Household and firm leverage, capital flows and monetary policy in a small open economy

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Abstract

This paper outlines a framework for analysing the interaction between financial frictions at the household and firm level, liability dollarization and optimal monetary policy in a small, open economy subject to productivity and capital inflow shocks. It is found that, first, for the shocks under review, the extent of co-movement of financial variables pertaining to entrepreneurs and homeowners crucially depends on the degree of exchange rate flexibility. Second, for a central bank not concerned with financial stability, reacting to inflation and output is considered optimal. Third, including financial stability in the central bank's objectives results in an optimal monetary policy rule reacting to exchange rate depreciation, but not to credit growth, even in the case of large capital inflow shocks. In fact, reacting to credit growth reinforces the initial shock, increasing financial imbalances.

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1 Introduction

The recent financial crisis started in August 2007 posed a serious threat to the macroeconomic and financial stability of countries worldwide. While the roots of the crisis lie in a complex interplay between policies encouraging borrowing for mortgage purposes, the failure of correctly assessing the risk inherent in mortgage backed securities and inadequate capitalization of financial institutions in the United States, it quickly spilled over to developed and emerging countries worldwide leading to an economic downturn of global proportions. For the purpose of this study, three aspects of the recent turmoil are worth emphasizing. First, recent events demonstrate that financial imbalances with potentially systemic implications can arise even in an environment of stable inflation and economic growth. Secondly, developments in the real estate market, involving credit to households and real estate price dynamics were of key importance in triggering the global financial turmoil, and as such shoud not be disregarded in macroeconomic and monetary policy making. Third, imbalances related to the dynamics of credit and leverage built-up in good times can significantly exacerbate the impact of downturns. Understanding the interaction between credit flows, leverage and monetary policy is essential for a thorough assessment of the adequate monetary policy responses to be implemented.

These considerations particularly hold for emerging economies, whose exposure to vulnerabilities is enhanced by their superior sensitivity to external developments brough about by trade and financial linkages. A prominent example is the experience of the new EU member states of Central and Eastern Europe (CEE), where a remarkable economic performance since the mid-1990s was dramatically reversed by the global credit crunch and exacerbated by existing imbalances. In the years preceding the financial crisis, Emerging Europe saw a prolonged period of steady economic growth, driven by a demand boom and accompanied by high credit growth, fostered to a large extent by the massive waves of foreign capital flowing in the region. The increased availability of foreign funds channeled mainly by the banking sector boosted the supply of credit for both housing and investment purposes, often denominated in foreign currency (mainly Euro and Swiss franc)[1]. Cheaper mortgage loans and the consequent increased demand for real estate inflated housing prices, with a positive effect on consumption through wealth effects. At the same time, investment in the corporate sector increased to several times its level at the beginning of the decade, fueling asset prices growth. Hence, the flows of foreign capital and the consequent increase in domestic lending spurred an overall increase in leverage in the transition economies. Three were the main source of macro-financial vulnerability to which the CEE countries were exposed in the run-up to the crisis. First, the increased dependence on foreign financing exposed them to risks of contagion from external shocks. Secondly, rapid growth in bank credit and asset prices significantly contributed to financial fragility, by increasing leverage and hampering the resilience of the economy during downturns. Third, liability dollarization and resulting currency mismatches exacerbated existing imbalances.When the financial crisis hit and

[1] Sirtaine and Skamnelos (2007) document that, in 2005, foreign currency lending as a share of total lending amounted to more than 70% in Estonia and Latvia, while Lithuania, Hungary, Poland, Slovenia and Romania settled on values ranging from 50% to 70%. By 2008, foreign currency loans reached values greater than 80% of the total in Estonia and Latvia and doubled in Bulgaria, exceeding 60% of total loans (Rancière et al. 2010).

foreign capital inflows dried up, Emerging Europe was dragged into the spiral and suffered large losses in terms of GDP growth. However, countries which experienced the strongest credit boom before the crisis and large macroeconomic and financial imbalances (notably, the Baltic countries) faced the largest contraction in GDP growth (Bakker and Gulde (2010)).

While central banks around the globe developed strategies to react to the financial crisis, a debate among academics and policymakers emerged on the necessity to reconsider the objectives and instruments of monetary policy in tranquil times. On one side, the appropriateness of the traditional monetary policy objectives, i.e. inflation and output stability, is reexamined, on the grounds that they might not be necessarily conducive of financial stability. On the other hand, a debate spurred on the implementation of monetary policy, reconsidering the effectiveness of inflation targeting regimes whereby central banks set the policy rate reacting to inflation and a measure of economic activity. Hence, the dispute on monetary policy conduct in the aftermath of the crisis evolves around two main questions. Should central banks be concerned about financial, in addition to macroeconomic, stability? And, if so, should central banks react to indicators of financial overheating when setting the monetary policy rate?

This paper presents a framework to analyze the two issues relevant to the current monetary policy debate in a small open economy reflecting the characteristics of many emerging European economies in the run-up to the crisis. In particular, the economy is characterized by capital inflows directed to the financing of both mortgage and investment loans. Credit frictions due to asymmetric information à la Bernanke, gertler and Gilchrist (1999) are present at both the entrepreneurial and household level, allowing to explore the interaction between leverage dynamics in the two sectors. In addition, liabilities in the two sectors are denominated in foreign currency, further increasing the dynamic interaction of leverage in the two sectors when faced to the considered shocks. The objective of this paper is threefold. First, I compare the dynamics of the economy in response to productivity and capital inflow shocks under different monetary policy rules that have been widely considered in the literature for emerging economies (i.e. standard Taylor rule, Taylor rule with exchange rate smoothing and fixed exchange rate) and a Taylor rule reacting to credit growth. Secondly, the dynamic interaction between leverage at the household and entrepreneurial level is analysed and compared. Third, I compute the optimal unrestricted monetary policy rule for a small open economy subject to productivity and capital inflow shocks, under two central bank objectives, namely macroeconomic stability and macroeconomic *cum* financial stability.

This study is tied to three main strands of literature. First, it relates to studies exploring the interplay between financial frictions and liability dollarization, with their monetary policy consequences, in small open DSGE models for emerging economies. This strand of literature, exemplified by the studies of Cespedes (2000), Cespedes, Chang and Velasco (2004), Devereux, Lane and Xu (2006), Gertler, Gilchrist and Natalucci (2007), Batini and Levine (2008), Merola (2010) and Faia (2010) highlights the balance sheet effect of exchange rate fluctuations and examines the exchange regime most suited to isolate small open dollarized economies against foreign shocks. While these studies are insightful in providing evidence in support of the superiority of a flexible currency even in the presence of liability dollarization, they abstract from three issues, which are of particular relevance in light of the experience of emerging European economies in the run-up to the crisis. First, they do not consider the housing market and the interplay with financial frictions at the household and firm level. Second, they discard potential financial stability objectives of the small open economy's central bank. Their conclusions concerning the superiority of flexible exchange rate regimes relies on the volatility of output and inflation, without consideration of the volatility of financial variables. Third, they model capital inflow shocks as an exogenous increase in the foreign interest rate or in the country's risk premium. However, the experience of many emerging economies revealed that capital flows are largely influenced by waves of optimism and pessimism of international investors, often unrelated to country risk premia or interest rate differentials. Therefore, in this paper, I model capital inflows in this spirit, following Curdia (2006 and 2007). Capital inflows and their implications for monetary policy are considered in studies by Ozkan and Unsal (2012) and Unsal (2013). In both cases, capital inflows (or sudden stops in Ozkan and Unsal (2012)) are considered in the financing of capital investment and intermediate goods purchases only, disregarding the household sector which, however, is an important recipient of foreign capital for housing purposes[2].

A second strand of literature this paper is related to studies incorporating credit frictions in mortgage credit in DSGE models. This strand of literature, pioneered by Iacoviello (2005) and extended by Aoki et al. (2004), Christensen et al. (2007), Parès and Notarpietro (2008), Kannan et al. (2009), Iacoviello and Neri (2010), Brzoza-Brezina and Makarski (2009), Solomon (2010), Ajevskis and Vitola (2011), Forlati and Lambertini (2011), is motivated by the importance of housing as source of collateral and of the negative implications of housing price bubbles for macroeconomic and financial stability. Most of these studies model financial frictions in mortgage credit following the collateral constraint framework of Kiyotaki and Moore (1997), whereby the amount of credit granted to households is limited by the value of the real estate property. Only few studies in the literature adopt the asymmetric information framework proposed by Bernanke, Gertler and Gilchrist (1999) in introducing financial frictions to mortgage credit (Aoki et al. (2004), Solomon (2010) and Forlati and Lambertini (2011))[3]. Among these, only Solomon (2010) examines the interaction between consumer debt and firm debt over the business cycle, focussing on the quantitative importance of feedback effects between the debt levels in the two sectors. His model abstracts from rigidities in price and wage setting, and from monetary policy considerations. His estimation of the model with U.S. data reveals that, while credit frictions at the firm level significantly amplify the response of investment to shocks, they do not amplify output responses. Furthermore, tighter borrowing conditions for households contribute to ease those for firms, leading to a negative co-movement of financial variables across sectors. However, all three studies are set in a closed economy context, and their conclusions are of limited relevance to small, open, dollarized economies. In particular, exchange rate fluctuations have nontrivial consequences

[2] Furthermore, the monetary policy implications are studied assuming the central bank has macroeconomic stability as its sole objective and credit to households is not considered.

[3] Aoki et al. (2004) focus on the implications of credit frictions at the household level for the transmission of monetary shocks. They conclude that the presence of asymmetric information in the credit contract between financial intermediaries and households financing housing purchases amplifies the transmission of changes in the interest rate to housing investment, house prices and consumption. The objective of Forlati and Lambertini's (2011) study is to examine the impact of shocks to mortgage default rates on the macroeconomy, and to evaluate different parametrizations of the central bank's policy rule. They conclude for the superiority of low-inertial rules in stabilizing the economy after an exogenous increase in mortgage defaults. In particular, as inertial rules imply smoother reductions in the nominal interest rate, they imply larger output contractions.

for domestic production and prices, thereby influencing consumption and housing demand. Furthermore, balance sheet effects of currency movements at both the household and firm level considerably enrich the dynamics, possibly reverting the monetary policy implications drawn for developed countries[4].

Finally, this paper contributes to the debate concerning the possible amendment of the traditional objectives and instruments of monetary policy to include financial stability considerations. On one hand, proponents of the inflation targeting regime argue that, to the extent that asset price inflation and credit growth lead to an expansion of aggregate demand through their effect on wealth and spending, a monetary policy reacting to inflation and output will automatically counteract financial imbalances (Bernanke and Gertler (2001), Bernanke (2002), Bullard and Schaling (2002), Faia and Monacelli (2003), Ferguson (2003) Distayat (2005)). On the other hand, proponents of a "leaning against the wind" approach claim that setting monetary policy only considering developments in inflation and the output gap might be a too narrow approach, and that better results in terms of stabilization could be achieved by explicitly targeting unsustainable increases in asset prices and excessive credit growth, even at the cost of increased variability in inflation and output (Cecchetti et al. (2000), Borio and Lowe (2002 and 2004), Bordo and Jeanne (2002), White (2006), Curdia and Woodford (2010) and and Woodford (2012)) [5].

The presented analysis leads to the conclusion that, first, adding financial stability to the central bank's objectives does not result in an optimal reaction to credit growth, while some degree of reaction to exchange rate depreciation is optimal. This seems to suggest that in a small open and dollarized economy, a the central bank with financial stability objectives but equipped with one instrument, namely the nominal interest rate, cannot simultaneously achieve macroeconomic and financial stability. A tightening of monetary policy in reasponse to capital inflow shocks results in further exchange rate appreciation, which further strengthens borrowers' balance sheet and encourages more foreign borrowing. Concerning the interaction between households' and entrepreneurial financial variables, I find that their extent of co-movement crucially depends on whether the exchange rate is flexible or pegged, in the case of both technology and capital inflow shocks. Specifically, I find that under a fixed (flexible) exchange rate regime, a negative (positive) correlation arises. The analysis reveals that sectorial capital inflow shocks spill over to the other sector mainly through their effect on domestic production through increased demand of domestic goods used for investment purposes, and through balance sheet effects of currency appreciation.

[4]Specifically, Forlati and Lambertini's (2011) prescription for non-inertial rules might be reverted in an open economy context, as large interest rate responses imply exchange rate fluctuations that have large repercussions on trade and balance sheets.

[5]In recent contributions, Curdia and Woodford (2010) and Woodford (2012) strongly encourage central banks to acknowledge the influence of monetary policy on financial stability, arguing that the monetary policy trade-off between inflation and financial stability is very similar to that between inflation and output stabilization. In the same way as central banks strike a balance between price stability and output gap stabilization engaging in a so-called "flexible inflation targeting regime", they may very well be able to find a short-run path for the economy balancing inflation stability against output gap and financial stabilization. The validity of a central bank's financial stability objective from a welfare standpoint has been emphasized by Angeloni and Faia (2013).

2 The Model

The small open economy is populated by six agents: households, entrepreneurs, firms, capital and housing producers, and the central bank. The model features financial frictions affecting the credit relationships of both households and firms in a New Keynesian setting. Credit frictions are modeled following Bernanke, Gertler and Gilchrist (1999), postulating the existence of an asymmetric information problem between borrowers and lenders implying costly state verification and generating an external finance premium directly linked to borrowers' leverage. Furthermore, debt is denominated in foreign currency, therefore, exchange rate movements impact on borrowers' balance sheets.

The capital inflow shock is embedded into the asymmetric information set-up following Curdia (2007, 2008), i.e. assuming that foreign lenders have a distorted perception of borrowers' creditworthiness. In good (bad) times, waves of optimism (pessimism) lead to higher (lower) perceived creditworthiness of domestic borrowers and hence to a loosening (tightening) of credit conditions which trigger a self-fulfilling virtuous (vicious) cycle of economic expansion (contraction). To introduce the capital inflow shock consistently in the two sectors (real estate and capital investment), I assume the existence of capital and housing producers that buy final goods and convert them in new housing and capital stock. In the production sector, entrepreneurs invest in new capital goods using their own net worth and borrowing from foreign financial intermediaries, who face a costly state verification problem and charge an external finance premium dependent on leverage. They rent their capital to production firms who produce for the domestic and foreign market, and are subject to staggered price setting. The housing market is modeled following Aoki, Proudman and Vlieghe (2004), assuming two behavioral types of households: homeowners and consumers. Homeowners are analogous to entrepreneurs: they use own net worth and borrowed funds to finance housing investment. The credit relationship is characterized by the same asymmetric information problem faced by entrepreneurs. Homeowners then rent the housing stock to consumers, which also consume domestic and imported goods and supply labor to domestic firms. Wealth effects from house price fluctuations are incorporated assuming that, at the end of each period, homeowners perform a transfer to consumers within the household. Finally, monetary policy is conducted by the central bank setting the nominal interest rate according to a policy rule.

2.1 Households

Households are composed of two behavioral types, homeowners and consumers. While the former undertake housing investment and own the housing stock, the latter rent housing services and consume consumption goods. Consumers are further divided in two types. A fraction n of consumers is Ricardian (R), has access to domestic and foreign assets and is able to smooth consumption over time. The remaining $(1-n)$ consumers are non-Ricardian (NR), and consume their current income in each period.[6] Both types of consumers supply

[6] In the context of this study, this modeling choice is dictated by the necessity to incorporate a transfer from homeowners to consumers, in order to obtain wealth effects from investment. In general, the introduction of Non-Ricardian households in DSGE models is motivated by the empirical evidence suggesting a high dependence of consumption from current income, which cannot be obtained when households satisfy the

differentiated labor services to unions, which act as wage setters in monopolistically competitive markets. Income of NR consumers is then made up of wage income plus a transfer received from homeowners. Finally, as the economy is open, the consumption bundle is composed of domestic and imported goods.

2.1.1 Consumers

The utility function common to all consumers is expressed in terms of consumption (C_t) and labor services (N_t) :

$$U\left(C_{t,}N_t\right) = \frac{\left(C_t - \tau C_{t-1}\right)^{1-\sigma}}{1-\sigma} - \chi_N \frac{\left(N_t\right)^{1+\varphi}}{1+\varphi}$$

Where τ is the habit formation parameter, σ and φ are respectively the elasticities of intertemporal substitution and of labor supply, and χ_N is a scaling parameter for the disutility of working hours. The consumption bundle C_t is composed of consumption goods c_t and housing services h_t:

$$C_t = \left[\gamma_c^{\frac{1}{\varsigma}} \left(c_t\right)^{\frac{\varsigma-1}{\varsigma}} + \left(1-\gamma_c\right)^{\frac{1}{\varsigma}} \left(h_t\right)^{\frac{\varsigma-1}{\varsigma}}\right]^{\frac{\varsigma}{\varsigma-1}}$$

Where ς is the elasticity of substitution between consumption and housing services, and γ_c is the weight of goods consumption in the overall basket. Furthermore, consumers allocate consumption between domestically produced (c_t^H) and imported (c_t^F) goods, so that $c_t = \left[\gamma_h^{\frac{1}{\eta}} \left(c_t^H\right)^{\frac{\eta-1}{\eta}} + \left(1-\gamma_h\right)^{\frac{1}{\eta}} \left(c_t^F\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$, where η represents the elasticity of substitution between domestic and foreign goods. It follows that the consumer price index P_t is defined as $P_t = \left[\gamma_h \left(P_t^H\right)^{1-\eta} + \left(1-\gamma_h\right) \left(P_t^F\right)^{1-\eta}\right]^{\frac{1}{1-\eta}}$, where P_t^H and P_t^F are respectively the price of domestically produced and imported goods. As all consumers share the same preferences and face the same prices, intratemporal optimization results in the following demand schedules for consumption, housing services, domestic and imported goods:

$$\frac{c_t}{h_t} = \frac{\gamma_c}{1-\gamma_c} \left(\frac{1}{p_t^h}\right)^{-\varsigma} \quad (1)$$

$$c_t^H = \gamma_h \left(p_t^H\right)^{-\phi} c_t \quad (2)$$

$$c_t^F = \left(1-\gamma_h\right) \left(p_t^F\right)^{-\phi} c_t \quad (3)$$

Furthermore, I assume that housing services are a constant fraction s of the housing stock:

$$h_t = sH_t \quad (4)$$

permanent income hypothesis (Gali', Lopez-Salido and Vallés (2007). Campbell and Mankiw (1989) and Mankiw (2000) provide empirical evidence on the relationship between consumption and income in advanced economies).

While intratemporal choices are analogous for the two types of consumers, only Ricardian consumers face an intertemporal choice problem, maximizing the discounted value of lifetime utility subject to the budget constraint[7]:

$$C_t^R + \frac{R_t B_t}{P_t} + R_t^* \Psi_t \frac{S_t B_t^*}{P_t} = \frac{W_t}{P_t} N_t^R + \frac{B_{t+1}}{P_t} + \frac{S_t B_{t+1}^*}{P_t} + \Pi_t - T_t^R$$

Ricardian consumers have access to domestic (B_t) and foreign (B_t^*) borrowing. While both assets are of a risk-free nature, access to the international financial market is subject to small transaction costs Ψ_t. Hence, while the domestic asset carries the gross domestic risk-free interest rate R_t, the cost of foreign borrowing is $R_t^* \Psi_t$, where the portfolio adjustment cost Ψ_t is a function of the aggregate foreign debt of the small open economy $(B_{t+1}^* + L_{t+1}^E + L_{t+1}^H)$[8]:

$$\Psi_t = \exp\left[-\phi_B \left(\frac{S_t(B_{t+1}^* + L_{t+1}^E + L_{t+1}^H)}{Y_t} - \frac{S(B^* + L^E + L^H)}{Y}\right)\right] \tag{5}$$

Furthermore, Ricardian households receive profits from the ownership of firms (Π_t) and pay lump-sum taxes to the government (T_t^R). Denoting with λ_t the lagrange multiplier on the budget constraint, the following conditions hold:

$$\lambda_t = \left(C_t^R - \tau C_{t-1}^R\right)^{-\sigma} \tag{6}$$

$$\lambda_t = \beta E_t \left\{\lambda_{t+1} \frac{R_t}{\pi_{t+1}}\right\} \tag{7}$$

$$\lambda_t = \beta E_t \left\{\lambda_{t+1} \frac{S_{t+1}}{S_t} \Psi_t \frac{R_t^*}{\pi_{t+1}}\right\} \tag{8}$$

Non-Ricardian consumers are of measure $(1-n)$ and are assumed to fully consume their income in every period. Consumption of NR households is then determined by their wage income, dividends from homeowners[9] (D_t) and lump-sum taxes (T_t^{NR}), as follows:

$$C_t^R = \frac{W_t}{P_t} N_t^{NR} + D_t - T_t^{NR} \tag{9}$$

Aggregating over R and NR consumers, total consumtpion results in: $C_t = nC_t^R + (1-n)C_t^{NR}$.

The wage setting process and the consequent labor supply decision are governed by unions. Both R and NR consumers supply differentiated labor services to a continuum of monopolistically competitive unions[10], which act as wage setters taking the aggregate wage

[7] Variables pertaining to Ricardian (Non-Ricardian) consumers are denoted with the superscript R, (NR).

[8] Variables without time subscript denote steady state values. This specification of the portfolio adjustment cost implies that the cost of foreign borrowing is higher the higher the net indebtness of the economy. While the coefficient ϕ_B is so small that it does not affect the dynamics of the model, introducing a portfolio adjustment cost in small open economy models guarantees the existence of a well defined steady state and delivers a stationary path for net foreign assets and consumption (Schmitt-Grohé and Uribe (2003)).

[9] Details on the specification of the transfer follow in section 3.1.2.

[10] See Conen and Straub (2004) for this specification in the context of Ricardian and Non-Ricardian

W_t and the aggregate labor demand N_t^d as given. Unions pool the wage income of all consumers and then distribute the aggregate wage income in equal proportion among the latter. The union then takes W_t and N_t^d as given and sets the optimal wage $\tilde{W}_t(i)$ to equate the union's expected average marginal return and the marginal cost of supplying labor [11]. However, in doing so the union faces nominal rigidities in the Calvo fashion. Specifically, in each period the wage can be optimized only in a fraction $(1-\theta^w)$ of labor markets. In the remaining fraction θ^w the real wage is indexed to past inflation resulting in the following law of motion of the aggregate wage (where ε_w represents the elasticity of substitution between different labor types):

$$W_t = \left[(1-\theta^w)\,\tilde{W}_t^{1-\varepsilon_w} + \theta^w\left(W_{t-1}(i)\pi_{t-1}\right)^{1-\varepsilon_w}\right]^{\frac{1}{1-\varepsilon_w}} \tag{13}$$

Given the assumptions concerning the population of consumers, aggregate labor supply is given by $N_t = nN_t^R + (1-n)N_t^{NR}$.

However, given the hypothesis that unions pool wage incomes of R and NR consumers, labor market equilibrium requires:

$$N_t = N_t^R = N_t^{NR} \tag{14}$$

In order to ensure that the wage rate is the same for the two consumer types, hours worked must be equalized.[12]

2.1.2 Homeowners

Housing investment decisions are made by homeowners, who act like entrepreneurs in the model. Homeowners are risk neutral, they purchase housing from housing producers, transform it into homogeneous rentable units and rent them to consumers. At the end of period t the $i-$th homeowner has available net worth equal to $NW_{t+1}^H(i)$. At time t she purchases unfinished housing $(H_{t+1}(i))$ from housing producers at a unit price $Q_{h,t}$ and finances the part of investment in excess of her net worth by stipulating foreign currency loans $L_{t+1}^H(i)$.[13] In the next period, she will use unfinished housing to produce rentable units, which will be

consumers.

[11] The first order conditions can be formulated in the following recursive fashion, where $\Lambda_{t+k} = (C_{t+k})^{-\sigma}$ is the marginal utility of consumption of all consumers:

$$K_t^w = \left(\frac{\varepsilon_w - 1}{\varepsilon_w}\right)\tilde{W}_t\Lambda_t N_t\left(\frac{W_t}{\tilde{W}_t}\right)^{\varepsilon_w} + \beta\theta^w\left(\frac{\pi_{t+1}}{\pi_t}\frac{\tilde{W}_{t+1}}{\tilde{W}_t}\right)^{\varepsilon_w - 1} K_{t+1}^w \tag{10}$$

$$F_t^w = \chi_H\left(N_t^d\right)^{\varphi}\left(\frac{W_t}{\tilde{W}_t}\right)^{\varepsilon_w} N_t + \beta\theta^w\left(\frac{\pi_{t+1}}{\pi_t}\frac{\tilde{W}_{t+1}}{\tilde{W}_t}\right)^{\varepsilon_w} F_{t+1}^w \tag{11}$$

$$K_t^w = F_t^w \tag{12}$$

[12] This also arises as a result of the fact that firms allocate their labor demand uniformly across labor varieties, independently of their consumer type (R or NR).

[13] Note that loans are stipulated in period t but will be repayed at $t+1$, hence the choice of subscript. Similarly, housing purchased at time t will be used in the next period, hence the time subscript.

rented to consumers at a rental price $P_{h,t+1}$. Homeowners borrow from a competitive foreign financial intermediary whose relevant opportunity cost is the gross risk-free rate prevailing in the foreign country, R^*_{t+1}. The typical homeowner faces the following budget constraint, expressed in domestic currency:

$$NW^H_{t+1}(i) = Q_{h,t}H_{t+1}(i) - S_t L^H_{t+1}(i)$$

The expected gross return of a unit of housing investment is composed of the return from renting houses to consumers (i.e. the rental price of houses, $P_{h,t}$) and the value of the undepreciated housing stock, adjusted for the change in price:

$$E_t\left\{R^H_{t+1}\right\} = E_t\left\{\frac{sP^h_{t+1} + (1-\delta_h)Q_{h,t+1}}{Q_{h,t}}\right\} \tag{15}$$

Where δ_h is the depreciation rate of the housing stock.

Each homeowner has access to a stochastic technology that transforms $H_{t+1}(i)$ units of unfinished housing into $H_{t+1}(i) = \omega^H_{t+1}(i)H_{t+1}(i)$ rentable units. The idiosyncratic productivity shock $\omega^H_{t+1}(i)$ is *iid* across homeowners and time and it is assumed to follow a lognormal distribution with density $f(\omega^H)$ and $E\left\{\omega^H\right\} = 1$[14]. The realization of productivity is freely observed by homeowners, but lenders can only observe it by incurring a monitoring cost proportional to the gross payoff to the homeowner's project $(\mu^H(\omega^H_{t+1}(i)R^H_{t+1}Q_{h,t}H_{t+1}(i)))$: this asymmetric information is at the core of the external finance premium. Furthermore, following Curdia (2007), I assume that lenders have a distorted perception of the productivity parameter. In particular, the lenders' perception of productivity is $\omega^{H*}_{t+1} = \omega^H_{t+1}\upsilon^H_t$ where $\upsilon^H_t \in [0,1]$ is the misperception factor which evolves according to $\ln(\upsilon^H_t) = \rho_\upsilon \ln(\upsilon^H_{t-1}) + \xi^H_\upsilon$. ξ^H_υ is a shock to lenders perceptions of homeowners' productivity and it is the origin of capital inflows in the model. When υ^H_t increases, lenders perceive homeowners' to be more productive or, in other words, they perceive their default probability to be lower. Hence, they will charge a lower premium, allowing borrowers to expand their balance sheet. The optimal credit contract between financial intermediaries and homeowners specifies a fixed payment (equal to $R^H_{L,t+1}$) to the lender whenever the return to to investment is above the cutoff value $(\bar{\omega}^H_{t+1}(i))$ that determines default. Otherwise, the homeowner defaults on her debt and the lender seizes the remaining value of the project, after paying the monitoring cost. The non-default cutoff value is the productivity level $\bar{\omega}^H_{t+1}(i)$ equating the homeowner's receipts with the repayment of the loan:

$$\bar{\omega}^H_{t+1}(i)\frac{Q_{h,t}H_{t+1}(i)R^H_{t+1}}{S_{t+1}} = R^H_{L,t+1}\frac{(Q_{h,t}H_{t+1}(i) - NW^H_{t+1}(i))}{S_t} \tag{16}$$

Taking as given $Q_{h,t}$, R^H_{t+1} and net worth $NW^H_{t+1}(i)$, the optimal contract is fully specified in terms of the threshold productivity level $\bar{\omega}^H_{t+1}(i)$ and demand for initial investment $H_{t+1}(i)$.[15] The optimal contract maximizes the expected payoff of the borrower subject to

[14] In particular, $\omega^H \sim \log N\left(-\frac{\sigma^2_H}{2}, \sigma^2_H\right)$, where σ^2_H represents the variance of the underlying Normal distribution.

[15] Recall that P^h_{t+1} is a market price, and as such it will be determined by the equilibrium between demand and supply of rentable houses.

the lender's participation constraint. The expected payoff of the homeowner is:

$$E_t\left[\left(Q_{ht}H^H_{t+1}(i)R^H_{t+1}\right)\left(A^H(\bar{\omega}^H_{t+1}(i))\right)\right] = \tag{17}$$
$$E_t\left[\left(\int_{\bar{\omega}^H_{t+1}(i)}^{\infty}\omega^H_{t+1}(i)f(\omega^H)d\omega^H\right)\left(Q_{h,t}H_{t+1}(i)R^H_{t+1}\right)-\left(\int_{\bar{\omega}^H_{t=1}(i)}^{\infty}f(\omega^H)d\omega^H\right)R^H_{L,t+1}L^H_{t+1}(i)\right]$$

Where $A^H(\bar{\omega}^H_{t+1}(i))$ represents the fraction of the expected payoff captured by homeowners. As foreign lenders are risk neutral, they engage in the contract if it guarantees an expected payoff at least equal to what they would obtain by investing in the risk-free asset. The following participation has to hold:

$$\frac{R^H_{t+1}Q_{h,t}H_{t+1}(i)}{S_{t+1}}\left[B^H\left(\bar{\omega}^H_{t+1},\upsilon^H_t\right)\right] = R^*_t L^H_{t+1}(i) \tag{18}$$

Where $R^H_{t+1}Q_{h,t}H_{t+1}(i)\left[B^H\left(\bar{\omega}^H_{t+1},\upsilon^H_t\right)\right] = \left[\begin{array}{c}\left(\int_{\bar{\omega}^H_{t+1}(i)}^{\infty}f(\omega^{H*})d\omega^{H*}\right)R^H_{L,t+1}L^H_{t+1}(i)+\\ \left(\int_0^{\bar{\omega}^H_{t+1}(i)}\omega^{H*}_{t+1}f(\omega^{H*})d\omega^{H*}\right)(1-\mu^H)Q_{h,t}H_{t+1}(i)R^H_{t+1}\end{array}\right]$ is teh lender's expected payoff and $B^H\left(\bar{\omega}^H_{t+1},\upsilon^H_t\right)$ is the fraction of homeowner's payoff captured by the lender (recall the definition $\omega^{H*}_t = \omega^H_t\upsilon^H_t$), net of monitoring cost.

As ω^H_{t+1} is iid and independent of all other shocks in the model, homeowners are identical $ex-ante$, face the same contract and will be charged the same lending rate. The first order conditions of the optimal credit contract are obtaining maximizing (17) subject to (18) [16]:

$$E_t\left(R^h_{t+1}\right) = R^*_{t+1}\left[\frac{A'^H(\bar{\omega}^H_{t+1})}{B^H\left(\bar{\omega}^H_{t+1},\upsilon^H_t\right)A'^H(\bar{\omega}^H_{t+1})-B'^H\left(\bar{\omega}^H_{t+1},\upsilon^H_t\right)A^H(\bar{\omega}^H_{t+1})}E_t\left\{\frac{S_{t+1}}{S_t}\right\}\right] \tag{19}$$

$$\frac{Q_{h,t}H_{t+1}}{NW^H_{t+1}} = \frac{1}{\left(1-\frac{S_t}{S_{t+1}}\frac{R^H_{t+1}}{R^*_{t+1}}B^H\left(\bar{\omega}^H_{t+1},\upsilon^H_t\right)\right)} \tag{20}$$

Equation (20) implies that the demand for unfinished housing by homeowners is positively related to the rental price of housing P^h_{t+1}, which enters R^h_{t+1}, and inversely related to the price of housing good, $Q_{h,t}$. Equation (19) is the basis of the financial accelerator in the model. It links the cost of external finance to homeowners' financial position and, hence, to their demand for housing good. In fact, risk premia are a positive function of $\bar{\omega}^H_{t+1}$ which is, in turn, a positive function of the homeowner's leverage. Hence, lower leverage implies lower probability of default and hence a lower risk premium. Furthermore, as borrowing is denominated in foreign currency, exchange rate movements also affect the risk premium: a domestic currency appreciation (decrease in S_{t+1}) lowers the risk premium both directly and indirectly by decreasing the value of outstanding debt and thereby lowering leverage.

The description of homeowners' behavior is by the description of the evolution of their net worth. A the end of each period, non-defaulting homeowners keep their payoff net of

[16] Here, $A'(\omega) = \frac{\partial A(\omega)}{\partial\omega}$.

loan repayment, which is going to increment their stock of equity. Furthermore, homeowners perform a transfer (D_t) to consumers within the household[17], which positively depends on the inverse leverage ratio ($\frac{NW^H_{t+1}}{Q_{h,t}H_{t+1}}$) and is given by:

$$D_t = \chi_D \left(\frac{NW^H_{t+1}}{Q_{h,t}H_{t+1}} \right) \tag{21}$$

This simple rule captures the concept that, following a rise in real estate prices, homeowners are faced with two choices. They can either keep the transfer constant and accumulate more net worth (thereby increasing their equity and enjoying looser credit conditions in the future), or they can increase the transfer to consumers leading to an increase of current household consumption. Hence, this is a simple way to generate wealth effects of real estate prices, and a positive correlation between housing prices and consumption observed in the data (see Iacoviello (2010)). Furthermore, homeowners are assumed to be endowed with a unit of labor, which they supply inelastically to domestic firms. The evolution of homeowners' net worth can be represented as:

$$NW^H_{t+1} = A^H(\bar{\omega}^H_t)R^H_t Q_{h,t-1}H^H_t - D_t + W^H_t N^H_t \tag{22}$$

2.2 Housing and Capital Producers

Housing and capital producers operate in a regime of perfect competition.[18] In each period, they combine investment goods ($I_{j,t}$, with price $P^I_{j,t}$, $j = k, h$) and the old undepreciated capital (housing) stock to produce new capital (housing) goods, which will be sold at the real price $Q_{k,t}$ ($Q_{h,t}$)[19]. Investment is subject to adjustment costs, represented by the function $\Phi_{j,t} = \frac{\kappa_j}{2}\left(\frac{I_{j,t}}{I_{j,t-1}} - 1\right)^2$ (Smets and Wouters (2003)). Capital producers choose the optimal amount of investment so as to maximize the profits, leading to the following first order condition:

$$\begin{aligned} 1 \;=\;& q_{k,t}\left[1 - \frac{\kappa_t}{2}\left(\frac{I_{k,t}}{I_{k,t-1}} - 1\right)^2 - \kappa_t\left(\frac{I_{k,t}}{I_{k,t-1}} - 1\right)\left(\frac{I_{k,t}}{I_{k,t-1}}\right)\right] \\ & + \beta E_t\left\{\frac{\lambda_{t+1}}{\lambda_t} q_{k,t+1}\left[\kappa\left(\frac{I_{k,t+1}}{I_{k,t}} - 1\right)\left(\frac{I_{k,t+1}}{I_{k,t}}\right)^2\right]\right\} \end{aligned} \tag{23}$$

Where $q_{k,t}$ is the real price of the capital stock defined as $\frac{Q_{k,t}}{P_t}$. The law of motion of the economy wide capital stock is:

$$K_{t+1} = \left[1 - \frac{\kappa_t}{2}\left(\frac{I_{k,t}}{I_{k,t-1}} - 1\right)^2\right] I_{k,t} + (1 - \delta_k) K_t \tag{24}$$

[17] Here, the transfer is not fully microfounded. Its specification follows Aoki, Proudman and Vlieghe (2004).

[18] Here, I denote with subscript k (h) variables pertaining to capital (housing) producers.

[19] The investment bundle for both producers has a similar composition of the consumption bundle, cfr equation ().

Analogous expressions hold for housing producers, with the subscript k replaced by h.

2.3 Entrepreneurs

The behavior of entrepreneurs closely mirrors that of homeowners. Entrepreneurs engage in capital investment, and in each period they purchase capital from capital producers ($Q_{k,t}K_{t+1}$) using their net worth (NW^E_{t+1}) and borrowing from foreign financial intermediaries (L^E_{t+1}) with a lending rate $R^E_{L,t+1}$. The return from capital investment, R^E_{t+1}, is given by the return from renting capital to firms (r^K_t) and the capital gain:

$$R^E_{t+1} = \frac{r^K_{t+1} + (1-\delta_k)\, Q_{k,t+1}}{Q_{k,t}} \tag{25}$$

Furthermore, each entrepreneur has a stochastic technology $\omega^E_{t+1}(i) \sim \log N(-\frac{\sigma^2_E}{2}, \sigma^2_E)$, the realization of which determines the profitability of their investment and, then, their default probability. The threshold productivity level that discriminates between defaulting and non-defaulting entrepreneurs is given by:

$$\bar{\omega}^E_{t+1}(i)\frac{Q_{k,t}K_{t+1}(i)R^E_{t+1}}{S_{t+1}} = R^E_{L,t+1}L^E_{t+1}(i) = R^E_{L,t+1}\frac{(Q_{k,t}K_{t+1}(i) - NW^E_{t+1}(i))}{S_t} \tag{26}$$

Finally, as in the case of homeowners, lenders have a distorted perception of entrepreneurial productivity, given by $\omega^{E*}_{t+1} = \omega^E_{t+1}\upsilon^E_t$ where $\upsilon^E_t \in [0,1]$ is the misperception factor which evolves according to $\ln(\upsilon^E_t) = \rho_\upsilon \ln(\upsilon^E_{t-1}) + \xi^E_\upsilon$. The optimal financial contract is identical to that faced by homeowners and the first order conditions result in:

$$E_t\left(R^E_{t+1}\right) = R^*_{t+1}\left[\frac{A'^E(\bar{\omega}^E_{t+1})}{B^E\left(\bar{\omega}^E_{t+1}, \upsilon^E_t\right)A'^E(\bar{\omega}^E_{t+1}) - B'^E\left(\bar{\omega}^E_{t+1}, \upsilon^E_t\right)A^E(\bar{\omega}^E_{t+1})}E_t\left\{\frac{S_{t+1}}{S_t}\right\}\right] \tag{27}$$

$$\frac{Q_{k,t}K_{t+1}}{NW^E_{t+1}} = \frac{1}{\left(1 - \frac{S_{t+1}}{S_t}\frac{R^E_{t+1}}{R^*_{t+1}}B^H\left(\bar{\omega}^E_{t+1}, \upsilon^E_t\right)\right)} \tag{28}$$

Contrary to the case of homeowners, entrepreneurs do not pay a transfer. In order to characterize the evolution of their net worth it is assumed that entrepreneurs have finite horizon: in particular, a proportion $(1-\varrho)$ of entrepreneurs die in each period but are immediately replaced by newcomers, so that the total population is constant. This is necessary to guarantee that the net worth of entrepreneurs does not grow to the point they can finance their investment using their equity only. Furthermore, entrepreneurs are endowed with a unit of labor that they supply inelastically to firms, paying a wage W^E_t. At the end of period t, entrepreneurs collect their investment payoff and honour the debt obligations contracted in the previous period. Net worth of surviving entrepreneurs is then composed of the profits from investment and wage income:

$$NW^E_{t+1} = \varrho\left[A^E(\bar{\omega}^E_t)R^E_t Q_{k,t-1}K_t\right] + W^E_t \tag{29}$$

Entrepreneurs exiting the market consume their remaining equity:

$$P_t C_t^E = (1-\varrho) A^E(\bar{\omega}_t^E) R_t^E Q_{k,t-1} K_{t-1} \tag{30}$$

Entrepreneurs consume domestic and import good in the same mix as consumers, the deman functions of which are:

$$C_{H,t}^E = \gamma_h \left(p_t^H\right)^{-\phi} C_t^E \tag{31}$$
$$C_{F,t}^E = (1-\gamma_h) \left(p_t^F\right)^{-\phi} C_t^E \tag{32}$$

2.4 Firms

There exist two types of firms in the economy. A continuum of intermediate producers indexed by $f \in [0,1]$ operates in a monopolistically competitive environment and produce differentiated goods employing capital and labor. Furthermore, these firms face price rigidities à la Calvo, implying staggered priced setting. Then, a set of perfectly competitive final goods producers aggregate costlessly the differentiated intermediate goods into a single final good, which is then sold to consumers (both domestically and abroad).

2.4.1 Final good producers

Final good producers operate in a perfectly competitive environment. They purchase intermediate goods $Y_t(f)$ and aggregate them to obtain the final good $Y_t = \left[\int_0^1 Y_t(f)^{\frac{\varepsilon-1}{\varepsilon}} df\right]^{\frac{\varepsilon}{\varepsilon-1}}$[20]. The final good is sold both domestically and abroad. In particular, the export good is produced one-for-one by a representative competitive producer, using the domestic final good as input. The foreign demand for the domestic good is given by:

$$X_t = \gamma^* \left(\frac{P_t^x}{P_t^*}\right)^{-\mu_x} Y_t^* \tag{33}$$

Where P_t^* is the foreign price index and Y_t^* is foreign output. μ_x represents the elasticity between domestically produced and imported goods in the foreign country. Finally, γ^* is the share of imports in the foreign country's consumption basket. I assume that the law of one price holds in the export market, implying that the domestic good sells for the same price on the two markets when converted to the same currency. Hence, defining the nominal exchange rate S_t as the price of the foreign currency in terms of domestic currency, the price of exports in foreign currency is $P_t^x = \frac{P_{H,t}}{S_t}$:

2.4.2 Intermediate goods producers

A continuum of intermediate good producers indexed by f operate under monopolistic competition and is owned by Ricardian households. Producers use capital and three types of labor inputs (N_t, N_t^E and N_t^H, supplied respectively by consumers, entrepreneurs and home-

[20] ε denotes the elasticity of substitution between varieties of domestic goods.

owners) to produce differentiated goods. The production function for domestic intermediate good producers is:

$$Y_t(f) = e^{A_t} K_t^{\alpha}(f)\, N_t(f)^{(1-\alpha)(1-\Omega_E-\Omega_H)}\, N_t^E(f)^{(1-\alpha)\Omega_E}\, N_t^H(f)^{(1-\alpha)\Omega_H} \tag{34}$$

Where α is the share of capital in production, Ω_E and Ω_H are the shares of entrepreneurial and homeowners' labor in production. Cost minimization implies the following standard factor demand functions, where $r_{k,t}$ denotes the rental rate of capital:

$$W_t = MC_t(1-\alpha)(1-\Omega_E-\Omega_H)\frac{Y_t(f)}{N_t(f)} \tag{35}$$

$$W_t^E = MC_t(1-\alpha)\Omega_E\frac{Y_t(f)}{N_t^E(f)} \tag{36}$$

$$W_t^H = MC_t(1-\alpha)\Omega_F\frac{Y_t(f)}{N_t^H(f)} \tag{37}$$

$$r_t^K = MC_t\alpha\frac{Y_t(f)}{K_t(f)} \tag{38}$$

Price setting is staggered. In each period, only a fraction $(1-\theta)$ of firms are allowed to reset their price optimally. The fraction θ that is not allowed to optimize sets the price equal to that prevailing in the previous period, indexing it to past inflation at a rate γ_p and to the steady state inflation rate at rate $(1-\gamma_p)$. As all firms allowed to optimize set the same price, denoted as $\tilde{P}_{H,t}$, the domestic good price evolves as: $P_t^H = \left[\theta\left(P_{t-1}^H\left(\pi_{t-1}^H\right)^{\gamma_p}\left(\pi^H\right)^{1-\gamma_p}\right)^{1-\varepsilon} + (1-\theta)\left(\tilde{P}_t^H\right)^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}}$.

2.4.3 Import firms

Importers operate in a monopolistically competitive environment. They purchase the foreign differentiated good at the (domestic currency) price $S_t P_t^*$, repackage it and resell it in the domestic market. Price setting is staggered à la Calvo: in each period, they can optimally reset prices with probability θ_m. This introduces imperfect exchange rate pass-through in import prices following Monacelli (2003). The price index of imported goods is given by $P_t^f = [(1-\theta_m)(P_{f,t}^{new})^{1-\mu_m} + \theta_m(P_{t-1}^f)^{1-\mu_m}]^{\frac{1}{1-\mu_m}}$, where μ_m is the elasticity of substitution between different varieties of import goods. Each firm in the import sector chooses the optimal price as to maximize discounted profits[21] subject to the demand constraint $Y_{t+k}^M(j) = \left(\frac{P_t^f(j)}{P_{t+k}^f}\right)^{-\mu_m} Y_{t+k}^M$, where $P_t^f = \left(\int_0^1 P_t^f(j)^{1-\mu} dj\right)^{\frac{1}{1-\mu}}$ and Y_t^M denotes aggregate imports demand. In the symmetric equilibrium, all firms allowed to reset price will set it at the same level, equal to a markup over current and expected future marginal costs (which in the case of import firms are equal to $\frac{S_{t+k}P_{t+k}^*}{P_{t+k}^f}$).

[21] As import firms are owned by Ricardian consumers, $\Lambda_{t,t+k} = \frac{C_t^{R\sigma}}{C_{t+k}^{R\ \sigma}}$ is the consumers' stochastic discout factor.

2.5 Aggregate demand and balance of payments

Domestically produced goods are used for domestic consumption by consumers and entrepreneurs, investment by housing and capital goods producers, government expenditure (G_t), exports (X_t) and to pay monitoring costs arising from imperfect information in the credit relationships between financial intermediaries and homeowners and entrepreneurs (M_t^H and M_t^E)[22]. Hence, the national accounting identity reads:

$$Y_t = c_t^H + C_{H,t}^E + I_{k,t}^H + I_{h,t}^H + G_t + X_t + M_t^H + M_t^E \tag{39}$$

Imported goods are used for consumption and investment, hence total imports (Y_t^M) are defined as:

$$Y_t^M = c_t^F + C_{F,t}^E + I_{k,t}^F + I_{h,t}^F \tag{40}$$

Finally, the balance of payments of the small open economy is obtained by aggregating the budget constraints of consumers, homeowners and entrepreneurs, and results in the following expression:

$$S_t R_t^* (\Psi_t B_t^* + L_t^E + L_t^H) - S_t (B_{t+1}^* + L_{t+1}^E + L_{t+1}^H) = S_t P_t^* X_t - S_t P_t^* Y_t^M \tag{41}$$

Where the nominal foreign interest rate, R_t^*, is taken as given by the small open economy.

2.6 Monetary and fiscal policy

Government in this setting is in charge of conducting monetary and fiscal policy. As for the latter, the government simply aims at maintaining fiscal balance:

$$G_t = T_t^R + T_t^{NR} \tag{42}$$

The general form of the rule used by the central bank to conduct monetary policy is:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left[\left(\frac{\pi_t}{\pi}\right)^{\rho_\pi} \left(\frac{Y_t}{Y}\right)^{\rho_Y} \left(\frac{S_t}{S_{t-1}}\right)^{\rho_S} \left(\frac{L_t}{L_{t-1}}\right)^{\rho_L}\right]^{(1-\rho_R)} \exp\left(\xi_{R,t}\right) \tag{43}$$

Where ρ_π and ρ_Y are, respectively, the weights that the monetary authority places on deviations of inflation and output from the steady state and $\xi_{R,t}$ is a monetary policy shock. It is assumed that the central bank adjusts the nominal interest rate also in response to changes in the exchange rate and total credit growth, the latter obtained aggreagating loans

[22] Given the distribution of ω_t^H and ω_t^E, the fraction of payoff used to monitor borrowers in the two sectors amounts to:

$$\begin{aligned} M_t^H &= \mu^H \cdot F\left(\frac{\ln \bar{\omega}_t^H - 0.5\sigma_H^2}{\sigma_H}\right) \cdot R_t^h Q_{h,t-1} H_t \\ M_t^E &= \mu^E \cdot F\left(\frac{\ln \bar{\omega}_t^E - 0.5\sigma_E^2}{\sigma_E}\right) \cdot R_t^E Q_{k,t-1} K_t \end{aligned}$$

granted to homeowners and entrepreneurs. However, setting the coefficients of the last two terms to zero, leads to a standard Taylor Rule. Furthermore, when $\rho_S \to \infty$, the central bank follows a pegged exchange rate. Finally, the monetary authority engages in interest rate smoothing whenever $\rho_R > 0$.

2.7 Exogenous processes

In the following analysis, three exogenous shocks are considered: aggregate technology (A_t), and perception of lenders on homeowners and entrepreneurial productivity (υ_t^H and υ_t^E). In particular, the latter two shocks are used as a proxy for capital inflows shocks to the small open economy. An increase in υ_t^H and υ_t^E, i.e. an increase in foreign lenders' perception of domestic borrowers' productivity, leads to a lowering of the external finance premium in the sector hit by the shock, and hence an increase in the demand for loans, which is satisfied by foreign lenders and hence amounts to a capital inflow.

Focussing on capital inflow and technology shocks is interesting because while they are both expansionary in nature, they affect different sides of the credit market. The technology shock increasese firms' productivity and leads firms to expand production, increasing their capital demand. This, in turn, translates in an increase in the demand for credit of the entrepreneurial sector. While demand for foreign funds increases, so does entrepreneurial leverage, thereby worsening balance sheet conditions.[23] On the other hand, capital inflow shocks affect the supply side of credit. When foreign lenders become optimist regarding domestic borrowers' productivity, they loosen credit conditions demanding a lower external finance premium, which drives down leverage and encourages borrowing. Hence, while a domestic technology shock "pulls" foreign capital in the small open economy, the capital inflow shock is of a "push" nature.[24] Exogenous variables obey the following autoregressive processes:

$$
\begin{aligned}
\log(A_t) &= \rho_A \log(A_{t-1}) + \xi_{A,t} \\
\ln(\upsilon_t^H) &= \rho_\upsilon \ln(\upsilon_t^H) + \xi_{\upsilon,t}^H \\
\ln(\upsilon_t^E) &= \rho_\upsilon \ln(\upsilon_t^E) + \xi_{\upsilon,t}^E
\end{aligned}
$$

2.8 Calibration

The calibration of the model parameters is largely drawn from existing studies on small open economies. In particular, I set the discount factor $\beta = 0.99$, implying an annual risk-free interest rate of 4%. The intertemporal elasticity of substitution (σ) is set to 1, so as the elasticity of labor supply (φ) following Christiano, Eichenbaum, and Evans (1997). In order to obtain a steady state labor supply of 0.33 the coefficient on labor in the utility function (χ_N) is calibrated at 8.8394. Regarding the composition of consumption, I set the share of

[23] We will see in the next section that, in case of foreign borrowing, the increase in leverage is partially offset by the exchange rate appreciation.

[24] See Fernandez-Arias (1996) for the introduction of the "push-pull" terminology in the context of capital inflows.

imported goods in the consumption basket at 0.4, consistent with the value set for Latvia by Ajevskis and Vitola (2011), which implies some degree of home bias. Furthermore, I set the consumption habit parameter at 0.8, following the estimates for Estonia by Gelain and Kulikov (2009). As in Aoki, Proudman and Vlieghe (2004) and Forlati and Lambertini (2011), the elasticity of substitution between consumption and housing services is set to 1. The same value is chosen for the elasticity of substitution between domestic and foreign goods in the consumption basket, following Gertler, Gali' and Natalucci (2003). Furthermore, I set the share of housing services in the consumption bundle $(1-\gamma_c)$ to 0.0950, so that in steady state, the imputed rents to consumption ratio is equal to 10.5, which is consistent with pre-crisis data of Central and Eastern European countries.[25] Setting a depreciation rate for the housing stock (δ_h) to 1% annually results to a steady state housing investment to output ratio of 1%, which is consistent with the average of $1,06\%$ observed in the data.[26]

Turning to the production side of the economy, I set the elasticity of substitution between different varieties of domestic goods to 6, implying a price markup of 20%. Following Ajevskis and Vitola (2011) and Merola (2010), I set the same elasticity of substitution for different varieties of labor. Furthermore, I set the price and wage stickiness parameters to 0.75, implying that prices and wages are adjusted, on average, every 4 quarters. The share of capital in production, α, is set to 0.35. Furthermore, the share of homeowners' and entrepreneurial labor in production is set to 0.01.

The parameters in the benchmark model calibration are set following Bernanke, Gertler and Gilchrist (1999). In particular, the standard deviation of the idiosyncratic productivity shock of homeowners and entrepreneurs (σ^H and σ^E) are set to 0.28. The monitoring cost parameters are calibrated at 0.12, implying a quarterly default probability of homeowners and entrepreneurs of 0.87% (3.48% annually). This results in an external finance premium equal to 228 basis points on an annual basis and in a steady state leverage ratio of 0.5. I can then back out the survival probability of entrepreneurs, which is calibrated at 0.98. The elasticity of the transfer from homeowners to consumers is calibrated at 0.0526.[27]

Finally, the standard deviation of the technology shock is set to 1, whereas that of the two perception shocks is set to 1%. All three shocks share the same persistence parameter, equal to 0.9.

3 Simulation Results

[25] The ratio has been calculated dividing imputed rents by total consumption expenditures, for the period 2003-2007 (Eurostat data).

[26] Here, I used Eurostat data on gross capital formation in the construction sector as a proxy for investment the real estate sector. Again, the average is computed over the period 2003-2007.

[27] While, for firms, this calibration is largely consistent with the values set by Ajevskis and Vitola (2011) for Latvia, they report much higher leverage ratios for the household sector. Hence, I also calibrate the model in order to deliver a higher leverage ratio (equal to 2.5) of homeowners. This amounts to setting the monitoring cost and the idiosyncratic volatility parameters to 0.18 and 0.2053 respectively. While the steady state default probability is unchanged, the steady state external finance premium rises to 340 basis points annually. This, however, does qualitatively alter the results.

In what follows, I illustrate the dynamic evolution of the main model's variables in response to technology and capital inflow shocks, under different specifications of the Taylor rule. First, this exercise allows to shed light on the interplay between financial frictions in both the financing of capital and real estate investment, and analyze the transmission of shocks across sectors. Secondly, it will allow comparison between different monetary policy rules, illustrating their effect not only on output and inflation, but also on credit variables and their interactions across sectors.

I consider four Taylor rules obtained as special cases of equation (43). In the first scenario, the central bank sets the interest rate according to a standard Taylor rule, reacting to deviations of output and inflation:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left[\left(\frac{\pi_t}{\pi}\right)^{\rho_\pi} \left(\frac{Y_t}{Y}\right)^{\rho_Y}\right]^{(1-\rho_R)} \exp\left(\xi_{R,t}\right) \tag{44}$$

Where variables without time subscript refer to steady state values (in particular, I set $\rho_\pi = 1.5$, $\rho_Y = 0.5$ and $\rho_R = 0.8$).

The second rule I consider is one in which the central bank sets the nominal interest rate reacting to a financial aggregate. The issue is then to choose what financial indicator is more appropriate for inclusion in the central bank's Taylor rule. Evidence presented by the IMF (2009) finds common patterns in economic variables in the period preceding an asset price bust. In particular, significant expansions in domestic credit and investment accompanied by current account deficits have been found to be recurrent in the run-up to a bust. Agénor and Pereira da Silva (2011) argue that in the context of middle income countries, central banks should conduct monetary policy by reacting to the economy's credit growth gap. They claim that, in so doing, the central bank can offset the acceleration mechanism that leads to credit growth and asset price inflation that is at the heart of financial imbalances. In particular, during upturns, informational asymmetries between borrowers and lenders are enhanced, and the prevailing loosening of lending standards erodes the resilience of the country to financial distress. Furthermore, studies as Claessens et al. (2011) and Calderón and Fuentes (2011) affirm that credit aggregates are useful leading indicators of asset price bubbles. In particular, while credit booms are not necessarily conducive of a crisis, the evidence suggests that almost all crises are preceded by a credit boom. Hence, I consider a scenario where the central bank monitors the growth in loans in addition to output and inflation when setting the policy rate[28]:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left[\left(\frac{\pi_t}{\pi}\right)^{\rho_\pi} \left(\frac{Y_t}{Y}\right)^{\rho_Y} \left(\frac{L_t}{L_{t-1}}\right)^{\rho_L}\right]^{(1-\rho_R)} \exp\left(\xi_{R,t}\right) \tag{45}$$

The third policy rule considered represents a situation where the central bank reacts to exchange rate movements. Rules of this kind have been widely considered for small open economies with a high degrees of dollarization, especially in light of the fact that many emerging economies engaged in exchange rate stabilization or opted for a fixed exchange rate regime. In particular, the main argument for exchange rate stabilization in this context relies on the fact that, when debt is denominated in foreign currency, exchange rate fluc-

[28] Here, I set $\rho_\pi = 1.5$, $\rho_Y = 0.5$, $\rho_R = 0.8$ and $\rho_L = 1.5$.

tuations affect the economy not only through trade, but also through balance sheet effects on borrowers.[29] In this context, an exchange rate appreciation that, on one side, reduces exports with negative effects on aggregate demand, relaxes credit conditions of indebted agents, thereby stimulating further borrowing. Studies in this field[30] find that the suboptimality of exchange rate stabilization as a monetary policy strategy is strictly connected with the degree of openness of the economy (Devereux, Lane and Xu (2006)) and the source of the shock (Faia (2010)).

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left[\left(\frac{\pi_t}{\pi}\right)^{\rho_\pi} \left(\frac{Y_t}{Y}\right)^{\rho_Y} \left(\frac{S_t}{S_{t-1}}\right)^{\rho_S} \right]^{(1-\rho_R)} \exp\left(\xi_{R,t}\right) \tag{46}$$

Here, the central bank reacts to devaluation pressures with a coefficient $\rho_S = 1.5$.[31]

Finally, I consider the case in which the central bank pursues a fixed exchange rate regime, obtained setting $\rho_S \to \infty$:

$$\Delta S_t = 0 \tag{47}$$

3.1 Domestic technology shock

A positive, one standard deviation technology shock (depicted in Figure 1) implies an unexpected improvement in domestic firms' productivity and an abatement of marginal costs. On one side, this leads to a decreased demand for labor which drives down employment and wages. The resulting decrease in labor income depresses households' consumption of both goods and housing services. On the other hand, the reduction in marginal costs leads firms to revise prices downwards, lowering home goods inflation. The decline in the price of domestic goods has two consequences on external balance. As domestic goods are cheaper, on one side export demand rises, and on the other hand a substitution effect kicks in, which shifts domestic purchases towards home produced goods, causing a decrease in imports. As a result, the trade balance shifts to surplus, and the resulting net inflow of currency puts appreciation pressures on the exchange rate. The reaction of the central bank depends on the chosen monetary policy strategy. If the central bank follows a fixed exchange rate regime, it keeps the nominal interest rate unaltered; if it follows a Taylor rule, it lowers the nominal interest rate in response to the decrease in inflation.

The overall macroeconomic adjustment and the behavior of financial variables in both the entrepreneurial and the homeowners' sector crucially depend on the monetary policy regime, mainly through its effects on aggregate demand and on borrowers' balance sheets. Concerning aggregate demand, the domestic technology shock exerts opposite effects on the demand of consumption goods and housing. While improved productivity leads to a decrease in firms' demand of labor and hence a drop in wages, dampening domestic consumption

[29] Krugman (1999), Aghion, Bacchetta, and Banerjee (2001).

[30] Cespedes (2000), Cespedes, Chang and Velasco (2004), Devereux, Lane and Xu (2006), Gertler, Gilchrist and Natalucci (2007), Batini and Levine (2008), Faia (2010).

[31] The coefficients on credit growth and exchange rate depreciation in the Taylor rules are set to the same value, equal to 1.5, to enhance comparability between responses across different specifications of the monetary policy rule.

(including housing services), external demand offsets the decline in consumption and boosts production, increasing firms' demand for capital. Hence, while demand for capital investment rises, demand for real estate investment contracts. Furthermore, it is important to notice that under a fixed exchange rate regime, the increase in export demand is much more pronounced, leading to a sharper expansion in production leading firms to limit their cutback in labor demand, which counteracts the fall in domestic consumption through a more muted decline in wage income. In any case, as capital demand surges, entrepreneurs engage in more projects, demand more credit and more unfinished capital goods, pushing up their price. While the raise in credit demand puts upwards pressures on entrepreneurial leverage, the increase in the price of capital partially offsets the worsening of entrepreneurs' balance sheet.

Figure 1: Responses to a domestic technology shock under different Taylor rules

Note: Responses to a one standard deviations technology shock, in percentage deviations from the steady state. The response of the domestic interest rate is in basis points

However, the monetary policy regime directly affects credit markets through balance sheet effects arising from exchange rate fluctuations. The exchange rate appreciation occurring when the central bank follows a taylor rule decreases the effective debt burden of entrepreneurs and homeowners. In the entrepreneurial case, this counteracts the increased demand for loans by lowering the (foreign currency) value of debt, pushing leverage below steady state values and lowering the external finance premium. In the fixed exchange rate case, the favorable exchange rate effect does not occur, hence the loan burden increases, and with it entrepreneurial leverage, dampening the overall acceleration and leading to a smoother increment in capital investment. Hence, the interaction between monetary policy regime and credit frictions affects entrepreneurs through two effects acting in opposite directions. A fixed exchange rate regime boosts exports but dampens the financial accelerator mechanism. An inflation targeting regime limits the effect of external demand, but strengthens the financial accelerator.

The balance sheet effect on homeowners operates in a similar fashion. Under flexible exchange rate, the loan burden decreases, thereby leading to lower leverage and external finance premium for homeowners and encouraging new real estate projects that ultimately reduce the rental price of houses. Hence, the positive balance sheet effect is able to offset the initial decrease in housing demand caused by the drop in overall consumption, leading to increased housing investment. In the case of a fixed exchange rate regime, a similar positive effect on real estate investment occurs, but for different reasons. Here, the increase in export demand leads domestic firms to reduce employment by less, implying a more muted effect on households' wage income and hence a smoother drop in consumption. Hence, demand for housing services decreases less markedly. Hence, loan demand from homeowners declines by less, as well as leverage and the external finance premium, leading to an increase in housing investment that is even higher than in the case of flexible exchange rate. Hence, also in the case of homeowners, the interaction between monetary policy regime and credit frictions exerts two effects acting in opposite directions. A fixed exchange rate regime impacts less on housing demand but dampens the financial accelerator mechanism. An inflation targeting regime implies a greater fall in rental housing demand, but strengthens the financial accelerator.

Hence, in the event of a technology shock, credit frictions at the entrepreneurial and homeowners' level can lead to different scenarios concerning the co-movement of financial variables in the two sectors depending on the monetary policy regime. Under a fixed exchange rate regime, albeit a positive co-movement of investment and asset prices in the two sectors, financial variables exhibit a negative correlation. While external finance premia and leverage increase in the entrepreneurial sector, they decrease in the real estate sector. On the contrary, under a flexible exchange rate regime as in the three taylor rules considered, financial variables co-move following a technology shock. While in both cases the shock exerts an opposite effect on the demand for goods (positive) and housing services (negative), in the flexible exchange rate regime, the balance sheet effect is able to offset the increase in leverage caused by the increased loan demand, while this effect does not operate in the case of pegged currency.

Finally, it is worth noting how the three considered Taylor rules do not imply large differences in the dynamic adjustment of real and financial variables. This is a direct consequence of the pattern of co-movement between financial variables in the entrepreneurial and homeowners' sectors. Following the shock, while entrepreneurs demand more credit, homeowners do not and, as a result, aggregate credit does not increase so much to warrant a stronger reaction of the central bank.

3.2 Capital inflow shock: entrepreneurs

Figure 2 depicts the responses to a positive increase in foreign lenders' perception of entrepreneurs' productivity under the three Taylor rules and fixed exchange rate scenarios. As foreign lenders become more optimist concerning the profitability of entrepreneurs, implying a smaller perceived probability of default, they loosen credit conditions. Hence, on impact, the external finance premium charged on domestic entrepreneurs decreases. As borrowing conditions improve and entrepreneurial net worth rises, leverage declines. Therefore, the abatement of the cost of external finance prompts entrepreneurs to engage in new investment projects, and to demand more credit. As capital investment increases and with it the supply of capital, production surges, and so does domestic price inflation. Furthermore, the positive inflow of capital exerts appreciating pressures on the domestic currency (the exchange rate decreases). After this impact effect, the macroeconomic adjustment crucially depends on the monetary policy rule followed by the domestic central bank. Under any Taylor rule, implying a flexible currency, the exchange rate appreciation leads to a decrease in the price of imports, which offsets the increase in domestic price inflation and leads to a decline in CPI inflation. Under an inflation targeting regime, as output rises above steady state values more than inflation contracts, the central bank raises the policy rate, thereby accommodating the exchange rate appreciation after the initial impact. While this doesn't improve the country's export performance, it has positive consequences on borrowers' balance sheet and it is the key channel of transmission of the shock to the real estate investment sector. In fact, as the exchange rate appreciates, borrowing conditions of homeowners improve. As the debt burden decreases, and with it the external finance premium and leverage, investment in the real estate sector grows. Hence, the positive effect of the initial shock to entrepreneurs' borrowing conditions positively spills over to homeowners through balance sheet effects, leading to a positive co-movement of financial variables across sectors. If the central bank engages in exchange rate targeting, it tries to offset the initial exchange rate appreciation and increases the nominal interest rate by a smaller amount. While this reduces the negative effect on exports and boosts aggregate demand, it somewhat dampens the positive balance sheet effect. However, even in this case the shock positively spills over to homeowners leading to an increase in housing investment and prices.

Figure 2: Responses to a one standard deviation capital inflow shock (entrepreneurs), under different Taylor rules

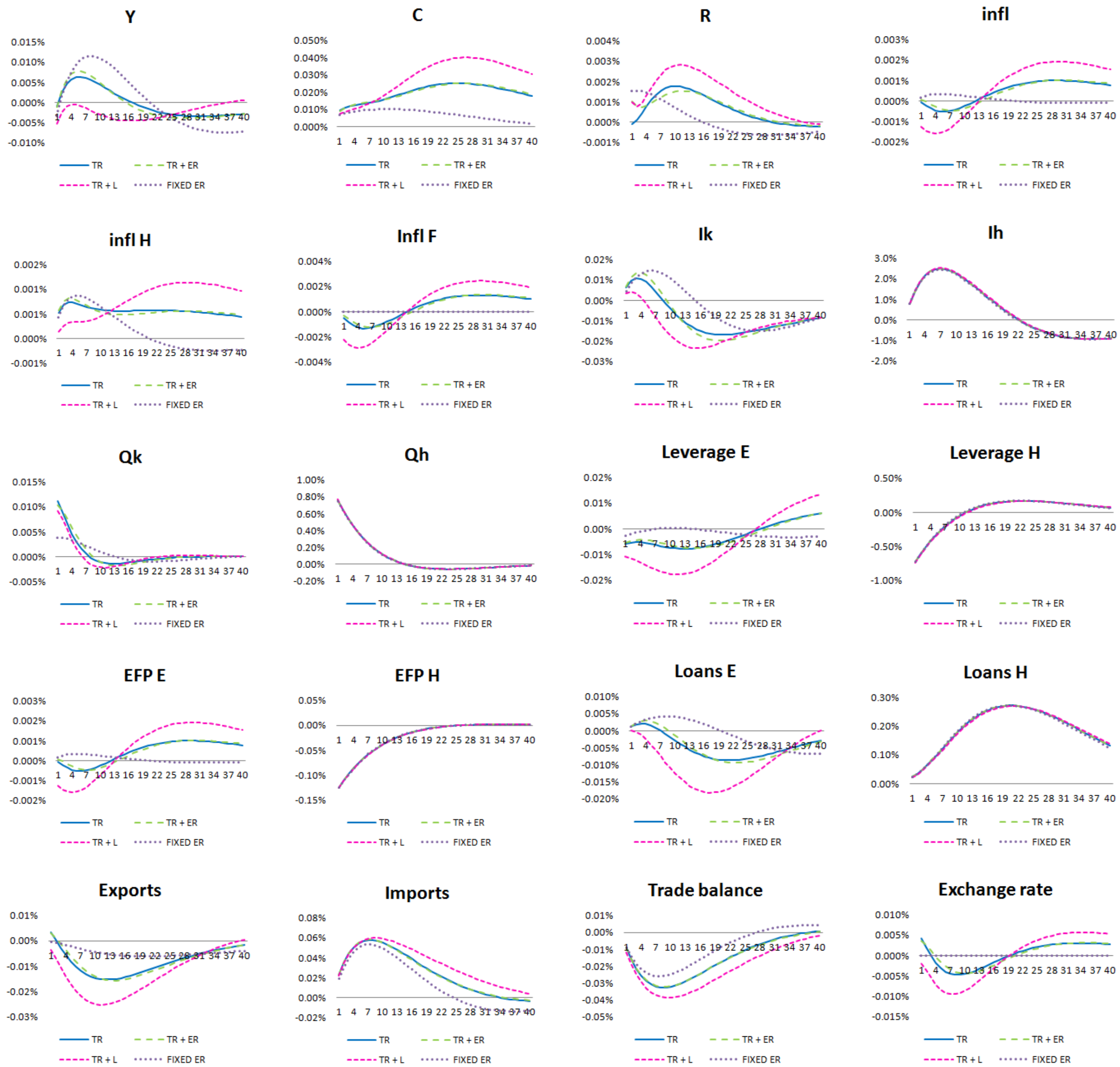
Note: Responses to a one standard deviations technology shock, in percentage deviations from the steady state. The response of the domestic interest rate is in basis points

In case the Taylor rule reacts to credit growth involves a stronger monetary policy contraction. As the capital inflow shock boosts entrepreneurial demand for credit and the balance sheet effect on homeowners' debt is not strong enough, overall credit growth rises. The increase in inflation and in agregate loans growth prompts the central bank to increase the interest rate. However, in case of foreign currency borrowing, the relevant opportunity cost of investment is the foreign interest rate, which is taken as given by the small open economy and stays constant. As the monetary policy tightening results in a stronger exchange rate appreciation, it strengthens borrowers' balance sheets, leading to a sharper decrease in leverage and a stronger improvement in balance sheet conditions. Furthermore, the stronger currency appreciation harms competitiveness, leading to a more pronounced fall in export demand which offsets the increase in output driven by the rise in domestic demand.

3.3 Capital inflow shock: homeowners

Figure 3 reveals that the effect of a capital inflow to the homeowners' sector implies a similar macroeconomic dynamics as a shock to credit to entrepreneurs. On impact, the shock reduces the external finance premium paid on real estate mortgages, thereby increasing the net worth of homeowners and reducing their leverage. As homeowners find it more convenient to invest in real estate projects, investment in the housing sector increases and house prices rise. The shock has a positive effect on overall consumption through three effects. On one side, the rise in housing prices boosts households' wealth, encouraging consumption. On the other hand, the increased supply of finished housing lowers their rental price, boosting demand. Finally, as the domestic currency appreciates, imports become cheaper and overall CPI inflation declines, stimulating purchases. The increased demand for domestic goods for consumption and housing investment purchases stimulates production, which leads to a raise in demand for capital goods. Hence, as returns to capital increase, the entrepreneurial sector is stimulated to undertake new investment projects. While this increases leverage and the external finance premium under a fixed exchange rate regime, if the central bank follows a Taylor rule, the appreciation of the domestic currency exerts a favorable balance sheet effect on entrepreneurial leverage. However, once again, when the central bank reacts to credit growth, the increase in the domestic interest rate is stronger, leading to a sharper decrease in exports which depress demand. In this case, production remains below steady state for quite some time after the shock. As a result, in spite of the decrease in entrepreneurial leverage, capital investment is negatively affected by the decline in capital demand by firms. On the contrary, when the central bank engages in exchange rate smoothing, it prevents a sharp fall in exports while still allowing for a positive balance sheet effect arising from the currency appreciation. Hence, the growth in domestic demand is able to compensate the fall in foreign demand, leading to an expansion of production.

Figure 3: Responses to a one standard deviation capital inflow (homeowners) shock, under different Taylor rules



Under the fixed exchange rate regime, the value of the currency is kept constant. This implies that the consumer price index does not benefit from the effect of the exchange rate appreciation, as the price of foreign goods is not affected. This, combined with the increase in domestic prices due to demand pressures implies that overall consumer price inflation rises. Furthermore, as the exchange rate does not appreciate, exports are only affected to the extent that the price of domestic goods rises. However, the fall in exports is negligible, and does not significantly counteract the increase in domestic demand, leading to higher production and hence higher capital investment. Furthermore, as balance sheet effects of exchange rate fluctuations are absent in this setting, entrepreneurial borrowing conditions are worse than in the case of flexible currency. Therefore, after an initial decrease in leverage and premium due to the increase in asset prices, as capital investment peaks leverage rises, albeit to a small extent. Hence, once again the exchange rate regime determines the extent of co-movement between sectorial borrowing conditions in the small dollarized economy. While a monetary regime implying a flexible exchange rate leads to positive co-movement, when the currency is pegged, the correlation weakens and slightly reverts direction.

4 Optimal monetary policy

In this section, I compute the optimal unrestricted optimal rule for the presented small open economy subject to productivity and capital inflow shocks.

I assume the central bank's objective is represented by a quadratic loss function, which the monetary authority attempts to minimize. I consider different scenarios according to the objectives of the central bank. In the first setting, the central bank is only concerned about stabilizing the real economy, and attempts to avoid excessive fluctuations in output and inflation. Furthermore, the central bank considers desirable to limit the volatility of the domestic interest rate. Hence, the loss function is defined as follows[32]:

$$L^{MS} = E_t \left[\hat{\pi}_t^2 + \lambda_y \hat{Y}_t^2 + \lambda_r \hat{R}_t^2 \right] \tag{48}$$

Where variables with a hat denote log deviations from steady state values. Furthermore, λ_y represents the relative weight the central bank places on output stability relative to inflation stability, and λ_r denotes the relative weight on interest rate variability.

In the second scenario, I consider a central bank also concerned with financial stability. In this setting, I specify the central bank's loss function as being a positive function of the volatility of aggregate credit growth in addition to output, inflation and interest rate volatility. In this case, the loss function is defined as:

$$L^{FS} = E_t \left[\hat{\pi}_t^2 + \lambda_y \hat{Y}_t^2 + \lambda_r \hat{R}_t^2 + \lambda_L (L_t/L_{t-1})^2 \right] \tag{49}$$

In particular, I consider two specifications of the loss function with financial stability objective, according to the central banks' preferences. In the first case, which I denote L_1^{FS}, the monetary authority of the small open economy considers monetary stability a priority, which translates in a lower weight on credit growth. Specifically, I set $\lambda_L = \lambda_y = 0.1$. The second specification corresponds to the case in which the central bank considers the macroeconomic stability and the financial stability objectives equally important. I denote the loss function corresponding with this case with L_2^{FS}, which is characterized by a weight on credit growth volatility equal to 1.

In what follows, I assume the economy is affected by the three considered shocks (i.e. domestic technology, and foreign lenders' perception of domestic entrepreneurs' and home-owners' productivity) at the same time. The calibration of the shock is similar to that used for the impulse response functions analysis, i.e. one standard deviation technology shock and

[32] In particular, I set $\lambda_y = 0,1$, $\lambda_r = 0.05$.

1% positive perception shocks. The optimized Taylor rule coefficients and the corresponding value of the loss functions are presented in Table 1.

Table 1: Optimized Taylor rule

	φ_r	φ_π	φ_y	φ_L	φ_S	$Loss$
Loss MS	0.7620	1.3659	0.7447	0.099	0.088	0.4526
Loss FS_1	0.7752	1.3615	0.7592	0.099	0.4826	0.4550
Loss FS_2	0.7818	1.373	0.7273	0.0997	0.487	0.4681

In all cases the coefficient on lagged interest rate reveal a quite high optimal inertia of the monetary policy rule. Given that, in the model, the relevant risk free rate for lenders is the foreign one, this result might be puzzling. However, in a small open economy, changes in the nominal interest rate are mirrored by exchange rate fluctuations, which impact the balance sheet of borrowers with foreign currency debt, leading to more volatility in financial variables, including credit growth. Therefore, even when the central bank is not concerned about financial stability, it considers desirable to smooth movements in the monetary policy rate. The optimized coefficients on inflation and output are broadly similar across loss function specifications. While going from L^{MS} to L_1^{FS} the optimal weight on inflation increases, that on output decreases, but these differences are of negligible importance. The most important result emerging from Table 1 concerns the optimized coefficients on aggregate credit growth and exchange rate stabilization. In the case the monetary authority is not concerned with financial stability, both optimized coefficients are close to zero. In this case, reacting to inflation and output deviations is optimal. On the contrary, when financial stability considerations are included in the central bank's objective, the optimized coefficient on exchange rate depreciation is positive and equal to 0.48, while the optimized coefficient on credit growth is still close to zero. These results can be better understood referring to the impulse-response functions analysis presented in the previous section. In Figure 2, I presented the responses to a 1% shock to foreign lenders' perceptions of entrepreneurial productivity. Comparing the impulse responses for the Taylor rule with exchange rate stabilization and the Taylor rule with credit growth reveals the reason why reacting to credit growth is suboptimal. The perception shock leads foreign lenders to lower the price of credit, which encourages borrowing and hence credit growth. The central bank observes the increase in loans and tightens the domestic interest rate quite sharply. Hence the central bank reacts by increasing the policy rate by a larger amount than under a standard Taylor rule with exchange rate smoothing.[33] However, in case of foreign currency borrowing, the relevant opportunity cost of investment is the foreign interest rate, which is taken as given by the small open economy and stays constant. As the monetary policy tightening results in a stronger exchange rate appreciation, it strengthens borrowers' balance sheets, leading

[33] Note that the coefficients on exchange rate depreciation and credit growth in the simple Taylor rules are equal, so as to enhance comparability between the two monetary strategies.

to a sharper decrease in leverage and a stronger improvement in balance sheet conditions. Furthermore, the stronger currency appreciation harms competitiveness, leading to a more pronounced fall in export demand which offsets the increase in output driven by the rise in domestic demand. As a result, in pursuing such a monetary policy strategy, the domestic central bank obtains results that conflict with its objectives. First, it does not succeed in smoothing credit developments as the economy is dollarized: on the contrary, it strengthens borrowers' balance sheets. This encourages the build-up of financial vulnerabilities of the kind many Eastern European economies were exposed to before the crisis: overexpansion of foreign currency debt and increase in leverage. Second, it offsets the positive effect of export demand on output, counteracting the expansionary effect of the capital inflow shock. Hence, the central bank can achieve a better result in terms of macroeconomic and financial stabilization if it includes an exchange rate term in the Taylor rule, simultaneously smoothing the volatility of credit aggregates and containing the negative effects of the domestic currency appreciation on exports.

One natural question that arises is whether these results are driven by the relatively small magnitude of the capital inflow shocks compared to the technology shock. Would the monetary authority of an economy hit by large capital inflow shock find it optimal to react to credit aggregates? In Table 2, I present optimized Taylor rule coefficients for different calibrations of the perception shocks.

Table 2: Optimal Taylor rule for different magnitudes of the perception shocks

	φ_r	φ_π	φ_y	φ_L	φ_S	Loss
$\sigma_{ve} = \sigma_{vh} = 0.01$						
Loss MS	0.7620	1.3659	0.7447	0.099	0.088	0.4526
Loss FS_1	0.7752	1.3615	0.7592	0.099	0.4826	0.4550
Loss FS_2	0.7818	1.373	0.7273	0.0997	0.487	0.4681
$\sigma_{ve} = \sigma_{vh} = 0.1$						
Loss MS	0.7619	1.365	0.744	0.100	0.088	0.4528
Loss FS_1	0.775	1.3615	0.7595	0.099	0.481	0.4552
Loss FS_2	0.7816	1.373	0.728	0.100	0.487	0.4613
$\sigma_{ve} = \sigma_{vh} = 0.5$						
Loss MS	0.7583	1.3655	0.7492	0.1054	0.087	0.4562
Loss FS_1	0.7707	1.360	0.766	0.106	0.485	0.4612
Loss FS_2	0.7751	1.368	0.749	0.1149	0.4868	0.4887

As it can be noticed, optimized Taylor rule coefficients do not change much across specifications and are similar to the baseline. Increasing the magnitude of the perception shocks results in slightly higher reaction coefficients on all variables in the Taylor rule. Furthermore, even for 10% perception shocks, the optimal reaction coefficient to credit growth is small, albeit it slightly increases. However, even confronted with capital inflow shocks of greater magnitudes, a strong reaction of the central bank to credit developments is not optimal. Hence, a central bank equipped with only one instrument cannot adequately manage capital inflow surges, as a monetary tightening results in a strengthening of borrowers' balance sheets through exchange rate effects and an even higher demand for foreign loans. This warrants the establishment of macroprudential instruments, especially designed to counteract the surge in financial imbalances. The analysis of such issues requires expanding the present model to include a financial sector channeling foreign loans to domestic borrowers, which will be a subject of future work.

5 Conclusion

In this paper, I analyze the interplay between financial frictions at the household and firm level, liability dollarization and monetary policy in a small open economy subject to productivity and capital inflow shocks, motivated by the pre-crisis experience of many Eastern European countries where large inflows of capital directed to the financing of investment and mortgage loans resulted in the build-up of vulnerabilities in the financial sector. In particular, I focus on the interaction of firm and household leverage in the transmission of shocks to domestic technology and capital inflows, under three specifications of the monetary policy rule that have been widely considered in the literature for emerging economies (i.e. inflation targeting, exchange rate targeting and fixed exchange rate) and a Taylor rule reacting to credit growth. Furthermore, I compute the optimal unrestricted monetary policy rule under two specifications of the central banks' objectives, namely macroeconomic stability and macroeconomic plus financial stability.

I find that, first, regardless of the monetary authorities' preferences, the optimized coefficient on lagged interest rate reveal a quite high optimal inertia of the monetary policy rule. Given that, in the model, the relevant risk free rate for lenders is the foreign one, this result might be puzzling. However, in a small open economy, changes in the nominal interest rate are mirrored by exchange rate fluctuations, which impact the balance sheet of borrowers with foreign currency debt, leading to more volatility in financial variables, including credit growth. Therefore, even when the central bank is not concerned about financial stability, it considers desirable to smooth movements in the monetary policy rate.

A second result concerns the optimized coefficients on exchange rate depreciation and credit growth. In the case the monetary authority is not concerned with financial stability, reacting only to inflation and output deviations is optimal. When financial stability considerations are included in the central bank's objective, the monetary authority finds it optimal to react to exchange rate depreciation with a positive coefficient, but not to credit market indicators. In fact, the optimized coefficient on credit growth is close to zero, even when the central bank considers the objectives of macroeconomic and financial stability as equally desirable. Following a shock that increases the demand for foreign loans (e.g. the perception shocks), a central bank monitoring the credit market tightens the domestic interest rate quite sharply. However, in case of foreign currency borrowing, the relevant opportunity cost of investment is the foreign interest rate, which is taken as given by the small open economy and stays constant. As the monetary policy tightening results in a stronger exchange rate appreciation, it strengthens borrowers' balance sheets, leading to a sharper decrease in leverage and a stronger improvement in balance sheet conditions. Furthermore, the stronger currency appreciation harms competitiveness, leading to a more pronounced fall in export demand which offsets the increase in output driven by the rise in domestic demand. As a result, in pursuing such a monetary policy strategy, the domestic central bank obtains results that conflict with its objectives. First, it does not succeed in smoothing credit developments as the economy is dollarized: on the contrary, it strengthens borrowers' balance sheets. This encourages the build-up of financial vulnerabilities of the kind many Eastern European economies were exposed to before the crisis: overexpansion of foreign currency debt and increase in leverage. Second, it offsets the positive effect of export demand on output, counteracting the expansionary effect of the capital inflow shock. Hence, the central bank can achieve a better result in terms of macroeconomic and financial stabilization if it includes an exchange rate term in the Taylor rule, simultaneously smoothing the volatility of credit aggregates and containing the negative effects of the domestic currency appreciation on exports. These results are robust to the relative magnitude of the capital inflow relative to the technology shock: even when faced when faced with large capital inflow shocks, reacting to credit growth is not optimal. This suggests that a central bank equipped with only one instrument cannot adequately manage capital inflow surges, as a monetary tightening results in a strengthening of borrowers' balance sheets through exchange rate effects and an even higher demand for foreign loans.

Finally, this framework allows to draw interesting insights on the interaction of firm and household leverage in an open economy setting, on the transmission of shocks, and on the role of the monetary policy regime in shaping it. In the case of both technology and capital inflow shocks, the extent of co-movement of financial variables pertaining to entrepreneurs and homeowners crucially depends on whether the exchange rate is flexible or pegged. Specifically, under a fixed exchange rate regime, a negative correlation arises, i.e. stronger balance sheet conditions of entrepreneurs lead to weakened or virtually unchanged balance sheet conditions for homeowners. Under a fixed exchange rate regime, a positive correlation of financial variables of the two types of borrowers arises, mainly operating through the balance sheet effect of exchange rate fluctuations. More specifically, a positive domestic productivity shock exerts opposite effects on capital and housing investment: while housing demand decreases (through a general decline in consumption demand due to lower wage income), capital demand increases because of increased production and external demand. Ceteris paribus, this leads to a fall in homeowners' leverage and a surge in entrepreneurial leverage. While this happens in the case of fixed exchange rate, under a Taylor rule the shock leads to a domestic currency appreciation, which strengthens the balance sheet of borrowers and offsets the opposite effect on investment demand in the two sectors.

In case of capital inflow shocks, similar conclusions can be drawn concerning the interaction between the monetary policy regime and the dynamics of financial variables across sectors. Furthermore, the analysis reveals that sectoral capital inflow shocks spill over to the other sector mainly through their effect on domestic production through increased demand of domestic goods used for investment purposes, and through balance sheet effects of currency appreciation.

The presented analysis can be extended in numerous directions, which will be explored in future research. First and most important, given the results of the optimal monetary policy analysis, a natural avenue for extending the present analysis is to consider the role of macroprudential policies in dealing with foreign capital inflows at the household and entrepreneurial level. To offer a meaningful modeling of macroprudential policy, a financial sector has to be added, which channels foreign funds to investors in the real estate and the production sector. Furthermore, in the presented model, I assumed that all debt is denominated in foreign currency, which is of course an extreme case. Current work is being done in these directions, and on the analysis of the interaction between monetary and macorprudential policy under different degrees of liability dollarization and economic openness. Further research could then be devoted to enriching the international dynamics, examining the international co-movement of asset (including real estate) prices, their consequences on banks' balance sheets and international policy coordination. Extending the model to a two country setting featuring banks engaging in cross-border activities would allow to study issues related to the international transmission of real estate price shocks as well as the effect of policies aimed at regulating the banking sector. Furthermore, this setting would allow to study the interplay between monetary and prudential policies both within a country and from an international cooperation perspective.

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