaulted capital in period t. Both the productive and defaulted capital depreciate at a rate δ. Each period, there is a probability η_K of turning one unit of defaulted capital into productive one. In consequence, a fraction η_K of the undepreciated defaulted capital becomes productive. Thus, the evolution of the productive capital stock is given by:

$$k_{t+1} = (1-\delta)\left(k_t - k_{D,t}^{new}\right) + \left(1 - \Delta\left(\frac{inv_t}{inv_{t-1}}\right)\right) inv_t + \eta_K(1-\delta)k_{D,t} \tag{8}$$

where $\Delta(\quad)$ is an adjustment cost in the change of investment and it can be interpreted as a time-to-build mechanism for capital accumulation. From the capital goods producer problem we obtain the demand for investment (new capital):

$$qr_t\left(1 - \Delta\left(\frac{inv_t}{inv_{t-1}}\right) - \Delta'\left(\frac{inv_t}{inv_{t-1}}\right)\frac{inv_t}{inv_{t-1}}\right) + E_t\left[sd_{t,t+1}qr_{t+1}\left(\Delta'\left(\frac{inv_{t+1}}{inv_t}\right)\left(\frac{inv_{t+1}}{inv_t}\right)^2\right)\right] = 1 \tag{9}$$

where $sd_{t,t+1}$ is the stochastic discount factor between period t and t+1 (the household intertemporal marginal rate of substitution of consumption, $sd_{t,t+1} = \beta\frac{u_{c,t+1}}{u_{c,t}}$), and Q_t (qr_t) is the nominal (real) price of installed capital.

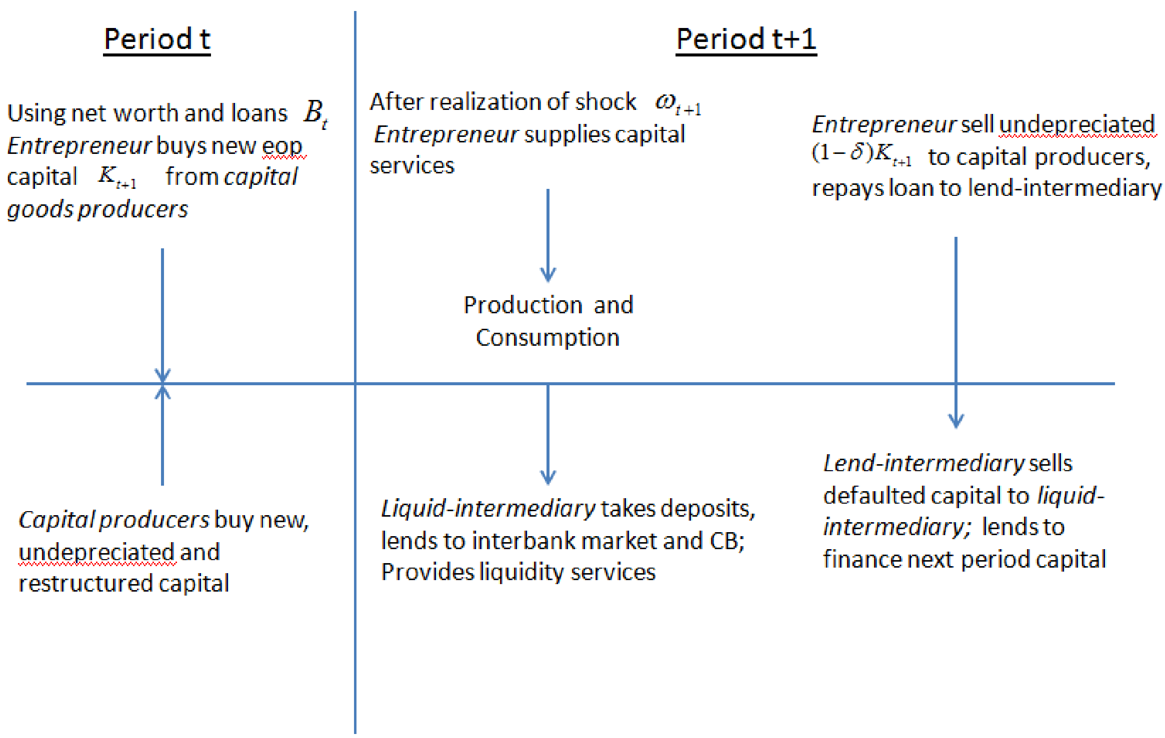
C. Financial Sector

The financial sector links depositors (households) and investors (entrepreneurs). It comprises two sets of intermediaries: lending and liquidity intermediaries, which interact through an interbank market, and summarize the provision of credit and liquidity services in this economy. In laying out this generic financial system, we follow Merton and Bodie (2004) and focus on the two key functions of providing credit and liquidity, while leaving the more specific institutional details to the calibration exercise—and the specifics of different actual economies.

Entrepreneurs in this economy use their nominal net worth ($netn_t$), and loans (B_t) from the lending intermediaries to purchase new, installed physical capital, k_{t+1}, from capital producers.

Entrepreneurs then experience an idioscincratic technological shock that converts the purchased capital into $\omega_{t+1}k_{t+1}$ units at the beginning of the period (where ω_{t+1} is a unit-mean, log-normally distributed random variable with standard deviation equal to σ_{ω}), and rent capital to goods producers. If they are successful, entrepreneurs sell their capital to capital producers at the end of the period and repay their loans. If they are unsuccessful and default, the lending intermediary takes control of the capital and sells (at a fire-sale price) the capital to the liquidity intermediary, that uses real and financial resources to restructure and sell it back to capital producers (the timeline of event is summarized in Figure 2).

Figure 2. Timing of Events



Lending intermediaries

Lending intermediaries get funds from the interbank market and lend them to entrepreneurs through BGG-type debt contracts. Since only the entrepreneurs observe the realization of the shock, they have an incentive to misrepresent the outcome, and this creates an agency–cost distortion that the debt contract attempts to minimize.

For each unit of capital, a successful entrepreneur obtains a nominal payoff equal to the rental rate of capital and the price of the undepreciated capital:

$$payn_t = P_t\left(rr_{K,t} + (1-\delta)qr_t\right) = VMPK_t + (1-\delta)Q_t \tag{10}$$

The contracts are characterized by a lending interest rate, R^l_{t+1}, such that if the entrepreneurs has a realization of ω_{t+1} and $\omega_{t+1}payn_{t+1}k_{t+1} \geq R^l_{t+1}B_t$, they pay back the loan in full to the lending intermediaries; if the realization falls short ($\omega_{t+1} payn_{t+1} k_{t+1} < R^l_{t+1} B_t$), the entrepreneur defaults on the loan.

It is convenient to define the *average* rate of return of capital as:

$$R^K_{t+1} = \frac{VMPK_{t+1} + (1-\delta) Q_{t+1}}{Q_t} \tag{11}$$

At the end of period t the entrepreneur has net worth N_t and borrows B_t from the lending intermediary to buy k_{t+1}. An endogenous cut-off $\bar{\omega}_{t+1}$ determines which entrepreneurs repay and which ones default, and it is determined by the expression

$$\bar{\omega}_{t+1} R^K_{t+1} Q_t k_{t+1} = R^l_{t+1} B_t \tag{12}$$

This equation implies that, *ceteris-paribus*, the lending rate R^l_{t+1} moves with the cut-off $\bar{\omega}_{t+1}$. Thus, instead of characterizing the loan contract in terms of R^l_{t+1}, we can do it in terms of $\bar{\omega}_{t+1}$.

When the entrepreneur defaults, the lending intermediary audits and takes control of the investment, which then is sold to the liquidity intermediary. In this case, the lending intermediaries still obtain the benefit of renting capital to output producers, but the default has costs due to the fact that the undepreciated capital is sold at a nominal (real) fire-sale price FS_t ($fsr_t = FS_t / P_t$). Thus, the actual payment that a lending intermediary can obtain from a defaulted loan ($\omega_t < \bar{\omega}_t$) is $\omega_t k_t (VMPK_t + FS_t)$.

The lending intermediary determines the cut-off $\bar{\omega}_t$with the zero-profit condition:

$$(1 - \Phi(\bar{\omega}_t;\, \sigma_\omega)) R^l_t B_{t-1} + k_t (VMPK_t + (1-\delta) FS_t) \int_0^{\bar{\omega}_t} \omega d\Phi(\omega;\, \sigma_\omega) = R^{IB}_{t-1} B_{t-1} \tag{13}$$

where $\Phi(\omega_t;\, \sigma_\omega)$ is the cumulative probability distribution (CDF) of ω_t given its standard deviation σ_ω, R^{IB}_{t-1} is the gross cost of funds and B_{t-1} is nominal borrowing. Using the relationship between R^l_{t+1} and $\bar{\omega}_t$ we can define the cost of default as,

$$\mu_t = \frac{(Q_t - FS_t)(1-\delta)}{payn_t} \tag{14}$$

In contrast to BGG (1999), that assume a constant μ_t, here the cost of default is endogenous and depends on the difference between the market prices of installed and defaulted capital. Under financial stress, fire-sale prices differ substantially from the price of installed capital, decreasing recovery values and increasing the cost of default.

Thus, we can define the share of $payn_t k_t$ going to the lending intermediaries as:

$$g(\bar{\omega}_t, \mu_t, \sigma_\omega) = \bar{\omega}_t \big(1 - \Phi(\bar{\omega}_t; \sigma_\omega)\big) + (1 - \mu_t) \int_0^{\bar{\omega}_t} \omega d\Phi(\omega; \sigma_\omega) \tag{15}$$

and the share of $payn_t k_t$ going to entrepreneurs as:

$$f(\bar{\omega}_t, \sigma_\omega) = \int_{\bar{\omega}_t}^{\infty} \omega d\Phi(\omega; \sigma_\omega) - \bar{\omega}_t\big(1 - \Phi(\bar{\omega}_t; \sigma_\omega)\big) \tag{16}$$

The optimal conditions for the loan contract that maximizes the entrepreneur payoff, subject to the lending intermediary zero profit condition, are the following (see appendix I for details):

$$Q_t E_t \left\{ R_t^{IB} \frac{f_{\bar{\omega}}(\bar{\omega}_{t+1}, \sigma_\omega)}{g_{\bar{\omega}}(\bar{\omega}_{t+1}, \mu_{t+1}, \sigma_\omega)} \right\} = E_t \left\{ \frac{payn_{t+1}}{\rho(\bar{\omega}_{t+1}, \mu_{t+1}, \sigma_\omega)} \frac{f_{\bar{\omega}}(\bar{\omega}_{t+1}, \sigma_t)}{g_{\bar{\omega}}(\bar{\omega}_{t+1}, \mu_{t+1}, \sigma_\omega)} \right\}, \tag{17}$$

which represents an arbitrage condition for the loans to entrepreneurs, and the break-even condition for financial intermediaries:

$$g(\bar{\omega}_{t+1}, \mu_{t+1}, \sigma_\omega) payn_{t+1} k_{t+1} = R_t^{IB} B_t, \tag{18}$$

In the expression (17), $\rho(\cdot)$ can be interpreted as a risk premium and it is defined as:

$$\rho(\bar{\omega}_t, \mu_t, \sigma_\omega) = \left[g(\bar{\omega}_t, \mu_t, \sigma_\omega) - f(\bar{\omega}_t, \sigma_\omega) \frac{g_{\bar{\omega}}(\bar{\omega}_t, \mu_t, \sigma_\omega)}{f_{\bar{\omega}}(\bar{\omega}_t, \sigma_\omega)} \right]^{-1} \tag{19}$$

In order to describe the evolution of the entrepreneurs' net worth, we will assume that a fraction $1 - \lambda$ of entrepreneurs survives to the next period while the rest (a fraction λ) die and consume all their wealth. The dead entrepreneurs are replaced by a new mass of entrepreneurs that start with a real net wealth equal to τ_E. For simplicity, we will consider that the surviving entrepreneurs also receive this real net wealth transfer. Thus, the net worth of entrepreneurs evolves according to:

$$netn_t = (1 - \lambda) f(\bar{\omega}_t, \sigma_\omega) payn_t k_t + P_t \tau_E, \tag{20}$$

and the dying entrepreneurs have the following consumption:

$$c_{K,t} = \lambda\, f(\bar{\omega}_t, \sigma_\omega) \frac{payn_t}{P_t} k_t \tag{21}$$

Liquidity Intermediaries

Liquidity intermediaries receive deposits from households, paying a gross rate R_t^D, and lend in the interbank market at an interest rate R_t^{IB} (and to the monetary authority at a rate R_t^{RE}). They use "excess reserves" and final goods to provide liquidity services that amount to liquidating or restructuring the capital of unsuccessful entrepreneurs.[4]

[4] Real resources are needed to conduct due diligence, assess future cash-flows of failed capital, and return to productive use. "Excess reserves" are the financial or liquid resources needed to buy that capital or distressed assets. As noted by Gorton and Huang (2004) there are many notions of "liquidity" and they mostly refer to situations where not all assets can be used to buy all other assets at a point in time. This amounts to a "liquidity-in-advance" constraint, as summarized in the technology below.

We assume that the demand for liquidation services is related to the stock of defaulted capital:

$$lq_t = \nu k_{D,t} \ . \tag{22}$$

The evolution of defaulted capital is given by:

$$k_{D,t+1} = (1-\eta_K)(1-\delta)k_{D,t} + k_{D,t+1}^{new} \tag{23}$$

where $k_{D,t+1}^{new}$ is the amount of new defaulted capital at the end of the period $t+1$

$$k_{D,t+1}^{new} = k_{t+1}\int_0^{\bar{\omega}_{t+1}} \omega d\Phi(\omega;\sigma_\omega). \tag{24}$$

Liquidity intermediaries provide these liquidity services using a technology that combines excess reserves and final goods in a complementary way:[5]

$$lq_t = \min[Z(n_t)^{1-\alpha_{lq}};\ \ Z_{xr}(xr_t)^{1-\alpha_{xr}}] \tag{25}$$

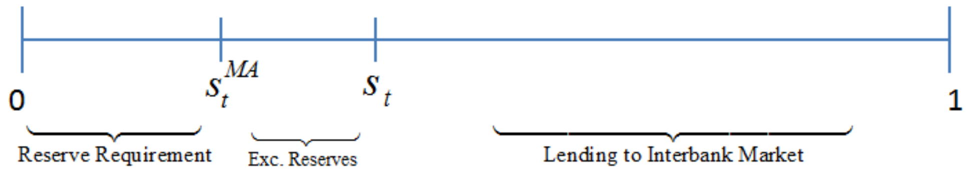
Thus, the problem of the liquidity intermediaries is to maximize current profits from lending to interbank markets and to the monetary authority as well as producing other liquidity services:

$$\max_{n_t, s_t, \left(\frac{D_t}{P_t}\right)} \left\{[(1-s_t)R_t^{IB} + s_t^{MA}R_t^{RE} - R_t^D]\frac{D_t}{P_t}\frac{P_t}{R_t^D} - P_t n_t\right\}$$
$$\begin{aligned} s.t.\ lq_t &= Z(n_t)^{1-\alpha_{lq}} \\ lq_t &= Z_{xr}(xr_t)^{1-\alpha_{xr}} \\ xr_t &= (s_t - s_t^{MA})\frac{D_t}{P_t} \end{aligned}$$

where $\left(\frac{D_t}{P_t}\right)$ is the real amount of deposits, a fraction $(1-s_t)$ of which is lent in the interbank market. The monetary authority imposes a reserve requirement of s_t^{MA}, and xr_t are excess reserves used in liquidation services (see Figure 3). Since the opportunity cost of funding for liquidity intermediaries is R_t^D, they discount the end-of-period net benefits of lending in the interbank market by this interest rate.

[5] The use of reduced-form technologies to produce financial services is common in monetary policy models (for instance, Chari, Christiano, and Eichenbaum (1995), Edwards and Vegh (1997), Goodfriend and McCallum (2007), Christiano, Motto and Rostagno (2010) and Curdia and Woodford (2010)).

Figure 3. Liquidity Intermediary Allocation Problem



Optimality conditions for the liquidation services (for details see appendix II) determine the fire-sales price of defaulted capital:

$$FS_t = \eta_K Q_t - \nu(f_t + g_t) + (1-\eta_K)(1-\delta)E_t\left[\frac{sd_{t,t+1}}{1+\pi_{t+1}}FS_{t+1}\right] \tag{26}$$

where f_t and g_t are the marginal costs of liquidation services attributed respectively to the use of final goods and excess reserves. These marginal costs of liquidation services are an important determinant of the spread between the interbank and deposit rates:

$$R_t^{IB} = \frac{g_t}{P_t}\frac{(1-\alpha_{lq})lq_t}{xr_t}R_t^D; \tag{27}$$

This spread can also be expressed in terms of the macro-prudential policy instrument, the time-varying reserve requirement s_t^{MA} (assuming $R_t^{RE} = 1$):

$$R_t^{IB} = (1-s_t^{MA})^{-1}[R_t^D - s_t^{MA}] \tag{28}$$

Finally, equilibrium in the interbank market means that the fraction of entrepreneurs debt financed in the interbank market has to be equal to the fraction of real deposits of the liquidity intermediaries lent in the interbank market:

$$\frac{D_t}{P_t}(1-s_t) = \frac{B_t}{P_t} \tag{29}$$

D. Aggregation and Price Rigidities

Total demand for final goods is given by:

$$da_t = c_t + c_{K,t} + inv_t + n_t \tag{30}$$

where final goods are a composite of domestic and imported goods:[6]

$$y_{s,t} = \left[(1-\alpha_d)^{1/\theta_d}(y_t - x_t)^{1-1/\theta_d} + (\alpha_d)^{1/\theta_d}(y_{f,t})^{1-1/\theta_d}\right]^{\frac{\theta_d}{\theta_d - 1}} \tag{31}$$

where x_t are exports of domestically produced goods while $y_{f,t}$ are imports of foreign goods.

[6] Details of the aggregation and the role of price-setting wholesalers can be found in appendix III.

The real marginal cost of final goods is given by (α_d is the share of foreign goods)

$$mgcr_t = \left[(1-\alpha_d) \ \ (\frac{P_{y,t}}{P_t})^{1-\theta_d} + (\alpha_d) \ \ (rer_t)^{1-\theta_d}\right]^{\frac{1}{1-\theta_d}} \tag{32}$$

and the relative demand for domestic and imported goods in the final good basket is:

$$\frac{y_t - x_t}{y_{f,t}} = \frac{(1-\alpha_d)}{\alpha_d}\left(\frac{rer_t}{P_{y,t}/P_t}\right)^{\theta_d} \tag{33}$$

where rer_t is the real exchange rate as defined previously, and θ_d is the elasticity of substitution between domestic and foreign goods in the composite good.

The wholesale firms that produce differentiated domestic goods operate in monopolistically competitive markets and set prices à-la-Calvo (1983). Thus, in each period only a fraction $1-\phi_p$ of the firms can change optimally their prices while all other firms can adjust the price according to a fraction $\chi_p \in [0,1]$ of past inflation. A log-lineal version of the Phillips' curve of final good inflation is (see appendix III for a complete derivation of the conditions):

$$\log(1+\pi_t) = \frac{\beta}{1+\beta\chi_p} E_t[\log(1+\pi_{t+1})] + \frac{\chi_p}{1+\beta\chi_p}\log(1+\pi_{t-1}) + \frac{(1-\phi_p)(1-\beta\phi_p)}{\phi_p(1+\beta\chi_p)}\log\left(\frac{mgcr_t}{MC}\right) \tag{34}$$

Finally, the balance of payments identity implies that:

$$rer_t B_t^* = R_{t-1}^* \Theta(B_{t-1}^*)\frac{B_{t-1}^*}{(1+\pi^*)} rer_t - \frac{P_{y,t}}{P_t} x_t + rer_t(y_{f,t}) \tag{35}$$

where $B_t^* = B_{H,t}^*$ is the stock of foreign debt of the economy, R_t^* is the (gross) foreign interest rate and π^* is the foreign inflation rate.

The foreign demand for exports is modeled as

$$x_t = \bar{x}\left(\frac{rer_t}{P_{y,t}/P_t}\right)^{\theta^*} \tag{36}$$

where θ^* is the price-elasticity of the foreign demand for domestic goods, and the exogenous evolution of the foreign interest rate is given by the following stochastic process:

$$\log\left(\frac{R_{t+1}^*}{R^*}\right) = \rho_{R*}\log\left(\frac{R_t^*}{R^*}\right) + \varepsilon_{R*,t+1} \tag{37}$$

E. Alternative Monetary and Macro-Prudential Frameworks

We start with a specification that removes the price rigidities and financial frictions, which we denote as the "natural" allocation of the model economy. When both frictions are present, we need to characterize the macroeconomic policies implemented to complete the model economy. We assume that the monetary policy instrument is the interbank market rate, R_t^{IB}, and that the macro-prudential tool is the time-varying reserve requirement, s_t^{MA}. We set different rules for these instruments as a way to define alternative monetary and macro-prudential arrangements.

1. *Standard Taylor-type rule and constant reserve requirement*. In this case monetary policy is characterized by the following reaction rule for the interbank rate (in annual terms):

$$\log\left(\frac{R_t^{IB}}{1+r}\right) = \psi_R \log\left(\frac{R_{t-1}^{IB}}{1+r}\right) + (1-\psi_R)\left(\psi_\pi \log(1+\pi_t) + \psi_y \log(y_t)\right)$$

where we set $\psi_R = 0, \psi_\pi = 1.5, \psi_y = 0.5$. The reserve requirement, s_t^{MA}, is constant and equal to its steady state value, $s^{MA} = 0.10$.

2. *Inflation Targeting (IT) regime and constant reserve requirement*. In this situation monetary policy is modeled as an implicit contingent rule that achieves a full stabilization of inflation in every period and every state. As in the previous case, the reserve requirement is constant at its steady-state level.

3. *Augmented Taylor-type rule with a countercyclical reaction to credit (entrepreneurs' loan)*. In this case, we extend the Taylor-type rule described in 1, to include a countercyclical reaction to fluctuations in entrepreneurs' loan:

$$\log\left(\frac{R_t^{IB}}{1+r}\right) = \psi_R \log\left(\frac{R_{t-1}^{IB}}{1+r}\right) + (1-\psi_R)\left(\psi_\pi \log(1+\pi_t) + \psi_y \log(y_t) + \psi_b \log(b_t)\right)$$

where we consider $\psi_R = 0, \psi_\pi = 5.0, \psi_y = 0.5, \psi_b = 1.0$. Again, the reserve requirement is constant at its steady-state level.

4. *Inflation targeting (IT) regime combined with a countercyclical reserve requirement*. As in case 2, the interbank rate follows an implicit rule that guarantees that inflation is fully stabilized in every period and state. The inflation targeting regime is combined with a macro-prudential rule that adjusts the reserve requirement counter-cyclically.[7] This possibility is modeled as follows:

$$\log\left(\frac{s_t^{MA}}{s^{MA}}\right) = -\phi_{xr} \log\left(\frac{xr_t}{xr}\right)$$

where $\phi_{xr} = 10$.

[7] Edwards and Vegh (1997) demonstrate the desirability of using a countercyclical reserve requirement in the context of a fixed-exchange-rate regime; however, they assume that the reserve requirement moves directly with foreign interest rates rather than with domestic financial conditions.

III. BASELINE CALIBRATION AND WELFARE ANALYSIS METHODOLOGY

The model is calibrated for a quarterly frequency.[8] Thus, household's discount factor will be set at $\beta = 0.99$ while household's utility per period is specified as:

$$u\left(c_t, h_t, \frac{M_t}{P_t}\right) = \ln\left(c_t - \gamma_h \frac{(h_t)^{1+\sigma_L}}{1+\sigma_L}\right) + \frac{a_m}{j}\left(\frac{M_t}{P_t}\right)^j,$$

where $\sigma_L = 1, \gamma_h$ is such that in the steady state hours worked corresponds to a third of the available hours for the representative household ($h = 1/3$). The steady state inflation rate is set at zero ($\pi = 0, \pi^* = 0$), implying that, at the steady state, the (gross) deposit rate is $R^D = \frac{1}{\beta} = 1.01$, which is approximately 4 percent on an annual basis.

The Calvo parameter is set at $\phi_p = 0.75$, which means that the average duration of not having optimally reset prices is four quarters. For the indexation of prices to past inflation, we choose full indexation with $\chi_p = 1.00$.

The ratio of net exports to GDP is 0.5 percent, which implies a foreign debt to annual GDP of around 12.4 percent. We model the external spread as $\Theta(B_t^*) = \left(\frac{B_t^*}{B^*}\right)^{\varrho}$ and we set a very elastic schedule or foreign supply of funds with $\varrho = 0.001$, similar to the value used by Schmitt-Grohé and Uribe (2001) to produce simulations close to a case with a fully elastic foreign supply of funds. The share of foreign goods in the final goods composite is 30 percent ($\alpha_d = 0.30$) while the elasticity of substitution between home and foreign goods is less than one ($\theta_d = \theta^* = 0.5$).

We assume that investment adjustment costs do not affect the steady-state allocations and $Q/P = 1$. This adjustment cost of investment satisfies $\Delta(1) = \Delta^{'}(1) = 0$ and $\Delta^{''}(1) = 5$, as in Smets and Wouters (2007). We choose a quarterly depreciation rate of capital of 2.5 percent ($\delta = 0.025$). The probability of selling the defaulted capital is set at $\eta_K = 1/4$, which implies that on average the defaulted capital takes one year to be restructured and become productive again.

The production technology assumes a share of capital around one third ($\theta_y = 0.36$) and by normalization we set $a = 1$ at the steady state. The reserve requirement at the steady state is $s^{MA} = 0.10$, and assuming $R^{RE} = 1$ we have that $R^{IB} = R^D + \frac{s^{MA}}{1-s^{MA}}(R^D - R^{RE}) = 1.0112$, which is equivalent to a steady state interbank rate of 4.5 percent on an annual basis.

For the financial contract we use three main parameters: (i) an annual default rate of 3 percent; (ii) a leverage ratio of 40 percent ($\frac{B}{Pk} = 0.4$); and (iii) an average cost of liquidation of $\mu = 0.60$. The default rate is in line with the value proposed by BGG (1999) while the leverage ratio is a mid-point between BGG (1999) and the leverage ratio estimated by Gonzalez-Miranda

[8] The model is calibrated to resemble a prototypical emerging market economy such as the ones in Figure 1.

(2012) for a sample of traded companies in Latin American countries. These parameter values imply a risk premium at the steady state $\rho(\bar{\omega}, \mu, \sigma_\omega) = 1.0234$, a recovery rate

$$recov_t = \frac{(1-\mu_t)\int_0^{\bar{\omega}_t} \omega d\Phi(\omega; \sigma_\omega) payn_t k_t}{\Phi(\bar{\omega}_t; \sigma_\omega)[R_{t-1}^{IB} B_{t-1}]}$$

of around 36 percent. This implies a return to capital and a lending rate of around 15 and 7 percent in annualized terms. We impose a death rate of entrepreneurs of 1 percent quarterly ($\lambda = 0.01$). With this parameter, the entrepreneurs' debt and deposits, as percentage of GDP in annual terms, are about 55 percent and 61 percent, respectively.

For the liquidation services, we use $\alpha_{lq} = \alpha_{xr} = 0.3$, which is coherent with the calibration used by Choi and Cook (2012). We normalize the steady state marginal cost of final goods and excess reserves needs for the liquidation services (f and g) such that the excess reserves corresponds to 0.25 percent of deposits. This normalization implies that excess reserves are around 0.15 percent as percentage of annual GDP.

We perform a numerical approximation of the equilibrium conditions to solve for the dynamics around the deterministic steady state of the model (see appendix IV for the full set of equilibrium conditions of the model economy). The simulations are performed with a first-order approximation. However, to compute the welfare we use a second-order approximation, which allow us to obtain the welfare ranking among alternative policy frameworks (Faia and Monacelli, 2007).[9] Although we have households and entrepreneurs for the computation of welfare, only the utility of households matters since entrepreneurs are risk neutral. Also, for the welfare computation we assume that the weight of real money balances in the household's utility is very small such that $a_m \approx 0$.

Thus, for the simulations we compute welfare under a policy framework i as:

$$W(i) = \sum_{t=1}^{T} \beta^t \ln\left(c(i)_t - \gamma_h \frac{(h(i)_t)^{1+\sigma_L}}{1+\sigma_L}\right)$$

where $c(i)_t$ and $h(i)_t$ are, respectively, the consumption and employment path under the policy framework i. T is the number of quarters of the simulation. For each policy framework we also compute the losses or gains in terms of steady-state consumption relative to the *natural equilibrium* welfare as the ζ_i that solves:

$$\sum_{t=1}^{T} \beta^t \ln\left((1+\zeta_i)c_{ss} - \gamma_h \frac{(h_{ss})^{1+\sigma_L}}{1+\sigma_L}\right) - W_{nat} = W_{nat} - W(i)$$

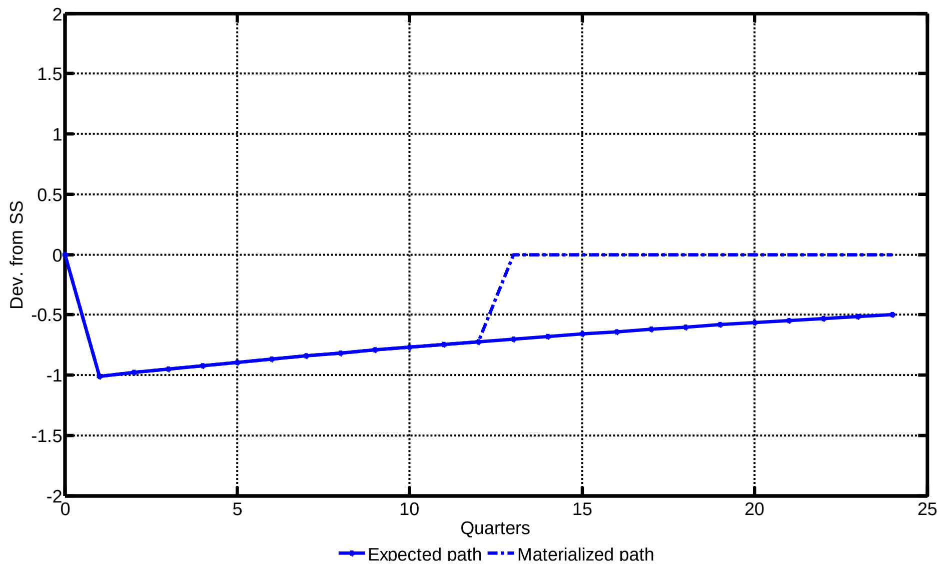
[9] Ozkan and Unsal (2013) follow a similar strategy to study productivity and financial shocks.

Where c_{ss} and h_{ss} are the deterministic steady-state levels of consumption and employment and $W_{nat} = \sum_{t=1}^{T} \beta^t \ln\left(c_{nat,t} - \gamma_h \frac{(h_{nat,t})^{1+\sigma_L}}{1+\sigma_L}\right)$ is the natural equilibrium welfare. The natural equilibrium would be such nominal and financial frictions are removed keeping the same deterministic steady state.

IV. Policy Responses to Capital Inflows and Reversals

We consider the responses of the model economy to a transitory reduction in the foreign interest rate, which is perceived to last according to a persistence coefficient $\rho_{R*} = 0.97$. However, after twelve quarters, the foreign interest unexpectedly rises to its original level. This situation is associated with large capital inflows that are suddenly reversed in the twelve quarter. Figure 4 illustrates the path for the foreign interest rate. Here we set $T = 25$ for the welfare analysis.

Figure 4. Expected and Materialized Path for the Foreign Interest Rate



The reduction in world interest rates triggers a sharp increase in aggregate demand, GDP and asset prices (see Figure 5, thin line). The “natural” (interbank) rate in the model without frictions follows the world rate and induces a current account deficit (i.e. and increase in foreign borrowing) and a real exchange rate appreciation. When the world rate unexpectedly increases back to its pre-shock level twelve quarters later, it sets in motion the reverse process, but the intrinsic dynamics of the model deliver only a slowdown in the increase in foreign debt—rather than a “sudden stop” or reversal of flows.

Figure 5. Comparing the Responses under Natural, Taylor Type Rule, and IT Regime

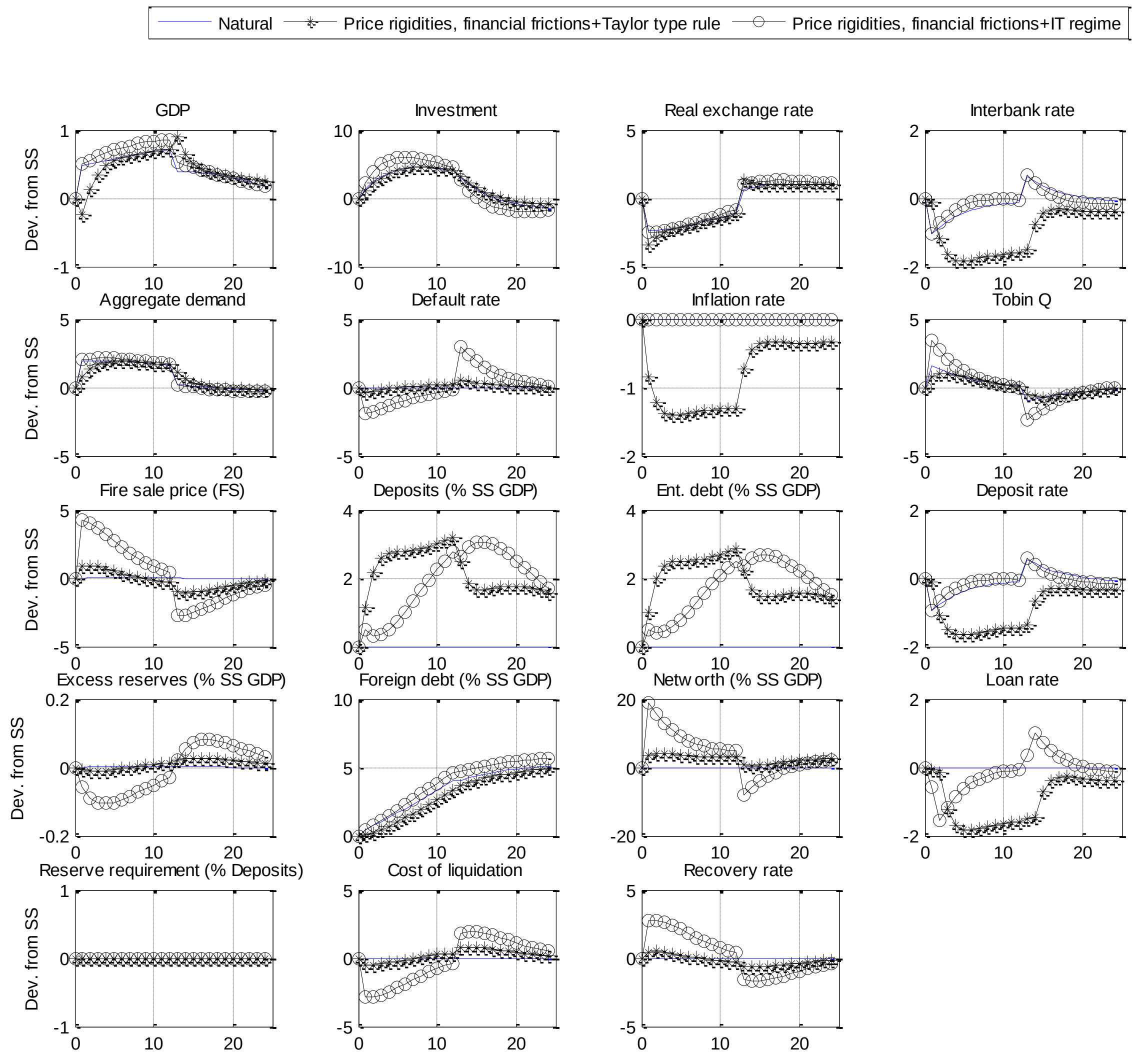


Table 1. Welfare Comparison between the standard Taylor Type Rule and the Inflation Targeting (IT) Regime

	Policy Framework	Welfare	Losses relative to welfare of steady-state consumption in the Natural Equilibrium
1	Standard Taylor type rule	-17.1602	11.27%
2	IT regime	-16.9999	11.15%

The first policy response we analyze is when the monetary authority follows a “standard” Taylor rule (Taylor, 1993). In this case, the policy (“interbank”) rate does not fall in the first quarter, leading to a sharp increase in the real interest rate that triggers a deflationary cycle and a stronger real exchange rate appreciation. The policy rate starts falling after the first quarter, even beyond the natural rate, and inducing a sharp increase in credit (entrepreneur debt).

The pure inflation targeting (IT) regime stabilizes inflation but exacerbates fluctuations in aggregate demand and asset prices.[10] Entrepreneur debt does not increase as much as before, in part because the sharp increase in the price of capital ("Tobin Q" in Figure 5) increases net worth—reducing the need for external funds. Associated with the higher asset price volatility are sharper swings in default and recovery rates, as well as a highly procyclical cost of liquidation (in contrast to the constant one in BGG, 1999). The procyclicality of the financial sector is also reflected in the more cyclical behavior of excess reserves used to provide liquidity services: they fall in the first three years, and are restored when world interest rates go back up thereafter.

As shown in Table 1, welfare is higher with the IT regime than with the standard Taylor rule. Despite inducing more financial volatility, the IT regime fully neutralizes the nominal friction and this dominates the cost of the financial frictions.

The first way to respond to the enhanced financial volatility is to add a term associated to credit growth in the Taylor rule.[11] In this "Augmented Taylor Rule", we also increase the weight given to inflation, to try to reap some of the gains associated with the pure IT regime. The results are shown in Figure 6. Despite reducing the volatility of asset prices and defaults, this rule still leads to a relatively fast increase in credit and it is dominated in welfare terms by the pure IT regime (Table 2).This result contrasts with the one found in Christiano et al (2010), where the addition of credit growth to the standard Taylor rule improves welfare. The reason for the different result is that the shock in Christiano et al (2010) is an expected increase in productivity that *raises* the natural interest rate. Here the initial shock *lowers* the natural interest rate, so adding credit growth with a positive coefficient in the Taylor rule moves the economy further away from the natural path. The result is however in agreement with Christiano et al (2010) in the sense that focusing exclusively on goods price inflation can lead to sharp moves in asset prices, thus making it desirable to move away from strict inflation targeting.

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[10] This is consistent with the stylized facts and analysis in Borio and White (2004).

[11] This is akin to "leaning-against-the-wind," although the expression could be applied more broadly to responses to asset prices and other indicators of financial conditions.

Figure 6. Comparing the Responses under Natural, IT Regime, and Augmented Taylor

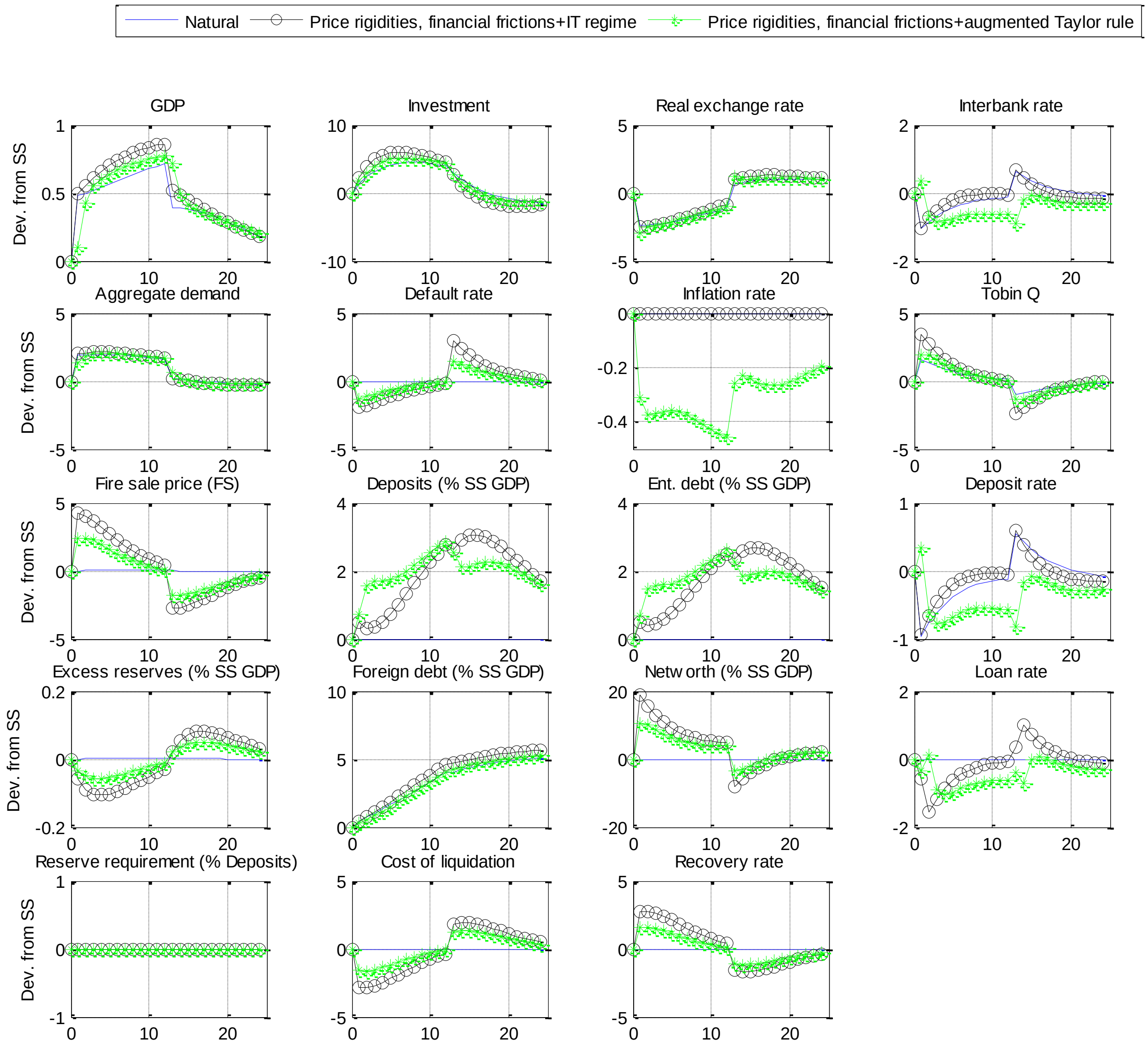


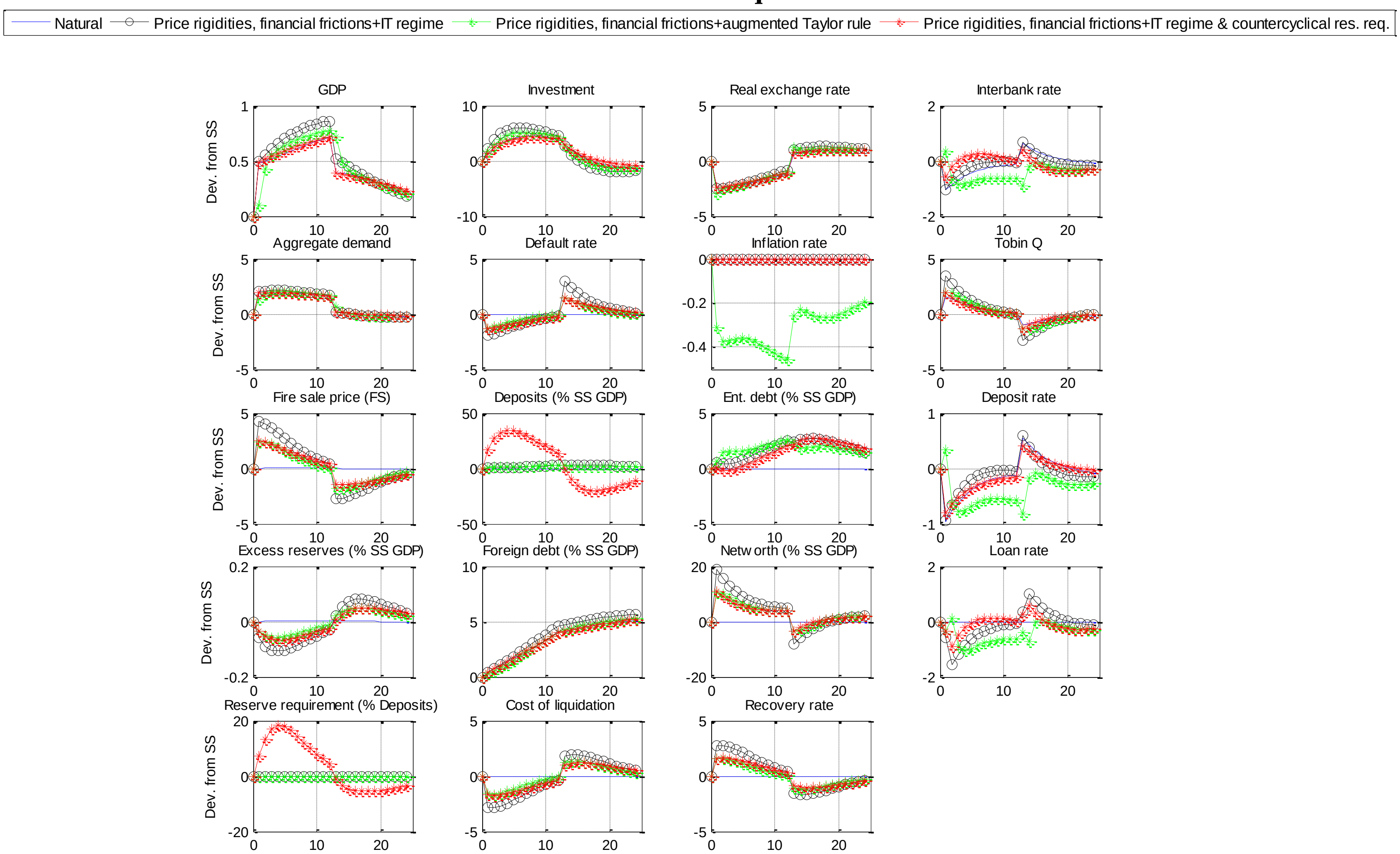
Table 2. Welfare Comparison between Inflation Targeting (IT) Regime and the Augmented Taylor Type Rule

	Policy Framework	Welfare	Losses relative to welfare of steady-state consumption in the Natural Equilibrium
2	IT regime	-16.9999	11.15%
3	Augmented Taylor type rule	-17.0887	11.22%

An alternative way to respond to two both the nominal and financial frictions is to use another, macroprudential instrument: a countercyclical reserve requirement (s_t^{MA}), as defined in regime #4 in section II.5.[12]

Reserve requirements increase substantially in the first two years, from 10 percent of deposits to just above 30 percent at the end of the first year. More importantly, they are reduced to less than the original 10 percent rate after the reversal in world interest rates (as done by several emerging market countries in the aftermath of the Lehman bankruptcy, Figure 1).
The combined monetary-macroprudential regime brings all macroeconomic variables closer to their "natural levels" and smoothes the volatility of financial variables (Figure 7). In particular, it is much more effective in containing credit growth than the "augmented" Taylor rule, and delivers clear welfare gains relative to all other regimes (Table 3).

Figure 7. Comparing Responses under IT Regime, Taylor Type Rules, and Countercyclical Reserve Requirement



[12] Bianchi (2010) demonstrates that, for a very generic bank balance sheet, capital and reserve requirements have similar effects (see also Benigno, 2012). Agénor et al (2013) study interactions between interest rate rules and a Basel III-type countercyclical capital regulatory rule in the management of housing demand shocks.

Table 3. Welfare Comparison between the Augmented Taylor Type Rule and Inflation Targeting with Countercyclical Reserve Requirement

	Policy Framework	Welfare	Losses relative to welfare of steady-state consumption in the Natural Equilibrium
3	Augmented Taylor type rule	-17.0887	11.22%
4	IT regime and Countercyclical RR	-15.4649	10.00%

The fact that the use of the macroprudential instrument improves welfare beyond the augmented Taylor rule underscores the drive to expand the macroeconomic policies tool-kit (IMF, 2013). Financial frictions abound and the use of an additional cyclical instrument results in a better management of the two frictions/distortions in the model. We interpret this result as reflecting the Tinbergen principle of "one instrument for each objective" and Mundell's "principle of effective market classification," whereby instruments should be paired with the objectives on which they have the most influence (see Glocker and Towbin, 2012, and Beau et al, 2012). In this case, the macroprudential instrument mitigates the financial friction while the monetary policy rate does the job for the nominal friction.

It is also important to note that the use of the macroprudential instrument has implications for the monetary policy instrument. In particular, while the "natural" interest rate falls in the early part of the exercise, the policy rate falls only marginally, but is driven above its original level after one year, to accommodate the impact of the increased reserve requirement. As noted in IMF (2013), "the conduct of both policies will need to take into account the effects they have on each other's main objectives"; we would add that this exercise demonstrates also the need to coordinate both policies instruments, especially when dealing with swings in capital flows.

V. Robustness

In this section we analyze the robustness of the results discussed in the previous section. In particular, we study ways in which both the financial and the nominal distortions could be enhanced and how those changes might alter the policy rankings. We also explore a calibration where liquidity services represent a larger share of financial services.

A. Foreign Borrowing and Dollarization

So far the only agents that hold foreign liabilities are the households. In this section, we assume that both entrepreneurs and lending intermediaries have direct access to external funding in world markets. For simplicity, we assume that these levels of borrowing are constant, thus capturing only the valuation or "balance sheet" effects associated with such borrowing (see Appendix V for details). We also allow, in a separate exercise, for dollarization of credit, i.e. half of the entrepreneurs' borrowing can be done in dollar-indexed instruments (Appendix VI).

The case where entrepreneurs and lending intermediaries have direct access to external funding yields the same ranking of policies as before (Figure 8 and Table 4). With dollarized liabilities, the initial real exchange rate appreciation magnifies the increase in entrepreneurs' net worth and requires less borrowing—indeed there is an initial reduction in credit. This case exemplifies an economy that is more integrated financially to the rest of the world, hence there is more transmission of the world interest rate shock and lending interest rates fall substantially in the early periods.

Figure 8. The Role of Direct Foreign Funding for Lending Intermediaries and Entrepreneurs

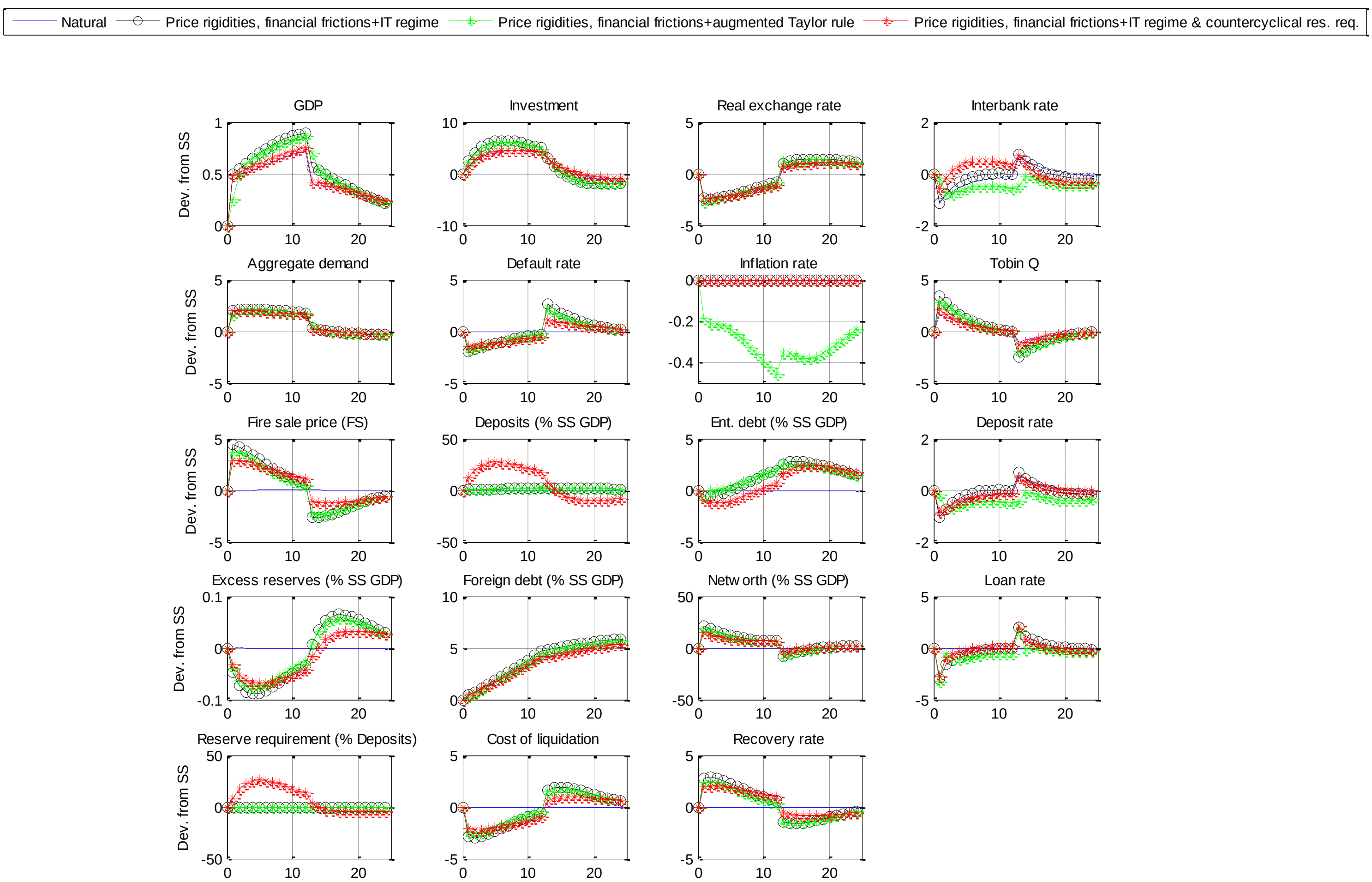


Table 4. Welfare Comparison with Foreign Borrowing

	Policy Framework	Welfare	Losses relative to welfare of steady-state consumption in the Natural Equilibrium
1	Standard Taylor type rule	-16.9037	10.85%
2	IT Regime	-16.7712	10.75%
3	Augmented Taylor type rule	-16.8059	10.78%
4	IT regime and Countercyclical RR	-14.1297	8.79%

The case with partial dollarization of entrepreneurs' borrowing exacerbates the financial distortion, leading to more financial volatility (or instability), and to a change in the ranking of policies. As can be seen in Figure 9, aggregate demand, GDP, the real exchange rate and financial variables fluctuate much more than before (with the default rate spiking to 12 percent and net worth increasing by more than 30 percent of GDP after the initial shock). As shown in Table 5, the IT regime with macroprudential policies continues to dominate all other monetary policy "only" regimes, but now the augmented Taylor rule dominates the IT regime. When partial dollarization enhances the financial friction, credit declines initially and the Augmented Taylor rule leads the economy closer to its "natural" state than the pure IT regime (as in Christiano et al 2010).

Figure 9. The Role of Partial Dollarization in the Entrepreneurs' Loan

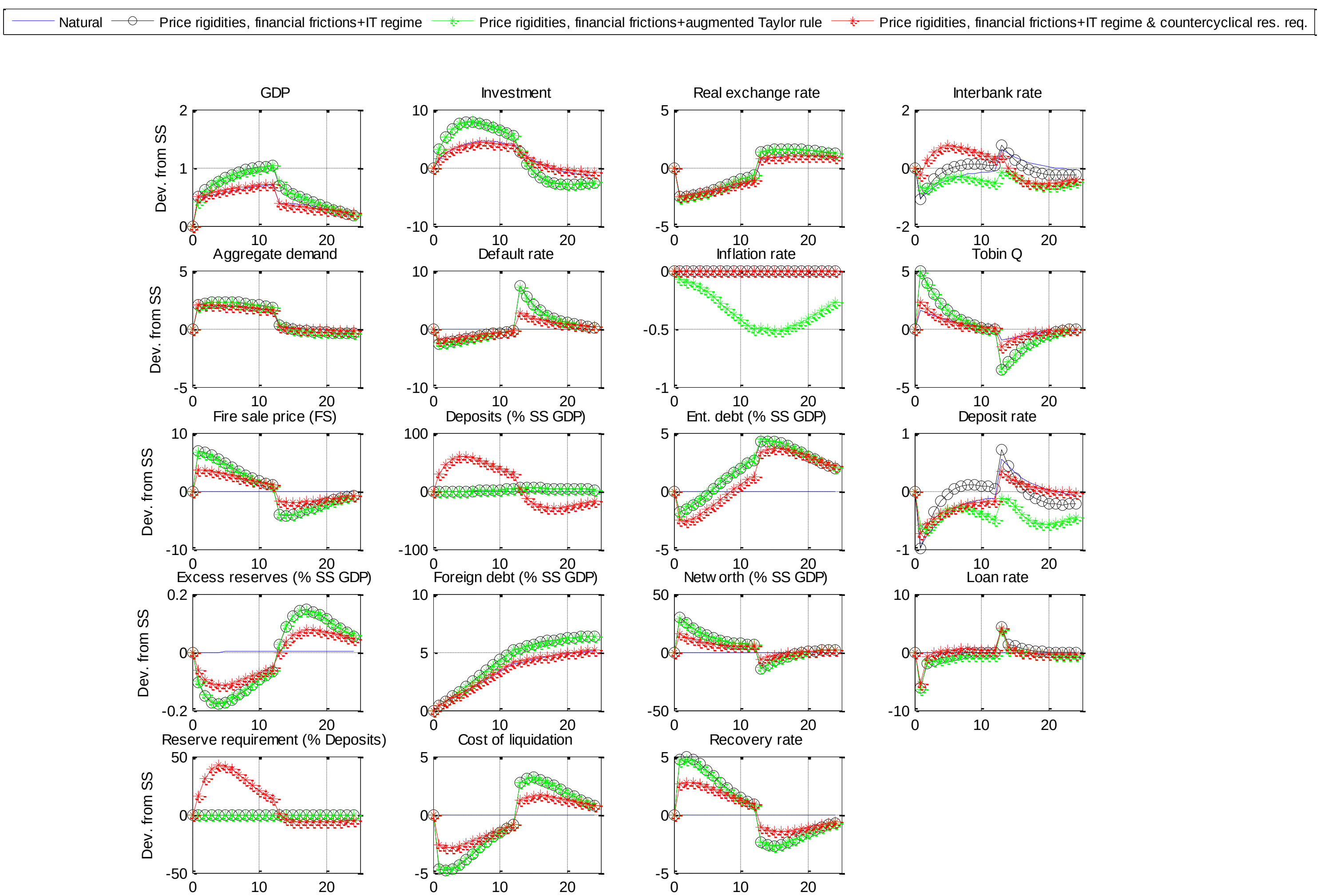


Table 5. Welfare Comparison with Partial Dollarization in Entrepreneurs' Loans

	Policy Framework	Welfare	Losses relative to welfare of steady-state consumption in the Natural Equilibrium
1	Standard Taylor type rule	-17.1063	10.65%
2	IT Regime	-16.8577	10.58%
3	Augmented Taylor type rule	-16.7650	10.56%
4	IT regime and Countercyclical RR	-10.8573	6.27%

B. Wage Rigidities

To model wage rigidities in a simple manner we follow closely Blanchard and Galí (2007), assuming that only a fraction $1-\phi_w$ of households can demand a nominal wage increase consistent with labor market conditions as summarized by equation (4). The rest of the households (a fraction ϕ_w) keep their nominal wages from the previous period. Hence, the aggregate nominal wage inflation is given by:

$$\text{(G.2)}\quad \log(1+\pi_t^w) = (1-\phi_w)\left(\log\left(-\frac{u_{h,t}}{u_{c,t}}\right) - \log\left(\frac{W_{t-1}}{P_{t-1}}\right)\right)$$

and the evolution of the aggregate real wage is given by

$$\text{(G.3)}\quad \log\left(\frac{W_t}{P_t}\right) - \log\left(\frac{W_{t-1}}{P_{t-1}}\right) = \log(1+\pi_t^w) - \log(1+\pi_t)$$
$$= (1-\phi_w)\left(\log\left(-\frac{u_{h,t}}{u_{c,t}}\right) - \log\left(\frac{W_{t-1}}{P_{t-1}}\right)\right) - \log(1+\pi_t)$$

This specification is meant to capture the notion that real wages may respond with inertia to labor market conditions and that inflation fluctuations can be a source of dynamics of real wages. For the model simulations under wage rigidities we use $\phi_w = 0.875$, which corresponds to a case where households set their nominal wages every 8 quarters.

The addition of this nominal rigidity further exacerbates asset price and default/recovery fluctuations (Figure 10), as well as exchange rate movements. And the welfare gains of using the countercyclical reserve requirement are even larger than with only price rigidities—reaching 2 percent of steady state consumption (Table 6).

Figure 10. The Role of Wage Rigidities

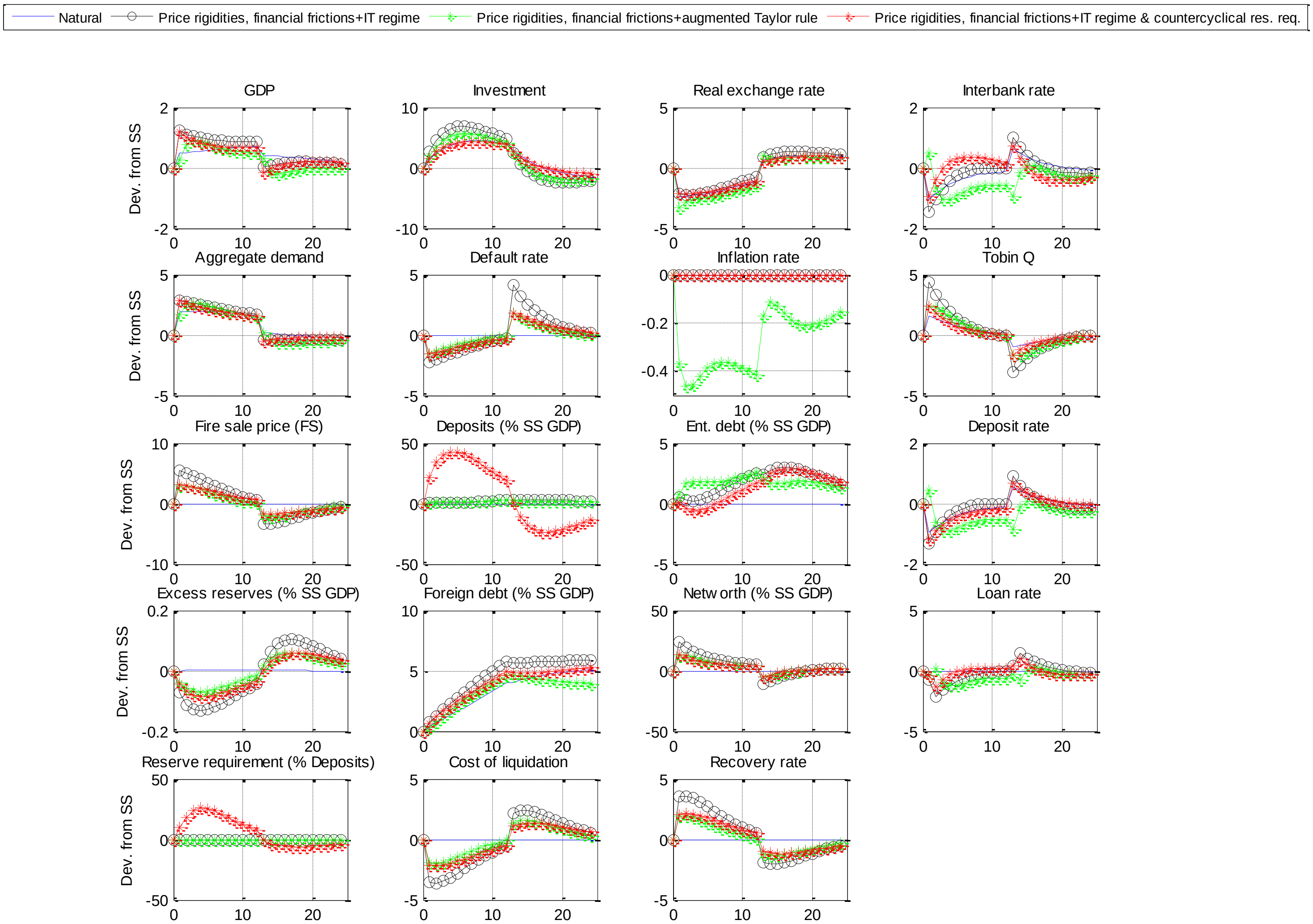


Table 6. Welfare Comparison with Wage Rigidities

	Policy Framework	Welfare	Losses relative to welfare of steady-state consumption in the Natural Equilibrium
1	Standard Taylor type rule	-17.6437	13.17%
2	IT Regime	-16.9368	12.63%
3	Augmented Taylor type rule	-17.3656	12.96%
4	IT regime and Countercyclical RR	-14.3495	10.65%

C. Larger "Excess Reserves"

As noted in section II.C, "excess reserves" are liquid assets that facilitate the purchase of defaulted or distressed capital. Hence, they may encompass a broader set of assets than the strict definition of excess reserves in traditional banks.[13] High-quality liquid assets, such as those included in the numerator of the Liquid Coverage Ratio (BCBS, 2013) would be closer to the spirit/nature of the assets used by our liquidity intermediary to buy defaulted/distressed assets.

In this section we explore the robustness of our results to a larger size of what we call "excess reserves." Our baseline calibration assumes that 0.25 percent of deposits are kept as excess reserves, and this could be considered a small fraction if one recognizes that banks hold around 10 percent of assets in trading-related assets (King, 2010) and around 12 percent in government securities.[14] However, the simplicity of our financial intermediaries balance sheet constrain how much we can increase "excess reserves" without deviating from other stylized facts we adopted for our calibration. Thus we assume in this section that "excess reserves" are 1.5 percent of deposits (six times bigger than in the baseline).[15] Since the amount of "excess reserves" is related to the resources demanded for liquidation services, we need to increase the average default rate (and reduce the average recovery rate) to induce a higher proportion of "excess reserves". We select a quarterly default rate of 4 percent and an average value of μ such that the recovery rate is around 31 percent on average.[16] We also modify the curvature of the liquidation technology setting $\alpha_{lq} = \alpha_{xr} = 0.15$. The remaining parameters of the liquidation services technology remain the same as the baseline calibration.[17]

The alternative calibration gives a higher role to financial frictions, resulting in more volatile asset prices, default and recovery rates, and a loan rate that is more pro-cyclical. Interestingly, an inflation targeting regime may not require a fall in the monetary policy rate in the boom phase of the cycle, in contrast to the responses in the baseline calibration—though this response of monetary policy is not effective in stabilizing GDP, aggregate demand or the financial variables. A more pro-cyclical financial sector constrains how loose monetary policy can be in response to a reduction in the world interest rate. In terms of welfare, the results still show the

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[13] Gray (2010) noted that reserves are used to smooth settlement of transactions and respond to unexpected deposit withdrawals. When reserves are kept for prudential purposes, they could be held not just with vault cash and deposits at the central bank, but also liquid treasury securities.

[14] The four countries in Figure 1, hold on average 12.4 percent of total assets in government securities, but there is wide variation across countries; for Brazil and Turkey the figure is around 20-24 percent, while for Colombia and Peru is around 2-4 percent (averages for the period 1998-2012). It is worth noting that this holding of government securities has been reduced in Brazil since 2006, reaching around 13 percent of total asset in 2012.

[15] In the case of Peru, the sum of government securities and cash held by commercial banks in the period 2003-2012 was equivalent to 25 percent of deposits, while the effective reserve requirement was about 23.5 percent. In the same period, excess reserves were 0.35 percent of deposits.

[16] This higher default rate could be rationalized as the "distress" rate obtained in estimates from credit default swap rates (see Hull, Predescu, and White, 2004)

[17] This calibration implies the following for steady-state rates: $R^K = 38.5\% > R^L = 15.8\% > R^{IB} = 4.5\% > R^D = 4\%$

superiority of a policy mix that uses simultaneously an inflation targeting regime with a countercyclical reserve requirement, though the welfare gains are smaller. More importantly, using the reserve requirement requires a monetary policy rate that increases in the boom phase and is reduced in the downturn. This behavior accommodates the countercyclical use of reserve requirements and highlights a bigger deviation of the monetary policy rate from the natural rate.

Figure 11. The Role of Higher Excess Reserves

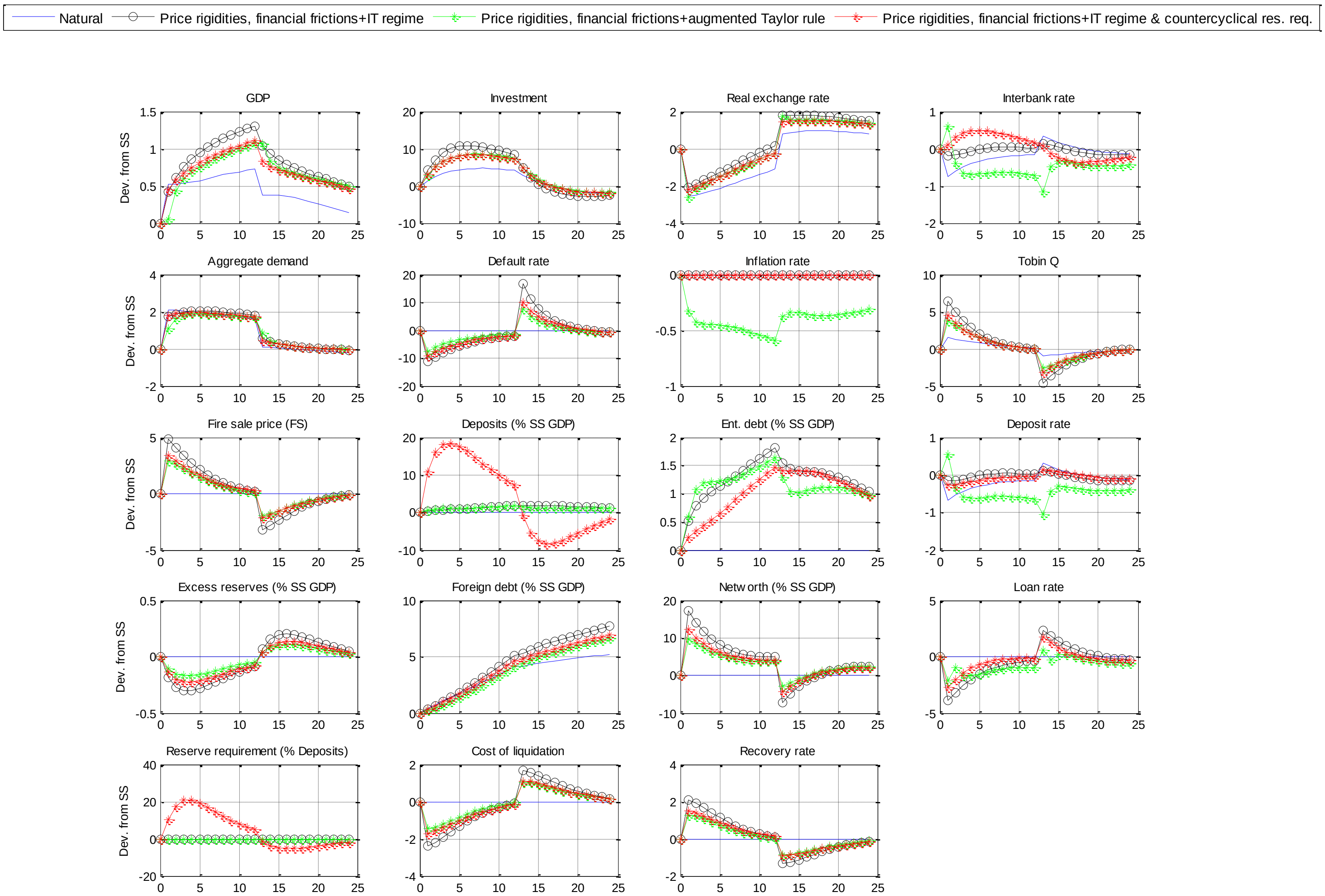

Table 7. Welfare Comparison with Higher Excess Reserves

	Policy Framework	Welfare	Losses relative the welfare of steady-state consumption in the Natural Equilibrium
1	Standard Taylor type rule	-22.9513	15.31%
2	IT Regime	-22.6254	15.04%
3	Augmented Taylor type rule	-22.8156	15.20%
4	IT regime and Countercyclical RR	-22.1323	14.63%

VI. CONCLUSIONS

The use of macro-prudential policy instruments has become increasingly popular in the aftermath of the 2007-09 financial crisis. In this paper we have shown that the use of cyclical macro-prudential policies increases welfare, especially in the context of an inflation targeting regime and even in the absence of externalities.[18] We obtain our result in a model with a fairly general but micro-founded financial system that provides credit and liquidity services. The dominance of a regime that uses monetary policy to mitigate a nominal friction and a countercyclical reserve requirement to mitigate the financial friction, is robust to institutional features such as dollarization of liabilities (that tend to exacerbate financial frictions), wage rigidities (that increases nominal frictions), and alternative calibrations of the financial system.

The paper also shows the importance of coordinating the use of the monetary policy rate to the countercyclical macro-prudential policy instrument. In particular, we show that the addition of financial variables such as credit growth to a standard Taylor rule delivers a slight improvement relative to the pure Taylor rule environment, but is dominated by the coordinated use of both instruments. When both instruments are used, the monetary policy rate may deviate substantially from the rate associated with a pure IT regime (and that of the economy's natural rate—that follows closely the world interest rate).

Our results also point to the potential perils of "leaning against the wind" regardless of the nature of the shock hitting the economy. IMF (2012) suggest that when macro-prudential policies operate less-than-perfectly, monetary policy may lean against the credit cycle—but also provide a number of cases and conditions under which this may not be optimal, especially in the open economy. In this paper, we have shown that when world interest rates are reduced dramatically, as in the current juncture, responding with the policy rate to increases in credit growth may not always be the right policy response. We have also shown that credit and asset prices may not move in the same direction in the aftermath of a shock, and leave for further research policy responses to asset prices and the exchange rate.

In sum, we can say that incorporating the impact of the shock on the "natural" interest rate, as well as coordinating with the response to the macro-prudential policy instrument, are useful guidelines for the conduct of monetary policy in the context of volatile capital flows.

[18] Bianchi, Boz, and Mendoza (2012) study the conditions under which macro-prudential instruments increase welfare in a model with pecuniary externalities.

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Appendix I. The Lending Problem

The lending problem results from the following maximization of the entrepreneurs' payoff:

$$\max_{k_{t+1},\overline{\omega}_{t+1}} E_t\{payn_{t+1}k_{t+1}f(\overline{\omega}_{t+1},\sigma_\omega)\}$$

(A.1) $s.t.\quad payn_{t+1}k_{t+1}g(\overline{\omega}_{t+1},\mu_{t+1},\sigma_\omega) \geq R_t^{IB}B_t = R_t^{IB}(Q_tk_{t+1} - netn_t)$ for all states in $t+1$, where $B_t = Q_tk_{t+1} - netn_t$ is the domestic loan to the entrepreneurs with net worth $netn_t$.

The first order conditions with respect to k_{t+1} and $\overline{\omega}_{t+1}$ for this problem are:

$$\text{(A.2)}\quad E_t\left\{\begin{array}{c} payn_{t+1}f(\overline{\omega}_{t+1},\sigma_\omega) \\ +\varphi_{t+1}(payn_{t+1}g(\overline{\omega}_{t+1},\mu_{t+1},\sigma_\omega) - Q_tR_t^{IB}) \end{array}\right\} = 0$$

$$\text{(A.3)}\quad payn_{t+1}k_{t+1}f_{\overline{\omega}}(\overline{\omega}_{t+1},\sigma_\omega) + \varphi_{t+1}payn_{t+1}k_{t+1}g_{\overline{\omega}}(\overline{\omega}_{t+1},\mu_{t+1},\sigma_\omega) = 0$$

where is φ_{t+1} the lagrange multiplier in condition (A.1). Combining (A.2) and (A.3) we obtain:

$$\text{(A.4)}\ Q_tE_t\left\{R_t^{IB}\frac{f_{\overline{\omega}}(\overline{\omega}_{t+1},\sigma_\omega)}{g_{\overline{\omega}}(\overline{\omega}_{t+1},\mu_{t+1},\sigma_\omega)}\right\} = E_t\left\{\frac{payn_{t+1}}{\rho(\overline{\omega}_{t+1},\mu_{t+1},\sigma_\omega)}\frac{f_{\overline{\omega}}(\overline{\omega}_{t+1},\sigma_\omega)}{g_{\overline{\omega}}(\overline{\omega}_{t+1},\mu_{t+1},\sigma_\omega)}\right\}$$

where $\rho(\cdot)$ is a risk premium defined as:

$$\text{(A.5)}\quad \rho(\overline{\omega}_t,\mu_t,\sigma_\omega) = \left[g(\overline{\omega}_t,\mu_t,\sigma_\omega) - f(\overline{\omega}_t,\sigma_\omega)\frac{g_{\overline{\omega}}(\overline{\omega}_t,\mu_t,\sigma_\omega)}{f_{\overline{\omega}}(\overline{\omega}_t,\sigma_\omega)}\right]^{-1}$$

To express in real terms we can define $payr_t = payn_t/P_t$ and $qr_t = Q_t/P_t$and re-write (A.4) as

$$\text{(A.6)}\quad qr_t\quad E_t\left\{R_t^{IB}\frac{f_{\overline{\omega}}(\overline{\omega}_{t+1},\sigma_\omega)}{g_{\overline{\omega}}(\overline{\omega}_{t+1},\mu_{t+1},\sigma_\omega)}\right\} = E_t\left\{(1+\pi_{t+1})\frac{payr_{t+1}}{\rho(\overline{\omega}_{t+1},\mu_{t+1},\sigma_\omega)}\frac{f_{\overline{\omega}}(\overline{\omega}_{t+1},\sigma_\omega)}{g_{\overline{\omega}}(\overline{\omega}_{t+1},\mu_{t+1},\sigma_\omega)}\right\}$$

where $1+\pi_{t+1} = P_{t+1}/P_t$. Similarly, defining entrepreneurs' debt and net worth in real terms ($b_t = B_t/P_t$ and $netr_t = netn_t/P_t$), we can have the following expressions for the recovery rate, net worth evolution and entrepreneurs consumption:

$$\text{(A.7)}\quad recov_t = \frac{(1-\mu_t)\int_0^{\overline{\omega}_t}\omega d\Phi(\omega;\sigma_\omega)payr_tk_t(1+\pi_t)}{\Phi(\overline{\omega}_t;\sigma_\omega)\left[R_{t-1}^{IB}b_{t-1}\right]},$$

$$\text{(A.8)}\quad netr_t = (1-\lambda)f(\overline{\omega}_t,\sigma_\omega)payr_tk_t + \tau_E,$$

$$\text{(A.9)}\quad c_{K,t} = \lambda\, f(\overline{\omega}_t,\sigma_\omega)payr_tk_t.$$

Appendix II. The Problem of Liquidity Intermediaries

As noted in the main text, the optimization's problem of the liquidity intermediaries is:

$$\max_{n_t, s_t, \left(\frac{D_t}{P_t}\right)} \left\{[(1-s_t)R_t^{IB} + s_t^{MA}R_t^{RE} - R_t^D]\frac{D_t}{P_t}\frac{P_t}{R_t^D} - P_t n_t\right\}$$

$$s.t.(B.1)\ \ lq_t = Z(n_t)^{1-\alpha_{lq}}$$

$$(B.2)\qquad lq_t = Z_{xr}(xr_t)^{1-\alpha_{xr}}$$

$$(B.3)\qquad xr_t = (s_t - s_t^{MA})\frac{D_t}{P_t}$$

The *Lagragian* of the problem is:

$$\mathcal{L} = \left\{[(1-s_t)R_t^{IB} + s_t^{MA}R_t^{RE} - R_t^D]\frac{D_t}{P_t}\frac{P_t}{R_t^D} - P_t n_t\right\} + f_t(Z(n_t)^{1-\alpha_{lq}} -\ lq_t)$$
$$+ g_t\left(Z_{xr}\left((s_t - s_t^{MA})\frac{D_t}{P_t}\right)^{1-\alpha_{xr}} -\ lq_t\right)$$

where F_t and are G_t the lagrange multipliers in constraint (B.1) and (B.2), respectively. These lagrange multipliers can be interpreted as the marginal cost of providing liquidation services from final goods and excess reserves. Thus, the first order conditions of the liquidity intermediaries' problem are:

$$\text{(B.4)}\ -P_t + f_t\frac{(1-\alpha_{lq})lq_t}{n_t} = 0 \Rightarrow \frac{f_t}{P_t} = \frac{n_t}{(1-\alpha_{lq})lq_t}$$

$$\text{(B.5)}\ -\frac{R_t^{IB}}{R_t^D}P_t + g_t\frac{(1-\alpha_{xr})lq_t}{xr_t} = 0 \Rightarrow \frac{R_t^{IB}}{R_t^D} = \frac{g_t}{P_t}\frac{(1-\alpha_{xr})lq_t}{xr_t}$$

$$\text{(B.6)}\ \frac{[(1-s_t)R_t^{IB} + s_t^{MA}R_t^{RE} - R_t^D]}{R_t^D}P_t + g_t\frac{(1-\alpha_{xr})lq_t}{xr_t}(s_t - s_t^{MA}) = 0 \Rightarrow$$
$$\frac{[R_t^D - (1-s_t)R_t^{IB} - s_t^{MA}R_t^{RE}]}{R_t^D} = \frac{g_t}{P_t}\frac{(1-\alpha_{xr})lq_t}{xr_t}(s_t - s_t^{MA})$$

Combining (B.5) and (B.6) we obtain:

$$\text{(B.7)}\ R_t^{IB}(s_t - s_t^{MA}) = [R_t^D - (1-s_t)R_t^{IB} - s_t^{MA}R_t^{RE}]$$

The (real) fire sales price can be expressed as the marginal present discounted value of the defaulted capital, which can be obtained through:

$$\text{(B.8)}\ \frac{FS_t}{P_t}k_{D,t} = \left(\eta_K\frac{q_t}{P_t} - \frac{mglq_t}{P_t}\right)k_{D,t} + E_t\left[sd_{t,t+1}\frac{FS_{t+1}}{P_{t+1}}k_{D,t+1}\right],$$

where $mglq_t$ is the marginal cost of liquidation services per unit of defaulted capital, $sd_{t,t+1}$ is the stochastic discount factor and

$$\text{(B.9)}\ \ k_{D,t+1} = (1-\eta_K)(1-\delta)k_{D,t} + k_{D,t+1}^{new}$$

Using the Lagrange multipliers of constraints (B.1) and (B.2) we obtain an expression for the marginal cost of liquidation services, $mglq_t = \nu(f_t + g_t)$. Taking derivative with respect to $k_{D,t}$ in both sides of (B.8) we obtain an expression for fire sales price, which is net of the cost of liquidation and takes account that a fraction of the defaulted capital is becoming productive each period:

$$\text{(B.10)}\quad \frac{FS_t}{P_t} = fsr_t = \eta_K qr_t - \nu\left(\frac{f_t}{P_t} + \frac{g_t}{P_t}\right) + (1-\eta_K)(1-\delta)E_t\left[sd_{t,t+1}\frac{FS_{t+1}}{P_{t+1}}\right]$$
$$= \eta_K qr_t - \nu(fr_t + gr_t) + (1-\eta_K)(1-\delta)E_t\left[sd_{t,t+1}fsr_{t+1}\right]$$

Appendix III. Price Rigidities, the Phillips Curve, and Aggregation of Final Goods Demand

There is one final good produced using the intermediate composite goods:

$$\text{(C.1)}\quad da_t = \left(\int_0^1 (da_{i,t})^{\frac{\epsilon-1}{\epsilon}} di\right)^{\frac{\epsilon}{\epsilon-1}}$$

where ϵ is the elasticity of substitution across the composite intermediate goods and da_t is total domestic demand. The final good market is perfectly competitive and the demand for each intermediate composite good i is given by

$$\text{(C.2)}\quad da_{i,t} = \left(\frac{P_{i,t}}{P_t}\right)^{-\epsilon} da_t \quad \text{for all } i$$

where $P_{i,t}$ is the price of the intermediate composite good i. The aggregate price level of domestic demand is then:

$$\text{(C.3)}\quad P_t = \left(\int_0^1 (P_{i,t})^{1-\epsilon} di\right)^{\frac{1}{1-\epsilon}}.$$

Each intermediate composite producer has the same technology:

$$\text{(C.4)}\quad da_{i,t} = \left[(1-\alpha_d)^{1/\theta_d}(y_{i,t})^{1-1/\theta_d} + (\alpha_d)^{1/\theta_d}(y_{f,i,t})^{1-1/\theta_d}\right]^{\frac{\theta_d}{\theta_d-1}}$$

where $y_{i,t}$ and $y_{f,i,t}$ are, respectively, the amount of domestic and foreign goods used by the intermediate composite producer i. The cost minimization implies

$$\text{(C.5)}\quad \frac{y_{i,t}}{y_{f,i,t}} = \frac{(1-\alpha_d)}{\alpha_d}\left(\frac{rer_t}{P_{y,t}/P_t}\right)^{\theta_d}$$

And the marginal cost (expressed in real terms) is

$$\text{(C.6)}\quad mgcr_t = \frac{mgc_t}{P_t} = \left[(1-\alpha_d)\left(\frac{P_{y,t}}{P_t}\right)^{1-\theta_d} + (\alpha_d)\left(\frac{e_t P_t^*}{P_t}\right)^{1-\theta_d}\right]^{\frac{1}{1-\theta_d}}$$

which is the same for all intermediate goods producers, because they face the same prices of domestic and foreign goods and their technology is constant return to scale. For the same reason, we can obtain:

(C.7) $$\frac{\int_0^1 y_{i,t}di}{\int_0^1 y_{f,i,t}di} = \frac{y_t - x}{y_{f,t}} = \frac{(1-\alpha_d)}{\alpha_d}\left(\frac{rer_t}{P_{y,t}/P_t}\right)^{\theta_d}$$

where we have used the fact that total demand for domestic goods is composed by the demand of intermediate composite producers and exports, x_t.The intermediate composite good producers set prices following Calvo's (1983) mechanism of price adjustment. In each period, a fraction $1-\phi_p$ of the producers can change optimally their prices. All other producers can only index their prices to past inflation with a weight χ_p. Thus, the problem for the intermediate composite producers i is the following:

$$\max_{P_{i,t}} \quad E_t\left\{\sum_{j=0}^{\infty} sd_{t,t+j}(\phi_p)^j\left(\frac{P_{i,t}\left(\frac{P_{t+j-1}}{P_{t-1}}\right)^{\chi_p}}{P_{t+j}} - mgcr_{t+j}\right)da_{i,t+j}\right\}$$

$$s.t.\, da_{i,t+j} = \left(\frac{P_{i,t}\left(\frac{P_{t+j-1}}{P_{t-1}}\right)^{\chi_p}}{P_{t+j}}\right)^{-\epsilon} da_{t+j}$$

The first order condition of this problem is:

$$(\mathrm{C.8})\ P_{i,t}(\epsilon-1)E_t\left\{\sum_{j=0}^{\infty} sd_{t,t+j}(\phi_p)^j\left(\frac{\left(\frac{P_{t+j-1}}{P_{t-1}}\right)^{\chi_p}}{P_{t+j}}\right)^{-\epsilon} da_{t+j}\right\}$$
$$= \epsilon E_t\left\{\sum_{j=0}^{\infty} sd_{t,t+j}(\phi_p)^j mgcr_{t+j} da_{t+j}\right\}.$$

Defining the following expressions in recursive manner:

(C.9) $$\Omega_{1,\mathrm{t}} = mgcr_t + \beta\phi_p E_t\left\{\left(\frac{(1+\pi_t)^{\chi_p}}{(1+\pi_{t+1})}\right)^{-\epsilon}\frac{da_{t+1}}{da_t}\frac{u_{c,t+1}}{u_{c,t+1}}\Omega_{1,\mathrm{t+1}}\right\}$$

(C.10) $$\Omega_{2,\mathrm{t}} = \frac{P_{i,t}}{P_t} + \beta\phi_p E_t\left\{\left(\frac{(1+\pi_t)^{\chi_p}}{(1+\pi_{t+1})}\right)^{1-\epsilon}\left(\frac{P_{i,t}/P_t}{P_{i,t+1}/P_{t+1}}\right)\frac{da_{t+1}}{da_t}\frac{u_{c,t+1}}{u_{c,t+1}}\Omega_{2,\mathrm{t+1}}\right\}$$

the optimal condition for price $P_{i,t}$ (C.8) can be written as:
(C.11) $(\epsilon-1)\Omega_{2,\mathrm{t}} = \epsilon\Omega_{1,\mathrm{t}}$

Using Calvo's pricing mechanism; we can express the price level aggregation as:

(C.12) $1=\phi_p\left(\frac{(1+\pi_{t-1})^{\chi p}}{(1+\pi_t)}\right)^{1-\epsilon}+(1-\phi_p)\left(\frac{P_{i,t}}{P_t}\right)^{1-\epsilon}$

Finally, the relationship between domestic demand and supply of final goods is given by

(C.13) $da_t disp_t = y_{S,t}$,

where $disp_t \geq 1$ is the inefficiency attributed to price dispersion and $y_{S,t}$ is the aggregate supply of the composite goods, defined as:

(C.14) $y_{s,t}=\left[(1-\alpha_d)^{1/\theta_d}(y_t-x_t)^{1-1/\theta_d}+(\alpha_d)^{1/\theta_d}(y_{f,t})^{1-1/\theta_d}\right]^{\frac{\theta_d}{\theta_d-1}}$

Again using the properties of Calvo's pricing mechanism, this price dispersion term evolves as:

(C.15) $disp_t=\phi_p\left(\frac{(1+\pi_{t-1})^{\chi p}}{(1+\pi_t)}\right)^{-\epsilon} disp_{t-1}+(1-\phi_p)\left(\frac{P_{i,t}}{P_t}\right)^{-\epsilon}$

Appendix IV. Complete Set of Equilibrium Conditions

The equilibrium for the model economy, given macroeconomic policy rules for R_t^{IB} and s_t^{MA}, is a sequence for $c_t, h_t, \frac{M_t}{P_t}, R_t^D, rer_t, \frac{W_t}{P_t}, y_t, \frac{P_{y,t}}{P_t}, rr_{K,t}, k_{t+1}, inv_t, k_{D,t+1}, k_{D,t+1}^{new}, qr_t, payr_t, fsr_t,$ $f(\bar{\omega}_t,\sigma_\omega), g(\bar{\omega}_t,\mu_t,\sigma_\omega), \bar{\omega}_t, \mu_t, b_t, netr_t, \rho(\bar{\omega}_t,\mu_t,\sigma_\omega), defrate_t, recov_t, c_{K,t}, lq_t, n_t, xr_t, s_t, \frac{D_t}{P_t},$ $fr_t, gr_t, da_t, y_{s,t}, x_t, y_{f,t}, mgcr_t, \pi_t, B_t^*, \frac{P_{i,t}}{P_t}, \Omega_{1,t}, \Omega_{2,t}, disp_t$, such as the following conditions are satisfied:

(D.1) $1=\beta R_t^D E_t\left[\frac{u_{c,t+1}}{u_{c,t}}\frac{1}{(1+\pi_{t+1})}\right]$

(D.2) $1=\beta R_t^*\Theta(B_t^*)E_t\left[\frac{u_{c,t+1}}{u_{c,t}}\frac{rer_{t+1}}{rer_t}\frac{1}{(1+\pi_{t+1}^*)}\right]$

(D.3) $u_{\frac{M}{P},t}=\frac{R_t^D-1}{R_t^D}u_{c,t}$

(D.4) $\frac{W_t}{P_t}=-\frac{u_{h,t}}{u_{c,t}}$

(D.5) $y_t=a_t(k_t)^{\theta_y}(h_t)^{1-\theta_y}$

(D.6) $\frac{W_t}{P_t}=\frac{P_{y,t}}{P_t}\frac{(1-\theta_y)y_t}{h_t}$

(D.7) $rr_{K,t}=\frac{P_{y,t}}{P_t}\frac{\theta_y y_t}{k_t}$

(D.8) $k_{t+1}=(1-\delta)(k_t-k_{D,t}^{new})+\left(1-\Delta\left(\frac{inv_t}{inv_{t-1}}\right)\right)inv_t+\eta_K(1-\delta)k_{D,t}$

(D.9) $k_{D,t}=(1-\eta_K)(1-\delta)k_{D,t-1}+k_{D,t}^{new}$

(D.10) $qr_t\left(1-\Delta\left(\frac{inv_t}{inv_{t-1}}\right)-\Delta'\left(\frac{inv_t}{inv_{t-1}}\right)\frac{inv_t}{inv_{t-1}}\right)+\beta E_t\left[\frac{u_{c,t+1}}{u_{c,t+1}}qr_{t+1}\left(\Delta'\left(\frac{inv_{t+1}}{inv_t}\right)\left(\frac{inv_{t+1}}{inv_t}\right)^2\right)\right]=1$

(D.12) $\mu_t=\frac{(qr_t-fsr_t)(1-\delta)}{payr_t}$

(D.13) $payr_t=\left(rr_{K,t}+(1-\delta)qr_t\right)$.

(D.14) $f(\overline{\omega}_t,\sigma_\omega)=\int_{\overline{\omega}_t}^{\infty}\omega d\Phi(\omega;\sigma_\omega)-\overline{\omega}_t\big(1-\Phi(\overline{\omega}_t;\sigma_\omega)\big)$

(D.15) $g(\overline{\omega}_t,\mu_t,\sigma_\omega)=\overline{\omega}_t\big(1-\Phi(\overline{\omega}_t;\sigma_\omega)\big)+(1-\mu_t)\int_0^{\overline{\omega}_t}\omega d\Phi(\omega;\sigma_\omega)$

(D.16) $(1+\pi_t)payr_t k_t g(\overline{\omega}_t,\mu_t,\sigma_\omega)=R_{t-1}^{IB}b_{t-1}$

(D.17) $b_t=(qr_t k_{t+1}-netr_t)$

(D.18) $qr_t E_t\left\{R_t^{IB}\frac{f_{\overline{\omega}}(\overline{\omega}_{t+1},\sigma_\omega)}{g_{\overline{\omega}}(\overline{\omega}_{t+1},\mu_{t+1},\sigma_\omega)}\right\}=E_t\left\{\frac{(1+\pi_{t+1})payr_{t+1}}{\rho(\overline{\omega}_{t+1},\mu_{t+1},\sigma_\omega)}\frac{f_{\overline{\omega}}(\overline{\omega}_{t+1},\sigma_\omega)}{g_{\overline{\omega}}(\overline{\omega}_{t+1},\mu_{t+1},\sigma_\omega)}\right\}$

(D.19) $\rho(\overline{\omega}_t,\mu_t,\sigma_\omega)=\left[g(\overline{\omega}_t,\mu_t,\sigma_\omega)-f(\overline{\omega}_t,\sigma_\omega)\frac{g_{\overline{\omega}}(\overline{\omega}_t,\mu_t,\sigma_\omega)}{f_{\overline{\omega}}(\overline{\omega}_t,\sigma_\omega)}\right]^{-1}$

(D.20) $recov_t=\frac{(1-\mu_t)\int_0^{\overline{\omega}_t}\omega d\Phi(\omega;\sigma_\omega)payr_t k_t(1+\pi_t)}{\Phi(\overline{\omega}_t;\sigma_\omega)\left[R_{t-1}^{IB}b_{t-1}\right]}$

(D.21) $defrate_t=\Phi(\overline{\omega}_t;\sigma_\omega)$

(D.22) $netr_t=(1-\lambda)f(\overline{\omega}_t,\sigma_\omega)payr_t k_t+\tau_E$

(D.23) $c_{K,t}=\lambda f(\overline{\omega}_t,\sigma_\omega)payr_t k_t$

(D.24) $lq_t=\nu k_{D,t}$

(D.25) $k_{D,t}^{new}=k_t\int_0^{\overline{\omega}_t}\omega d\Phi(\omega;\sigma_\omega)$

(D.26) $lq_t=Z(n_t)^{1-\alpha_{lq}}$

(D.27) $lq_t=Z_{xr}(xr_t)^{1-\alpha_{xr}}$

(D.28) $fsr_t=\eta_K qr_t-\nu(fr_t+gr_t)+(1-\eta_K)(1-\delta)\beta E_t\left[\frac{u_{c,t+1}}{u_{c,t+1}}fsr_{t+1}\right]$

(D.29) $fr_t=\frac{(n_t)^{\alpha_{lq}}}{Z(1-\alpha_{lq})}$

(D.30) $\frac{R_t^{IB}}{R_t^D}=gr_t\frac{(1-\alpha_{xr})lq_t}{xr_t}$

(D.31) $\frac{\left[R_t^D-(1-s_t)R_t^{IB}-s_t^{MA}R_t^{RE}\right]}{R_t^D}=gr_t\frac{(1-\alpha_{xr})lq_t}{xr_t}(s_t-s_t^{MA})$

(D.32) $xr_t=(s_t-s_t^{MA})\frac{D_t}{P_t}$

(D.33) $\frac{D_t}{P_t}(1-s_t)=b_t$

(D.34) $\Omega_{1,\mathrm{t}}=mgcr_t+\beta\phi_p E_t\left\{\left(\frac{(1+\pi_t)^{\chi p}}{(1+\pi_{t+1})}\right)^{-\epsilon}\frac{da_{t+1}}{da_t}\frac{u_{c,t+1}}{u_{c,t+1}}\Omega_{1,\mathrm{t+1}}\right\}$

(D.35) $\Omega_{2,\mathrm{t}}=\frac{P_{i,t}}{P_t}+\beta\phi_p E_t\left\{\left(\frac{(1+\pi_t)^{\chi p}}{(1+\pi_{t+1})}\right)^{1-\epsilon}\left(\frac{P_{i,t}/P_t}{P_{i,t+1}/P_{t+1}}\right)\frac{da_{t+1}}{da_t}\frac{u_{c,t+1}}{u_{c,t+1}}\Omega_{2,\mathrm{t+1}}\right\}$

(D.36) $(\epsilon-1)\Omega_{2,\mathrm{t}}=\epsilon\Omega_{1,\mathrm{t}}$

(D.37) $1=\phi_p\left(\frac{(1+\pi_{t-1})^{\chi p}}{(1+\pi_t)}\right)^{1-\epsilon}+(1-\phi_p)\left(\frac{P_{i,t}}{P_t}\right)^{1-\epsilon}$

(D.38) $da_t disp_t=y_{s,t}$

(D.39) $disp_t=\phi_p\left(\frac{(1+\pi_{t-1})^{\chi p}}{(1+\pi_t)}\right)^{-\epsilon}disp_{t-1}+(1-\phi_p)\left(\frac{P_{i,t}}{P_t}\right)^{-\epsilon}$

(D.40) $da_t=c_t+\ c_{K,t}+inv_t+n_t$

(D.41) $y_{s,t}=\left[(1-\alpha_d)^{1/\theta_d}(y_t-x_t)^{1-1/\theta_d}+(\alpha_d)^{1/\theta_d}(y_{f,t})^{1-1/\theta_d}\right]^{\frac{\theta_d}{\theta_d-1}}$

(D.42) $mgcr_t=\left[(1-\alpha_d)\quad(\frac{P_{y,t}}{P_t})^{1-\theta_d}+(\alpha_d)\quad(rer_t)^{1-\theta_d}\right]^{\frac{1}{1-\theta_d}}$

(D.43) $\frac{y_t-x_t}{y_{f,t}}=\frac{(1-\alpha_d)}{\alpha_d}\left(\frac{rer_t}{P_{y,t}/P_t}\right)^{\theta_d}$

(D.44) $rer_t B_t^*=R_{t-1}^*\Theta(B_{t-1}^*)\frac{B_{t-1}^*}{(1+\pi_t^*)}rer_t-\frac{P_{y,t}}{P_t}x_t+rer_t(y_{f,t})$

(D.45) $x_t = \bar{x}\left(\frac{rer_t}{P_{y,t}/P_t}\right)^{\theta^*}$

Appendix V. Extension with Foreign Funding for Lending Intermediaries and Entrepreneurs

In contrast to other studies, and to boost balance sheet effects, we can allow for the possibility that the financial intermediaries use foreign funds to finance entrepreneurs besides the interbank market. For simplicity, we assume the amount of external funds available in each period for the lending intermediaries is constant in foreign currency ($\bar{b}_{LI}^*$). Likewise, the entrepreneurs also have access to external funds to finance their investment in capital. Again, we consider that the amount of external funds for the entrepreneurs is constant in foreign currency ($\bar{b}_E^*$). Since in equilibrium $E_t\left[\frac{R_t^{IB}}{1+\pi_{t+1}}\right] \geq E_t\left[\frac{R_t^*\Theta_t}{1+\pi_{t+1}^*}\frac{rer_{t+1}}{rer_t}\right]$ both lending intermediaries and entrepreneurs will use the complete amount of external funds each period. The presence of these external funds will imply a direct balance sheet effect of exchange rate movements, which can magnified the impact of capital flows through the financial accelerator mechanism.

Thus, the loan contract now solves the following maximization problem

$$Max\ E_t\{payr_{t+1}k_{t+1}f(\bar{\omega}_{t+1},\sigma_t)\}$$

(E.1) $s.t.\ payr_{t+1}k_{t+1}g(\bar{\omega}_{t+1},\mu_{t+1},\sigma_t) \geq \frac{R_t^{IB}}{1+\pi_{t+1}}(b_t - rer_t\bar{b}_{LI}^*) + \frac{R_t^*\Theta_t}{1+\pi_{t+1}^*}\frac{rer_{t+1}}{}\bar{b}_{LI}^*$ for all states in $t+1$

where $b_t = (qr_t k_{t+1} - netr_t - rer_t\bar{b}_E^*)$ is the domestic loan to the entrepreneurs with net worth $netr_t$.

Thus, the equilibrium condition for the loan contract and entrepreneurs' variables are stated as follows.

- Arbitrage condition for the loans to entrepreneurs:

(E.2) $qr_t E_t\left\{\left[\frac{R_t^{IB}}{1+\pi_{t+1}}\right]\frac{f_{\bar{\omega}}(\bar{\omega}_{t+1},\sigma_t)}{g_{\bar{\omega}}(\bar{\omega}_{t+1},\mu_{t+1},\sigma_t)}\right\} = E_t\left\{\frac{payr_{t+1}}{\rho(\bar{\omega}_{t+1},\mu_{t+1},\sigma_t)}\frac{f_{\bar{\omega}}(\bar{\omega}_{t+1},\sigma_t)}{g_{\bar{\omega}}(\bar{\omega}_{t+1},\mu_{t+1},\sigma_t)}\right\}$

Definition of the recovery rate of financial intermediaries' loans:

(E.3) $recov_t = \frac{(1-\mu_t)\int_0^{\bar{\omega}_t}\omega d\Phi(\omega;\sigma_{t-1})payr_t k_t(1+\pi_t)}{\Phi(\bar{\omega}_t;\sigma_{t-1})\left[R_{t-1}^{IB}(b_{t-1}-rer_{t-1}\bar{b}_{LI}^*)+\frac{R_{t-1}^*\Theta_{t-1}(1+\pi_t)rer_t}{1+\pi_t^*}\bar{b}_{LI}^*\right]}$

- Definition of the risk premium:

(E.4) $\rho(\bar{\omega}_t,\mu_t,\sigma_{t-1}) = \left[g(\bar{\omega}_t,\mu_t,\sigma_{t-1}) - f(\bar{\omega}_t,\sigma_{t-1})\frac{g_{\bar{\omega}}(\bar{\omega}_{t+1},\mu_{t+1},\sigma_t)}{f_{\bar{\omega}}(\bar{\omega}_{t+1},\sigma_t)}\right]^{-1}$

- Budget constraints of entrepreneurs:

(E.5) $b_t = qr_t k_{t+1} - netr_t - rer_t \bar{b}_E^*$

- Break-even condition for financial intermediaries:

(E.6) $g(\bar{\omega}_t, \mu_t, \sigma_{t-1}) payr_t k_t = \left[\frac{R_{t-1}^{IB}}{1+\pi_t}\right](b_{t-1} - rer_{t-1}\bar{b}_{LI}^*) + \left[\frac{R_{t-1}^*\Theta_{t-1}}{1+\pi_t^*}\frac{rer_t}{}\right]\bar{b}_{LI}^*.$

- Real net worth of entrepreneurs:

(E.7) $netr_t = (1-\lambda)\left(f(\bar{\omega}_t, \sigma_{t-1}) payr_t k_t - \frac{R_{t-1}^*\Theta_{t-1}}{1+\pi_t^*}\frac{rer_t}{}\bar{b}_E^*\right) + \tau_E$

Again, all entrepreneurs receive a lump-sum transfers, τ_E, bit now they also make an interest payment for the constant amount of foreign debt $\bar{b}_E^*$ taken each period. Thus, a real appreciation of the currency increases the resources of entrepreneurs, improving their financial position and the demand for investment. As before, when an entrepreneur dies, which happens with a rate λ, he consumes all his wealth. Thus, consumption of entrepreneurs is:

$$\text{(E.8) } c_{K,t} = \lambda\left(f(\bar{\omega}_t, \sigma_{t-1}) payr_t k_t - \frac{R_{t-1}^*\Theta_{t-1}}{1+\pi_t^*}\frac{rer_t}{}\bar{b}_E^*\right)$$

$$\text{(E.9) } \frac{D_t}{P_t}(1-s_t) = (b_t - rer_t\bar{b}_{LI}^*)$$

Appendix VI. Financial Dollarization of the Entrepreneurs' Loans

Another modification of the baseline model can be the possibility that the loan contract to the entrepreneurs is set in or indexed to the foreign currency (dollars). Under this situation, we define $\psi \in [0,1]$ as the fraction of the loan set in domestic currency and $1-\psi$ as the fraction of the loan in foreign currency. For the exercise reported we consider $\psi = 0.5$.

Thus, the loan contract now solves the following problem:

$$Max\ E_t\{payr_{t+1}k_{t+1}f(\bar{\omega}_{t+1}, \sigma_t)\}$$

(F.1) $s.t. payr_{t+1}k_{t+1}g(\bar{\omega}_{t+1}, \mu_{t+1}, \sigma_t) \geq \left(\psi\frac{R_t^{IB}}{1+\pi_{t+1}} + (1-\psi)\frac{\tilde{R}_t^*}{1+\pi_{t+1}^*}\frac{rer_{t+1}}{rer_t}\right)b_t$ for all states in $t+1$,

where $\tilde{R}_t^* = R_t^{IB}E_t\left[\frac{rer_t}{rer_{t+1}}\frac{(1+\pi_{t+1}^*)}{(1+\pi_t^*)}\right]$ is the ex-ante real interest rate in terms of the foreign currency. We then find the first order conditions of this problem as we did in appendix I.