POLÍTICA Y ESTABILIDAD MONETARIA EN EL PERÚ

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6

Cyclical effects of credit conditions in a small open economy: The case of Peru

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In this chapter we extend a new Keynesian open economy model to include a housing market and credit constraints in line with Iacoviello (2005). This setup allows us to study the effect of changes in credit conditions, represented by the share of capital that agents can use as collateral for loans, in the business cycle. In our setup, the easing of credit conditions generates a downward pressure on inflation, higher housing prices, a GDP expansion and a real depreciation. Additionally, we analyze how the presence of credit constrained firms affects optimal monetary policy rules. We find that in the presence of exogenous shocks to credit conditions and pecuniary externalities, the central bank obtains relatively small gains by reacting to fluctuations in asset prices. In contrast, the use of a different instrument that reacts to changes in the financial conditions can provide significant gains in stabilizing the economy. These results support the argument for using a different instrument for macroprudential purposes instead of the central bank policy rate.

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6.1 Introduction

The recent financial crisis made manifest the importance of imbalances in housing markets and housing credit booms for the business cycle (see Kaminsky and Reinhart, 1998; Reinhart and Rogoff, 2009; Borio and Drehmann, 2009). One of the most accepted narratives links housing price dynamics to innovations in credit markets. For the United States, Korajczyk and Levy (2003) find evidence that book and market target leverage are procyclical for constrained firms. Landvoigt et al. (2012), using a detailed database of the housing market in California, find that the lower quality segment of the market experienced the highest capital gains during the 2000-2005 housing boom, a result explained by changes in the conditions faced by credit constrained agents. For the case of Peru, Orrego (2014) finds a strong and significant long-term relationship between the price of housing and mortgage credit over GDP.

Understanding the cyclical effects of credit conditions in a small open economy is key for monetary and macroprudential policy design. For this purpose, we introduce borrowing constraints, in line with Iacoviello (2005), into a small open economy model with nominal rigidities, in the spirit of Obstfeld and Rogoff (1995) and Galí and Monacelli (2005). As in Kiyotaki and Moore (1997), the introduction of such constraints is key to obtaining an amplification (procyclicality) effect in the housing markets that spills over into the rest of the economy. Thus, we are able to study how these credit constraints modify the central bank policy reaction. Additionally, we introduce a macroprudential instrument, in the form of Loan-to-Value (LTV henceforth) ratios, to gauge its effectiveness as a tool for macroeconomic stabilization.

Our goal is to get a better understanding of how monetary and macroprudential policies interact, hence we consider an economy with three different sets of policy setups: (i) a standard case where the central bank does not react to the price of assets, (ii) a central bank that reacts to asset prices, and (iii) a central bank that also uses a LTV rule that reacts to financial conditions. Our results support the argument for using a different instrument for macroprudential purposes than the central bank policy rate.

There is a growing literature that studies the interactions between monetary and macroprudential policies within a DSGE framework. In relation to other types of macroprudential regulation, Gerali et al. (2010) and Angelini et al. (2011) show how the introduction of capital requirements affects lending rates and weakens the monetary policy transmission channel. Agenor and Pereira da Silva (2009) focus on the trade-off occasioned by the impact on financial costs of banks in the face of changes to the equity-debt ratios. Benigno et al. (2013) find a “leaning-against-the-wind” motive in monetary policy that considers the value of a country’s collateral in foreign currency.

The rest of the chapter is organized as follows. Section 6.2 presents the model, Section 6.4 discusses the results under different types of intervention, and Section 6.3 concludes. Details on the derivations of the model, steady state computations and the log-linear form used in the simulations are available upon request.

6.2 The model

The model follows the contributions of Obstfeld and Rogoff (1995), Galí and Monacelli (2005), Christiano et al. (2005), among others, by depicting a small open economy with nominal frictions. Financial frictions are introduced following Iacoviello (2005). Two different types of agents make up the economy. The first type are unconstrained and relatively patient households, variables we denote by an H superscript. These agents will have access to international credit markets. The second type are entrepreneurs who produce wholesale goods and consume. They are relatively impatient and face collateral constraints in the spirit of Kiyotaki and Moore (1997). Enterpreneurs can only access the domestic credit market. We can rationalize this as a sector of bankers, who intermediate between the external investors and domestic firms.[1] The economy includes a retail sector owned by the patient households and a central bank, which acts also as the macroprudential regulator, setting the policy interest rate and establishing macroprudential rules.

6.2.1 Households

Each household chooses consumption of goods and housing services and supplies labor to entrepreneurs to maximize their lifetime utility function:

$$\mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left(\log c_t^H + j \log h_t^H - \frac{(L_t^H)^\eta}{\eta} \right) \right\} , \tag{6.1}$$

where c^H and L^H represent, respectively, the consumption of goods and labor supply of the patient households; h^H stands for the holdings of housing by the unconstrained

[1] Even though the situation seems to be rapidly changing, in developing countries there are few private sector firms that can obtain funds directly from abroad, or they do so under more restrictive conditions. See Rodrigues Bastos et al. (2015) for a study of corporate financing trends in Latin America. Note also that we do not consider credit constrained households. We leave this extension for future research.

agents and j controls the relative weight of this component in the utility function; $\mathbb{E}_t$ is the conditional expectation set at period t; and $0 < \beta < 1$ is the intertemporal discount factor.

The consumption basket of final goods is a composite of domestic and foreign goods, aggregated using the following consumption index:

$$c_t^H \equiv \left[\left(\gamma^H\right)^{1/\varepsilon_H} \left(c_t^{H,H}\right)^{\frac{\varepsilon_H - 1}{\varepsilon_H}} + \left(1-\gamma^H\right)^{1/\varepsilon_H} \left(c_t^{H,M}\right)^{\frac{\varepsilon_H - 1}{\varepsilon_H}} \right]^{\frac{\varepsilon_H}{\varepsilon_H - 1}}, \tag{6.2}$$

where ε_H is the elasticity of substitution between domestic ($c_t^{H,H}$) and foreign goods ($c_t^{H,M}$), and γ^H is the share of domestically produced goods in the consumption basket of the domestic economy. In turn, $c_t^{H,H}$ and $c_t^{H,M}$ are themselves indices of consumption across the continua of differentiated goods produced in the home country and those imported from abroad, respectively:

$$c_t^{H,H} \equiv \left[\left(\frac{1}{n}\right)^{\frac{1}{\varepsilon}} \int_0^n c_t^{H,H}(z)^{\frac{\varepsilon-1}{\varepsilon}} dz \right]^{\frac{\varepsilon}{\varepsilon-1}}, \tag{6.3}$$

$$c_t^{H,M} \equiv \left[\left(\frac{1}{1-n}\right)^{\frac{1}{\varepsilon}} \int_n^1 c_t^{H,M}(z)^{\frac{\varepsilon-1}{\varepsilon}} dz \right]^{\frac{\varepsilon}{\varepsilon-1}}, \tag{6.4}$$

where $\varepsilon > 1$ is the elasticity of substitution across goods produced within the home economy, denoted by $c_t^{H,H}(z)$, and within the foreign economy, $c_t^{H,M}(z)$. The household's optimal demands for home and foreign consumption are given by:

$$c_t^{H,H}(z) = \frac{1}{n}\gamma^H \left(\frac{P_t^H(z)}{P_t^H}\right)^{-\varepsilon} \left(\frac{P_t^H}{P_t}\right)^{-\varepsilon_H} c_t^H, \tag{6.5}$$

$$c_t^{H,M}(z) = \frac{1}{1-n}\left(1-\gamma^H\right) \left(\frac{P_t^M(z)}{P_t^F}\right)^{-\varepsilon} \left(\frac{P_t^M}{P_t}\right)^{-\varepsilon_H} c_t^H. \tag{6.6}$$

The demand functions are obtained by minimizing the total expenditure in consumption $P_t c^H$, where P_t is the consumer price index. Note that the consumption of each type of goods increases at the consumption level, and decreases in terms of their corresponding relative prices. Also, it is easy to show that the consumer price index, under these preference assumptions, is given by:

$$P_t \equiv \left[\gamma^H \left(P_t^H\right)^{1-\varepsilon_H} + (1-\gamma^H)\left(P_t^M\right)^{1-\varepsilon_H} \right]^{\frac{1}{1-\varepsilon_H}}, \tag{6.7}$$

where P_t^H and P_t^M denote the price level of the home produced and imported goods, respectively. Each of these price indexes is defined as follows:

$$P_t^H \equiv \left[\frac{1}{n}\int_0^n P_t^H(z)^{1-\varepsilon}dz\right]^{\frac{1}{1-\varepsilon}} \quad \text{and} \quad P_t^M \equiv \left[\frac{1}{1-n}\int_n^1 P_t^M(z)^{1-\varepsilon}dz\right]^{\frac{1}{1-\varepsilon}} \quad , \qquad (6.8)$$

where $P_t^H(z)$ and $P_t^M(z)$ represent the prices expressed in domestic currency of the variety z of home and imported goods, respectively.

We assume that unconstrained households can save and lend in both currencies. The flow of funds is given by:

$$P_t c^H + Q_t \Delta h_t^H + (1+i_{t-1})B_{t-1}^H + (1+i_{t-1}^*)S_t B_{t-1}^* = B_t^H + S_t B_t^* + W_t^H L_t^H + F_t \, , \qquad (6.9)$$

where W_t^H is the nominal wage, Q_t is the price of housing, i_t the domestic nominal interest rate, S_t represents the nominal exchange rate, and F_t are nominal profits distributed from firms in the home economy to the households. Following Schmitt-Grohé and Uribe (2003), in order to close the model we propose a debt elastic interest rate for foreign debt:

$$i_t^* = i_t^{**} + \mathcal{G}(B_t^*) \, , \qquad (6.10)$$

where i_t^{**} is the foreign interest rate and $\mathcal{G}'(\cdot) > 0$, $\mathcal{G}''(\cdot) > 0$.

The conditions that characterize the optimal allocation of unconstrained households are given by the following set of equations:

$$\frac{1}{c_t^H} = \beta \mathbb{E}_t \left\{ \frac{1+i_t}{c_{t+1}^H}\frac{P_t}{P_{t+1}} \right\} \, , \qquad (6.11)$$

$$\frac{W_t^H}{P_t} = c_t^H (L_t^H)^{\eta - 1} \, , \qquad (6.12)$$

$$\frac{Q_t}{c_t^H} = \frac{j}{h_t^H} + \beta \mathbb{E}_t \left\{ \frac{Q_{t+1}}{c_{t+1}^H}\frac{P_t}{P_{t+1}} \right\} \, , \qquad (6.13)$$

$$\frac{1}{c_t^H} = \beta \mathbb{E}_t \left\{ \frac{1 + i_t^{**} + \mathcal{G}'(B_t^*)}{c_{t+1}^H}\frac{S_{t+1}}{S_t}\frac{P_t}{P_{t+1}} \right\} \, . \qquad (6.14)$$

Equation (6.11) corresponds to the Euler equation that determines the optimal path of consumption for unconstrained households in the home economy, by equalizing the marginal benefits of savings to the corresponding marginal costs. Supply of labor is characterized by equation (6.12), where W_t^H/P_t denotes real wages. In a competitive labor market, the marginal rate of substitution equals the real wage. Domestic agents also extract utility from housing services. The equilibrium condition between goods and housing consumption is given by (6.13). Finally, we get a condition on the holding of foreign assets (6.14), which combined with (6.11) yields a modified uncovered interest rate parity condition:

$$1 + i_t = \mathbb{E}_t \left\{ [1 + i_t^{**} + \mathcal{G}'(B_t^*)] \frac{S_{t+1}}{S_t} \right\} . \tag{6.15}$$

6.2.2 Entrepreneurs

Entrepreneurs derive utility from goods consumption (c^E) and demand labor from households. They produce wholesale goods which are sold in a perfectly competitive market to retail firms. Each entrepreneur maximizes:

$$\mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \varrho^t \log(c_t^E) \right\} , \tag{6.16}$$

where the discount factor satisfies $0 \leq \varrho < \beta$, making entrepreneurs relatively more impatient than households. This assumption guarantees a binding credit constraint in the steady state.[2] Their consumption basket composition is similar to that of the unconstrained household. Their flow of funds is given by:

$$P_t MC_t Y_t^{int}(z) + B_t^E = P_t c_t^E + Q_t \Delta h_t^E + (1 + i_{t-1}) B_{t-1}^E + W_t^E L_t^E , \tag{6.17}$$

where MC_t stands for the real marginal cost of production, h^E is the housing capital in possession of entrepreneurs which is used as a production factor and serves as collateral for credit, and W^E and L^E are both the nominal wage paid to workers and the labor demand. Entrepreneurs will demand credit from households, which we denote by B^E. The technology for the intermediate good Y_t^{int} involves the use of both housing and labor:

$$Y_t^{int}(z) = A_t (h_{t-1}^E)^{\nu} (L_t(z))^{1-\nu} . \tag{6.18}$$

[2] This is a simplifying assumption. We acknowledge that a more precise approach dictates the use of a global solution method with an explicit occasionally binding constraint to capture the precautionary motive of the constrained agents. We leave this extension for future research.

Firms take as given the real wage W_t/P_t to households, and choose the demand of labor by minimizing costs given the technology. It is simple to verify that the demand for labor is given by:

$$L_t^E(z) = (1-\nu)\frac{MC_t(z)}{W_t^E/P_t}Y_t^{int}(z)\,. \tag{6.19}$$

As mentioned, producers of intermediate goods face a collateral constraint as in Kiyotaki and Moore (1997). Entrepreneurs are limited to borrow up to an exogenous time-varying share of the expected nominal value of their property, ζ_t. Thus:

$$B_t^E \leq \mathbb{E}_t\left\{\zeta_t Q_{t+1}h_t^E/(1+i_t)\right\}\,, \tag{6.20}$$

which yields a constrained optimization problem. We consider ζ_t to be stochastic, reflecting the changes observed in credit conditions over the business cycle. Thus, the economy is hit by shocks to financial conditions, as in Gerali et al. (2010).

The remaining first order conditions of the entrepreneur's problem are:

$$\frac{1}{P_t c_t^E} = \mathbb{E}_t\left\{\frac{\varrho(1+i_t)}{P_{t+1}c_{t+1}^E}\right\} + \lambda_t(1+i_t)\,, \tag{6.21}$$

$$\frac{Q_t}{P_t c_t^E} = \mathbb{E}_t\left\{\frac{\varrho}{P_{t+1}c_{t+1}^E}\left(\frac{\nu P_{t+1}Y_{t+1}}{X_{t+1}h_t^E} + Q_{t+1}\right) + \lambda_t\zeta_t\frac{1}{P_t}Q_{t+1}\right\}\,, \tag{6.22}$$

where λ_t stands for the Lagrange multiplier of the borrowing constraint.

6.2.3 Final goods producers

Producers of final goods acquire intermediate goods from entrepreneurs and transform them into differentiated retail goods. The marginal costs of these firms will be equal to the price of the intermediate goods. The market in which these firms operate exhibits monopolistic competition, where each firm faces a downward sloping demand function. We assume nominal rigidities in the form of an exogenous probability to change prices in each period, following Calvo (1983). Firms will choose prices, whenever they can adjust them, to maximize the discounted sum of profits given by:

$$\mathbb{E}_t\left\{\sum_{k=0}^{\infty}\left(\theta^H\right)^k\Lambda_{t+k}\left(\frac{P_t^{H,o}(z)}{P_{t+k}^H} - MC_{t+k}^H\right)Y_{t,t+k}^H(z)\right\}\,, \tag{6.23}$$

where $\Lambda_{t+k} = \beta^k U_{c^H,t+k}/U_{c^H,t}$ is the stochastic discount factor of the patient household, $MC^H_{t+k} = MC_{t+k}P_{t+k}/P^H_{t+k}$ is the real marginal cost expressed in units of goods produced domestically, and

$$Y^H_{t,t+k}(z) = \left[\frac{P^{H,o}_t(z)}{P^H_{t+k}}\right]^{-\varepsilon} Y^H_{t+k}\,.$$

is the quantity of good z demanded in $t+k$ when the price has been fixed in period t. Each firm z chooses $P^{H,o}_t(z)$ to maximize (6.23), from the first order condition:

$$\mathbb{E}_t\left\{\sum_{k=0}^{\infty}\left(\theta^H\right)^k \Lambda_{t+k}\left(\frac{P^{H,o}_t(z)}{P^H_t}F^H_{t,t+k} - \mu MC^H_{t+k}\right)(F^H_{t,t+k})^{-\varepsilon}Y^H_{t+k}\right\} = 0\,, \tag{6.24}$$

where $\mu \equiv \varepsilon/(\varepsilon-1)$ and $F^H_{t,t+k} \equiv P^H_t/P^H_{t+k}$.

The rate of inflation for domestically produced goods, π^H_t, satisfies:

$$\theta^H(1+\pi^H_t)^{\varepsilon-1} = 1-(1-\theta^H)\left(\frac{V^N_t}{V^D_t}\right)^{1-\varepsilon}\,. \tag{6.25}$$

Here V^D_t and V^N_t are recursive auxiliary variables constructed following Benigno and Woodford (2005). A similar approach is followed for the construction of the Phillips curves for imported and exported goods:

$$\theta^X(1+\pi^X_t)^{\varepsilon-1} = 1-(1-\theta^X)\left(\frac{V^{N,X}_t}{V^{D,X}_t}\right)^{1-\varepsilon}\,, \tag{6.26}$$

$$\theta^M(1+\pi^M_t)^{\varepsilon-1} = 1-(1-\theta^M)\left(\frac{V^{N,M}_t}{V^{D,M}_t}\right)^{1-\varepsilon}\,, \tag{6.27}$$

where θ^X and θ^M determine the degree of price stickiness in the exported and imported goods retail sectors, respectively.

The real marginal costs of the goods produced for exports is given by:

$$MC^X_t = \frac{P_t MC_t}{S_t P^X_t} = \frac{MC_t}{RER_t\left(P^X_t/P^*_t\right)}\,, \tag{6.28}$$

which depends inversely on the real exchange rate ($RER_t = S_tP^*_t/P_t$) and the relative price of exports to external prices (P^X_t/P^*_t). Similarly, the real marginal cost for the importers is given by the cost of purchasing the goods abroad ($S_t P_t^*$) relative to the price of imports (P_t^M):

$$MC_t^M = \frac{S_t P_t^*}{P_t^M} . \tag{6.29}$$

6.2.4 Foreign economy

The foreign economy is comprised of unconstrained households. Their consumption basket is similar to that of the domestic economy, and is given by:

$$C_t^* \equiv \left[\left(\gamma^F\right)^{1/\varepsilon_F} \left(C_t^X\right)^{\frac{\varepsilon_F - 1}{\varepsilon_F}} + \left(1 - \gamma^F\right)^{1/\varepsilon_F} \left(C_t^F\right)^{\frac{\varepsilon_F - 1}{\varepsilon_F}} \right]^{\frac{\varepsilon_F}{\varepsilon_F - 1}} , \tag{6.30}$$

where ε_F is the elasticity of substitution between domestic (C_t^X) and foreign goods (C_t^F), respectively, and γ^F is the share of domestically produced goods in the consumption basket of the foreign economy. Also, C_t^X and C_t^F are indices of consumption across the contina of differentiated goods produced, similar to C_t^H and C_t^M defined in equations (6.4). The demands for each type of good are given by:

$$C_t^X(z) = \frac{1}{n}\gamma^F \left(\frac{P_t^X(z)}{P_t^X}\right)^{-\varepsilon} \left(\frac{P_t^X}{P_t^*}\right)^{-\varepsilon_H} C_t^* , \tag{6.31}$$

$$C_t^F(z) = \frac{1}{1-n}\left(1 - \gamma^F\right) \left(\frac{P_t^F(z)}{P_t^F}\right)^{-\varepsilon} \left(\frac{P_t^F}{P_t^*}\right)^{-\varepsilon_H} C_t^* , \tag{6.32}$$

where P_t^X and P_t^F correspond to the price indices of exports and the goods produced abroad, respectively, and P_t^* is the consumer price index of the foreign economy:

$$P_t^* \equiv \left[\gamma^F \left(P_t^X\right)^{1-\varepsilon_F} + (1 - \gamma^F)\left(P_t^F\right)^{1-\varepsilon_F}\right]^{\frac{1}{1-\varepsilon_F}} . \tag{6.33}$$

As the economy becomes more open, the fraction of imported goods in the consumption basket of domestic households increases, whereas as the economy becomes larger, this fraction falls. This parametrization allows us to obtain the small open economy as the limiting case of a two-country economy model when the size of the domestic economy approaches zero, $n \to 0$. In this case, we obtain $\gamma^H \to \gamma$ and $\gamma^F \to 0$. Therefore, in the limiting case, the foreign economy does not use any home-produced intermediate goods for the production of foreign final goods, and the demand condition for domestic goods can be written as follows:

$$Y_t^H = \gamma \left(\frac{P_t^H}{P_t}\right)^{-\varepsilon_H} C_t \,, \tag{6.34}$$

$$M_t = (1-\gamma) \left(\frac{P_t^M}{P_t}\right)^{-\varepsilon_H} C_t \,, \tag{6.35}$$

$$X_t = (1-\gamma^*) \left(\frac{P_t^X}{P_t^*}\right)^{-\varepsilon_F} C_t^* \,. \tag{6.36}$$

Thus, given the small open economy assumption, the consumer price index for the home and foreign economy can be expressed in the following way:

$$P_t \equiv \left[\gamma \left(P_t^H\right)^{1-\varepsilon_H} + (1-\gamma)\left(P_t^M\right)^{1-\varepsilon_H}\right]^{\frac{1}{1-\varepsilon_H}} \quad \text{and} \quad P_t^* = P_t^F \,. \tag{6.37}$$

6.2.5 Monetary and macroprudential policies

The central bank implements monetary policy by setting the nominal interest rate according to a Taylor-type feedback rule that depends on the consumption basket inflation and the output gap. We add an extra term linked to deviations of the asset price Q_t. This interest rate rule is given by:

$$i_t = \rho_i i_{t-1} + (1-\rho_i)\left(\varphi_\pi \pi_t + \varphi_y y_t + \varphi_Q q_t\right) + \varepsilon_t^{MON} \,, \tag{6.38}$$

where $\varphi_\pi > 1$, variables written in lower cases represent deviations of their steady-state levels and ε_t^{MON} is a random monetary policy shock. We are interested in studying how the presence of shocks in credit conditions affects the reaction of the central bank.

Additionally, we introduce LTV rules to investigate if it is easier to stabilize the economy through the use of a separate instrument. Although the regulatory agency can impose these rules, a stochastic element will remain in the financial conditions. The LTV rule will be given by:

$$\zeta_t - \zeta = \rho_\zeta(\zeta_{t-1} - \zeta) + (1-\rho_\zeta)\left(\varphi_q q_t + \varphi_B b_t^E + \varphi_Y y_t + \varphi_{q^e}\mathbb{E}_t\{q_{t+1}\}\right) + \varepsilon_t^\zeta \,, \tag{6.39}$$

and encompasses four different policies: (1) reaction to current value of asset prices, (2) reaction to the level of debt, (3) reaction to the business cycle and (4) reaction to expected value of asset prices.

6.2.6 Market clearing

Domestic output is given by:

$$P_t^{def} Y_t = P_t^H Y_t^H + S_t P_t^X Y_t^X , \tag{6.40}$$

where Y_t is the GDP and P_t^{def} is its deflator. From equations (6.34) and (6.35) and the definition of the consumer price index, equation (6.40) becomes:

$$P_t^{def} Y_t = P_t C_t + S_t P_t^X Y_t^X - P_t^M Y_t^M , \tag{6.41}$$

where $c_t^E + c_t^H = C_t$. We have assumed that both types of agents in the economy share the same preferences over home and imported consumption goods.

To identify the GDP in this economy, Y_t, it is necessary to define the GDP deflactor, P_t^{def}, which is the weighted sum of the consumer, export and import price indices:

$$P_t^{def} = \phi_C P_t + \phi_X S_t P_t^X - \phi_M P_t^M , \tag{6.42}$$

where ϕ_C, ϕ_X and ϕ_M are steady state values of the ratios of consumption, exports and imports to GDP, respectively. The demand for intermediate goods is obtained by aggregating the production for home consumption and exports:

$$Y_t^{int}(z) = Y_t^H(z) + Y_t^X(z) = \left(\frac{P_t^H(z)}{P_t^H}\right)^{-\varepsilon} Y_t^H + \left(\frac{P_t^X(z)}{P_t^X}\right)^{-\varepsilon} Y_t^X . \tag{6.43}$$

Aggregating (6.43) with respect to z, we obtain:

$$Y_t^{int} = \frac{1}{m}\int_0^m Y_t^{int}(z)\,dz = \Delta_t^H Y_t^H + \Delta_t^X Y_t^X , \tag{6.44}$$

where $\Delta_t^H = \frac{1}{m}\int_0^m \left(P_t^H(z)/P_t^H\right)^{-\varepsilon} dz$ and $\Delta_t^X = \frac{1}{m}\int_0^m \left(P_t^X(z)/P_t^X\right)^{-\varepsilon} dz$ represent the relative price dispersion of each type of good. Here, m stands for the number of retail firms selling the same variety of goods. Up to a first order approximation, the dispersion variables have no impact on the dynamics of the model.

Similarly, the aggregate demand for labor is:

$$L_t^E = (1-\nu)\frac{MC_t}{W_t/P_t}\left(\Delta_t^H Y_t^H + \Delta_t^X Y_t^X\right) , \tag{6.45}$$

where market clearing for labor yields $L_t^E = L_t^H$. Finally, we assume a fixed housing supply, yielding $h_t^E + h_t^H = \bar{H}$.

After aggregating the household's budget constraints, the firm's profits and including the equilibrium condition in the financial market that equates household wealth with the stock of foreign bonds (B_t^*) expressed in domestic prices, we obtain the aggregate resources constraint of the home economy:

$$-\left\{\frac{S_t B_t^*}{P_t} - \frac{S_{t-1}B_{t-1}^*}{P_{t-1}}\right\} = \frac{P_t^{def}}{P_t} Y_t - C_t - \left\{\frac{\left(1 + i_{t-1}^*\right)}{\Pi_t}\frac{S_t}{S_{t-1}} - 1\right\}\frac{S_{t-1}B_{t-1}^*}{P_{t-1}}. \quad (6.46)$$

Equation (6.46) corresponds to the current account of the home economy. Since entrepreneurs can only access domestic bonds, this instrument is in zero net supply, $B_t^H + B_t^E = 0$. The left hand side is the change in net asset position in terms of consumption units. The right hand side is the trade balance, the difference between GDP and consumption which is equal to net exports and the investment income.

6.3 Simulations and results

6.3.1 Calibration

Table 6.1 shows the value for the model parameters.

Most of the housing market parameters are taken from Iacoviello (2005), given the scarcity of studies on housing markets in Peru. On the other hand, this choice facilitates the comparison of our results with the closed economy setup.[3] The time preference parameters for the patient households and relatively impatient entrepreneurs are set for 0.99 and 0.98, respectively.[4]

The housing preference parameter j is taken to match the ratio for personal residential housing to quarterly GDP, which is 0.1 for our case. We also provide results after setting $j = 0$, as a way to exclude wealth effects on housing prices. Regarding the steady-state loan-to-value ratio ζ, set it at 0.89, which means that in our economy

[3] It is important to remind the reader that we do not need a strict definition of collateralized debt, since what the LTV parameter measures is the willingness of banks to provide credit to entrepreneurs as a function of their outstanding capital wealth. This fact makes the choice of a parameter harder for the Peruvian case and for this reason we emphasize robustness exercises to the value of this parameter.

[4] Iacoviello (2005) uses 0.95 for the impatient household, based on estimates of discount factors for poor or young households in the US (Samwick, 2003).

the standard downpayment is 11% of the value of a house, although we provide results using different values for this parameter.

Since our goal is to parameterize the model for the Peruvian economy, the rest of the parameters are values typically used in this literature for the Peruvian economy. In particular, we borrow from Castillo et al. (2009). Finally, the standard deviations of all the shocks are set to one percent and the persistence parameters to 0.9.

Table 6.1 *Baseline calibration*

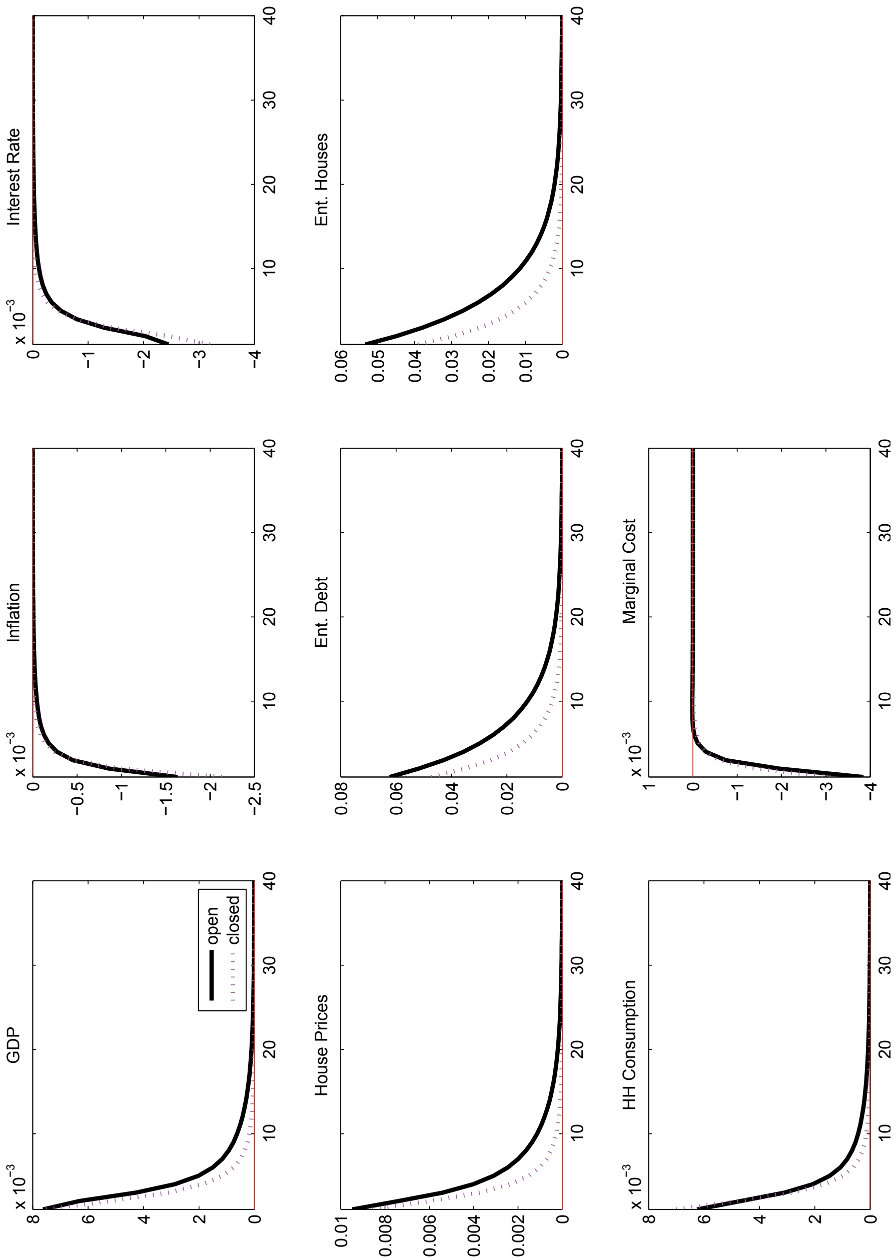
Parameter	Value	Description
β	0.99	Households' pure time-preference parameter
ϱ	0.98	Entrepreneurs' pure time-preference parameter
ζ	0.89	Steady state LTV ratio
η	1.01	Labor supply elasticity
ν	0.03	Housing share in production
j	0.10	Preference for housing in household's utility function
θ	0.01	Foreign interest rate premium
γ	0.60	Share of domestic tradables in domestic consumption
ε	1.50	Elasticity of substitution between home and foreign goods
ε_X	1.50	Elasticity of substitution between exports and foreign goods
θ_H	0.55	Domestic goods price rigidity
θ_M	0.75	Imported goods price rigidity
θ_X	0.25	Exported goods price rigidity
φ_π	1.50	Taylor rule reaction to inflation deviations
ρ_{y^*}	0.50	Foreign aggregate demand shock persistence
ρ_{π^*}	0.50	Foreign inflation shock persistence
ρ_{i^*}	0.50	Foreign interest rate shock persistence
ρ_a	0.50	Domestic productivity persistence parameter
ρ_ζ	0.90	LTV shock persistence parameter
h^e/h^h	1.00	Relative holding of housing
ϕ_C	1.00	Steady state consumption over aggregate demand ratio
ϕ_ϖ	−0.01	Net asset position over GDP ratio

Source: Author's own calculations.

6.3.2 Model dynamics

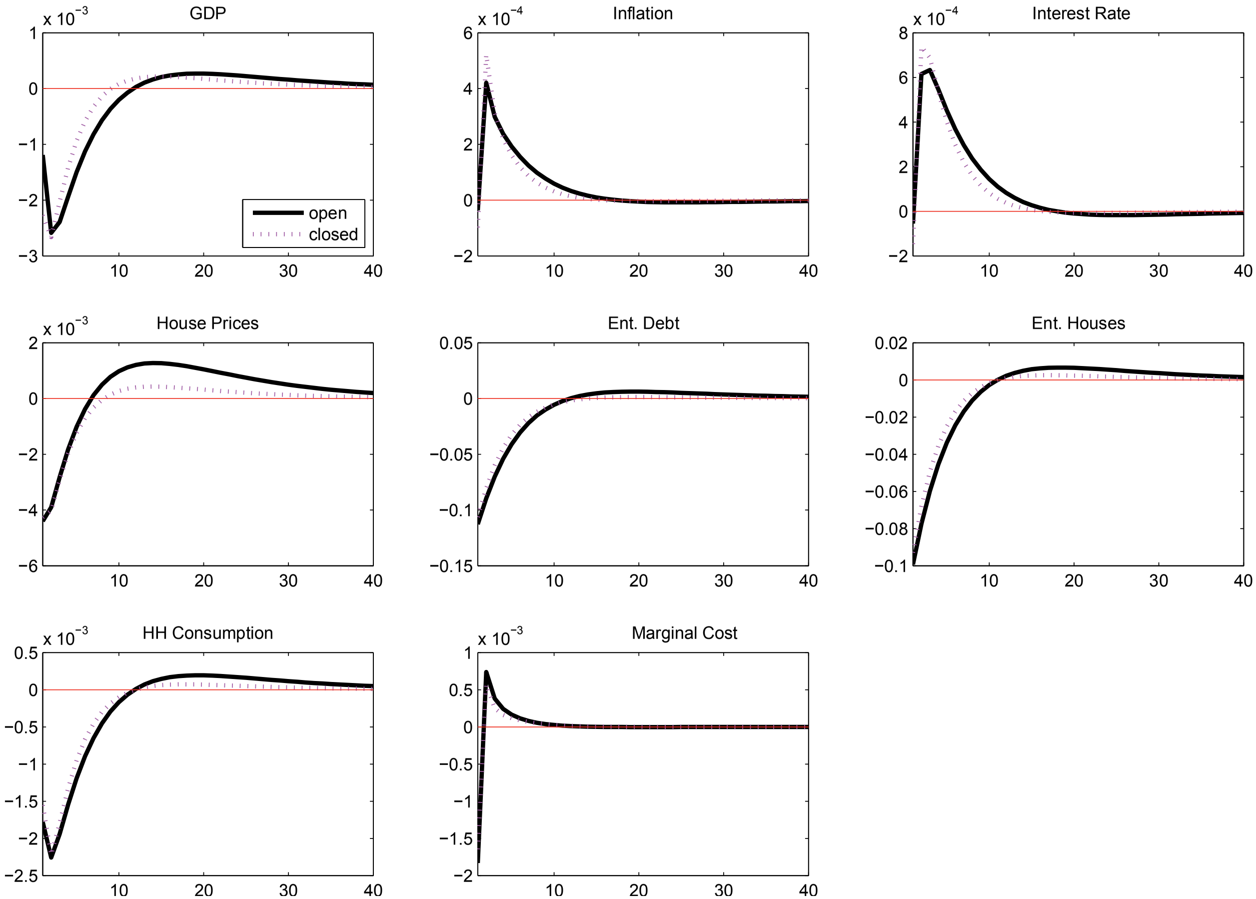
Figures 6.1 and 6.2 show the impulse response functions of the main variables of the model to a productivity shock and an LTV shock, respectively. The figures show responses compared to the reaction of the closed economy.

Figure 6.1 *Productivity shock: Open versus closed economies*



Source: Author's own calculations.

Figure 6.2 *Loan-To-Value shock: Open versus closed economies*



Source: Author's own calculations.

It is important to note that the economy reacts in a similar fashion, so the main prediction obtained in the closed economy model prevails. Hence, a productivity shock generates an increase in house prices (as they are used as a production factor) and a higher share of the houses (or land) in the hands of the entrepreneurs. Accordingly, their debt rises, as they can use their real state as collateral. The reaction of prices is expected, as the marginal cost of production falls. Note that there is a misallocation effect generated by the presence of credit constraints. Specifically, there is an asymmetry between the demand of factors as capital has an additional use. From equation (6.22), housing capital demand depends on its marginal productivity and its capacity to relax the entrepreneurs' borrowing constraint. The latter effect is influenced by credit conditions (ζ_t) and the wedge between the entrepreneur and the households discount factors, which is a function of the entrepreneurs' consumption growth and the domestic interest rate.

In summary, entrepreneurs will use more housing in the production of intermediate goods when (i) they are relatively more impatient (larger wedge between the interest rate and their stochastic discount factor) and (ii) housing capital can be used to raise more debt (higher LTV ratio). These two elements are interdependent: a higher equilibrium LTV ratio *ceteris paribus* allows more consumption smoothing in entrepreneurs and, consequently, lowers the volatility in their stochastic discount factor; a higher equilibrium LTV ratio amplifies the variations in asset prices by relaxing the credit constraints.

In the case of a positive productivity shock (Figure 6.1), as entrepreneurs become wealthier, their degree of impatience declines, dampening the effect in housing demand stemming from the shock. As in the standard model, the shock lowers marginal costs. This effect, however, is reinforced since entrepreneurs can produce with a mix of factors closer to the efficient one, as they become less impatient and the collateral motive becomes less relevant (a phenomenon reflected in a decreasing value of the Lagrange multiplier associated with the credit constraint). The decrease in the marginal cost translates into lower inflation, prompting a reaction from the central bank in the form of a cut in interest rates. This further facilitates access to credit, reinforcing the effect of the initial shock in credit conditions. Finally, households substitute their consumption of houses for more consumption, as the substitution effect kicks in.[5]

[5] In our setup, the number of housing units is fixed and households are not credit constrained. In the literature we can find attempts to introduce investment and production of housing, as well as credit constrained households. We will follow this path in future versions of the present work.

Thus, under this setup the informally accepted narrative that cheap rates entice entrepreneurs to take on more debt and generate an increase in asset prices, is present. This is the mechanism through which we obtain an 'amplification effect'.

A LTV shock, which we understand as more restrictive conditions for borrowing, has a negative effect on economic activity. Figure 6.2 shows how house prices drop and the economic activity follows through. Entrepreneurs are more constrained, reducing their production. The drop in supply triggers an increase in prices, supported by increased misallocation, to which the central bank reacts by making credit more expensive, further deteriorating credit conditions. The real exchange rate suffers an appreciation through non-tradable prices inflation, produced by higher marginal costs.

6.3.3 Policy exercises

We now present the dynamics of the model under different LTV rules. Figures 6.3 to 6.6 compare two different intervention rules with the baseline scenario. We first consider a debt-based rule:

$$\zeta_t - \bar{\zeta} = \rho_\zeta(\zeta_{t-1} - \bar{\zeta}) + (1 - \rho_\zeta)\varphi_B b_t^E + \varepsilon_t^\zeta \,, \qquad \text{(Debt-based rule)}$$

where $\varphi_B < 0$, and a rule that is a function of the value of assets:

$$\zeta_t - \bar{\zeta} = \rho_\zeta(\zeta_{t-1} - \bar{\zeta}) + (1 - \rho_\zeta)\varphi_q q_t + \varepsilon_t^\zeta \,. \qquad \text{(Asset-based rule)}$$

where also $\varphi_q < 0$.

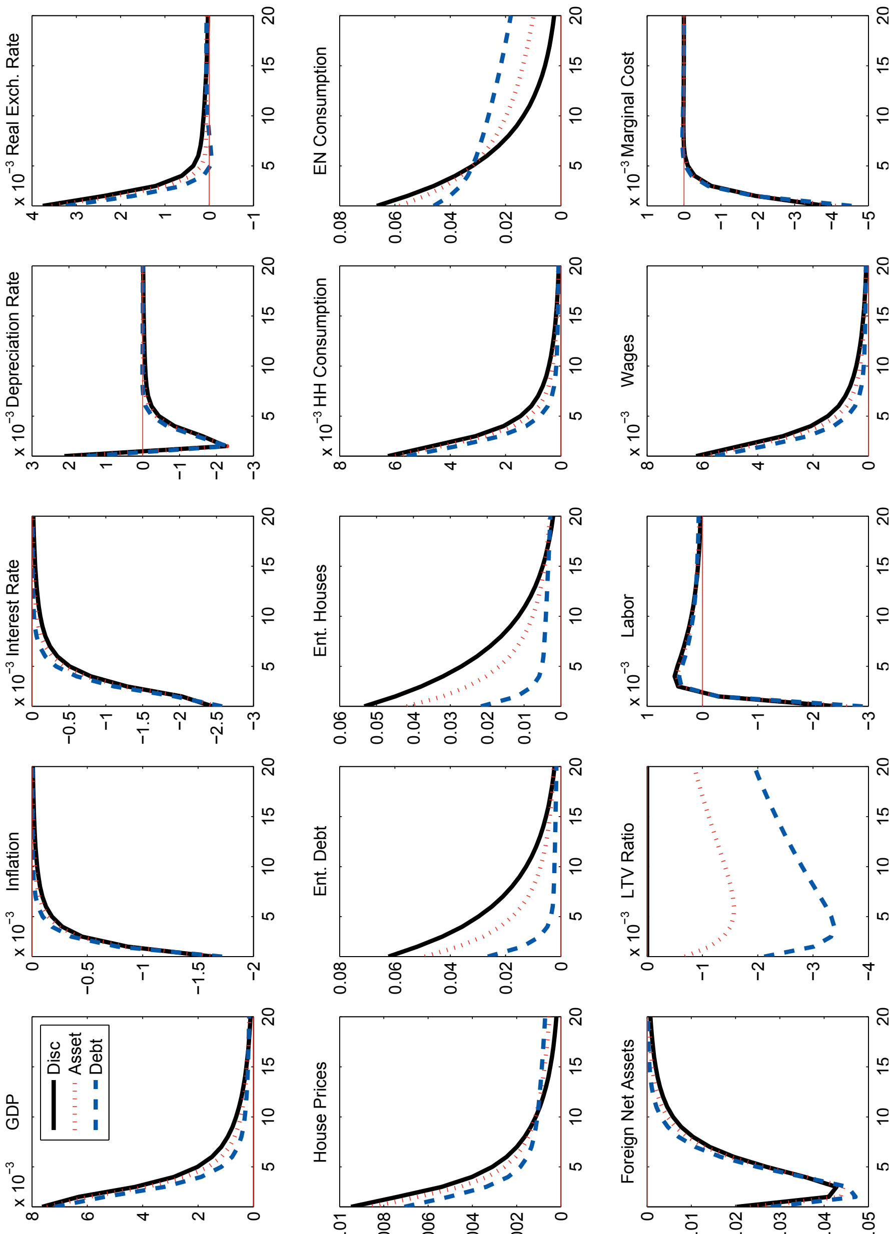
The analysis of the impulse responses reveals that both rules help in moderating the fluctuations generated by the shocks. The debt-based rule seems to generate the greatest impact on dampening the effects of productivity, LTV and monetary policy shocks, even though it introduces extra persistence in the form of a longer path back to the steady state of the economy.

Figures 6.7 to 6.10 compare the debt-based rule, our preferred one from the first exercise, with a purely countercyclical rule of the form:

$$\zeta_t - \bar{\zeta} = \rho_\zeta(\zeta_{t-1} - \bar{\zeta}) + (1 - \rho_\zeta)\varphi_Y y_t + \varepsilon_t^\zeta \,, \qquad \text{(Countercyclical rule)}$$

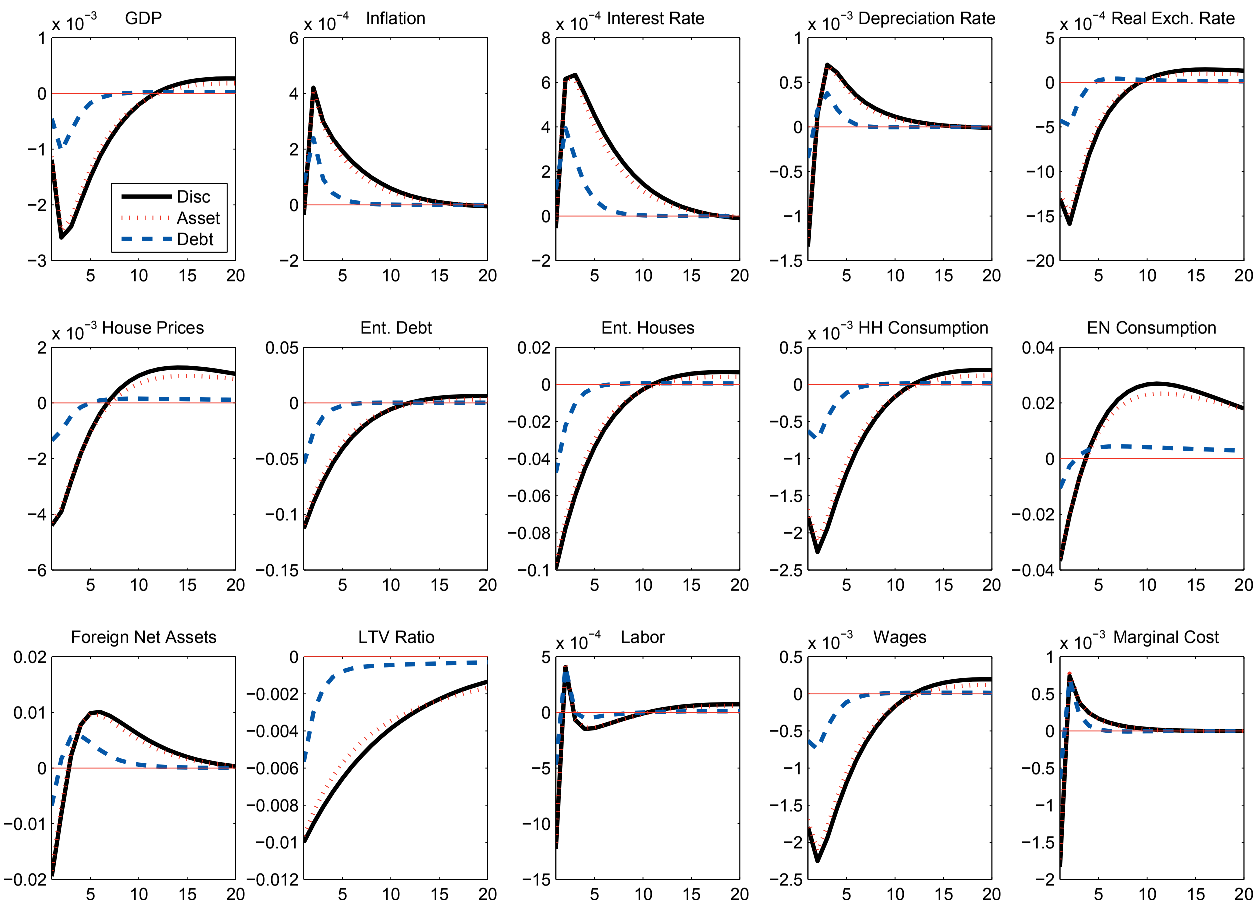
where $\varphi_y < 0$. This is a purely countercyclical rule, in the sense that we react to the position of the economy in the business cycle.

Figure 6.3 *Productivity shock: Debt versus asset price rules*



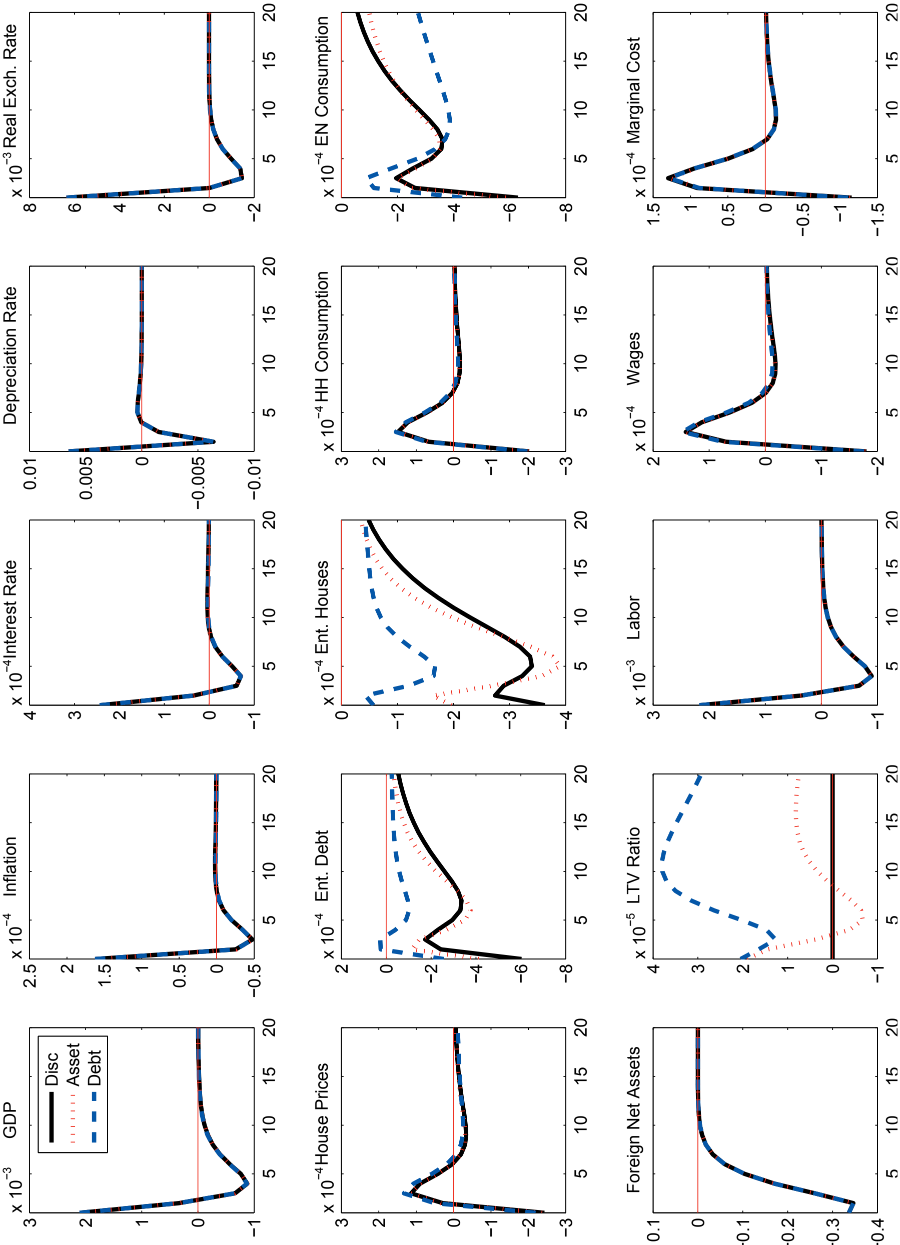
Source: Author's own calculations.

Figure 6.4 *Loan-To-Value shock: Debt versus asset price rules*



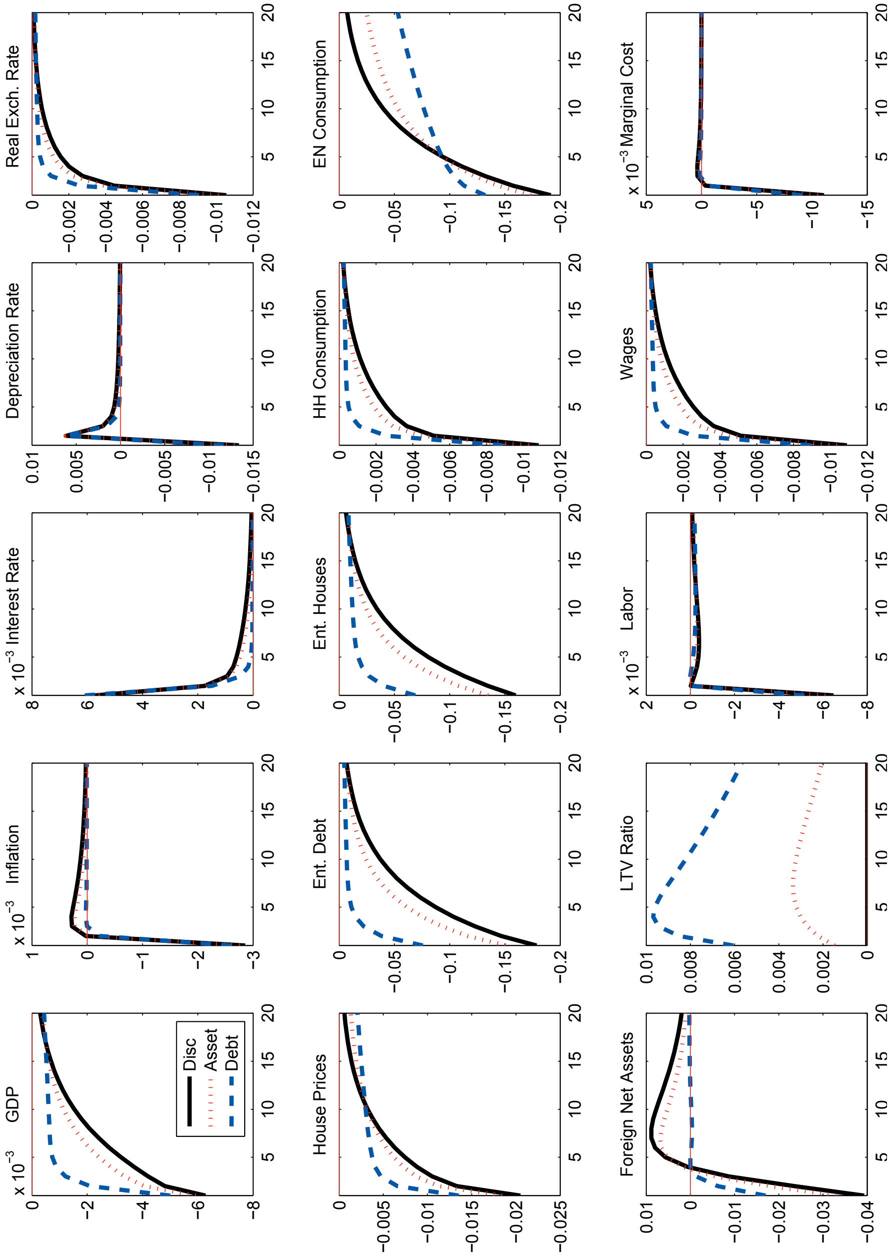
Source: Author's own calculations.

Figure 6.5 *Foreign interest rate shock: Debt versus asset price rules*



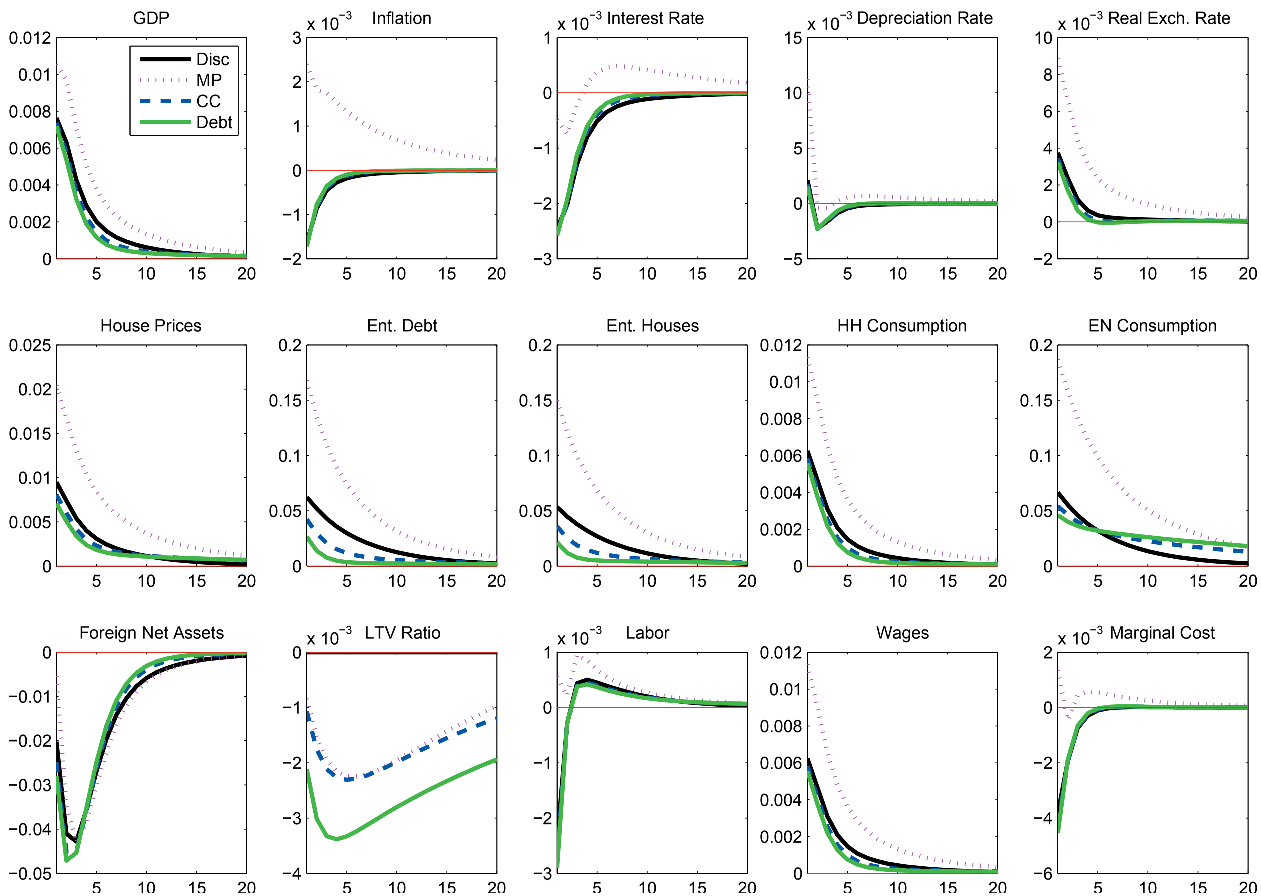
Source: Author's own calculations.

Figure 6.6 *Monetary policy shock: Debt versus asset price rules*



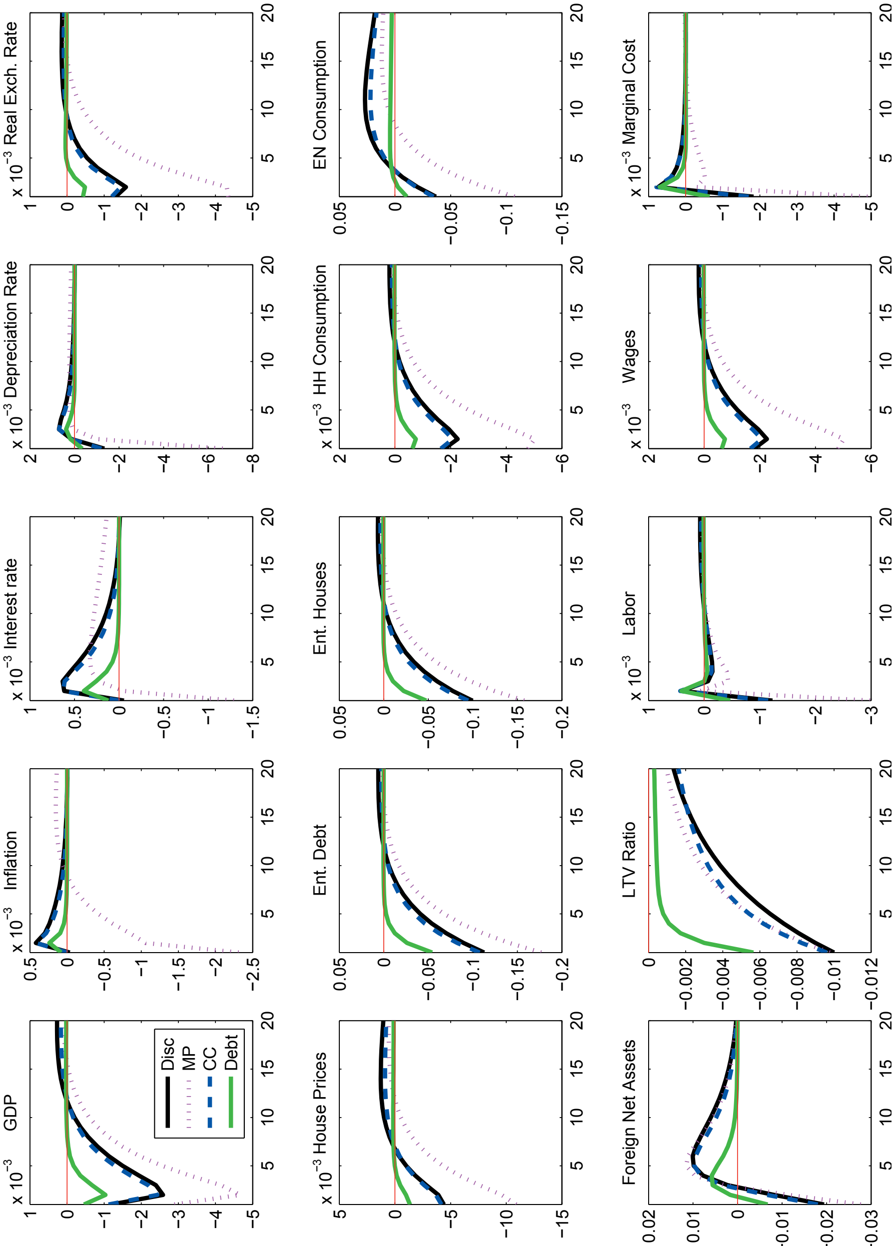
Source: Author's own calculations.

Figure 6.7 *Productivity shock: Monetary policy, purely countercyclical and debt rules*



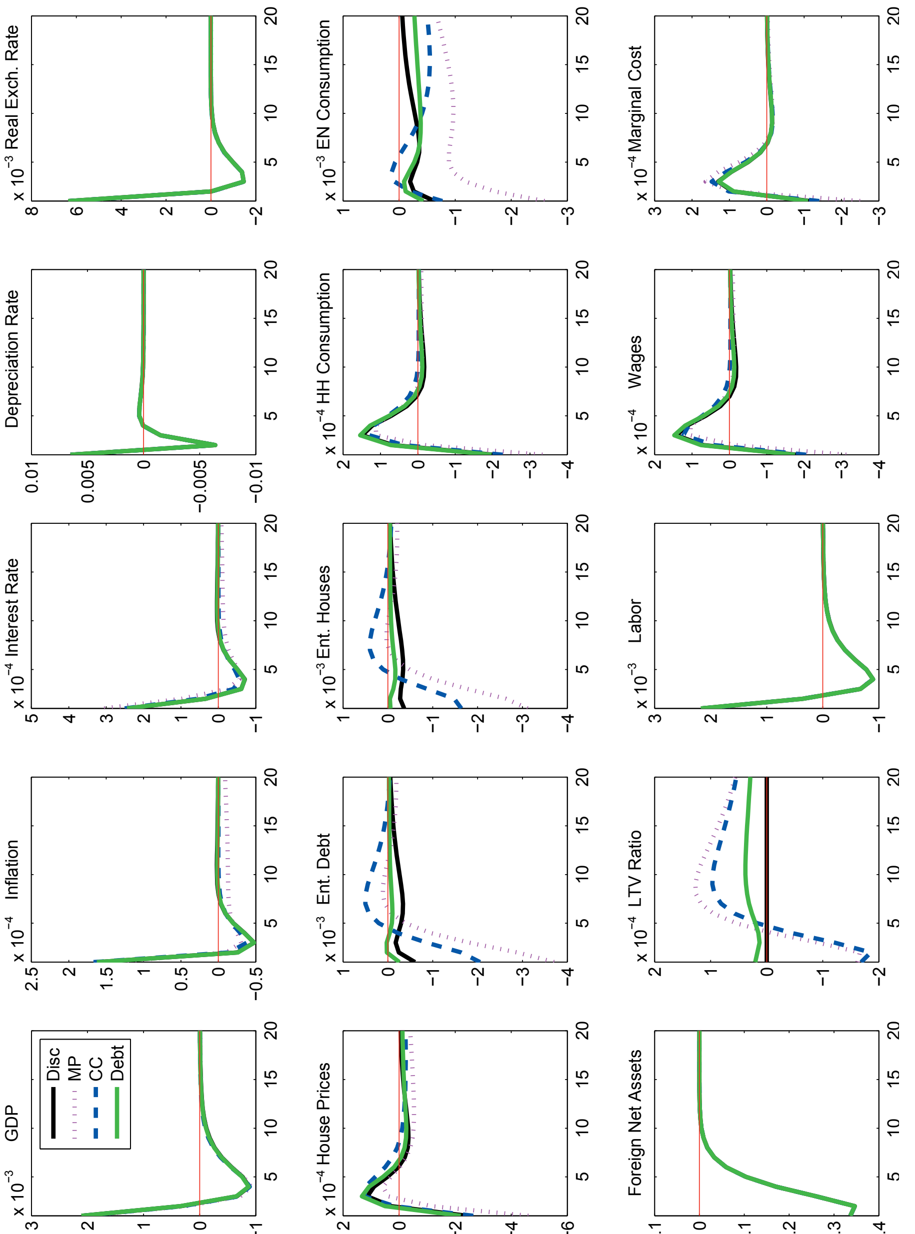
Source: Author's own calculations.

Figure 6.8 *Loan-To-Value shock: Monetary policy, purely countercyclical and debt rules*



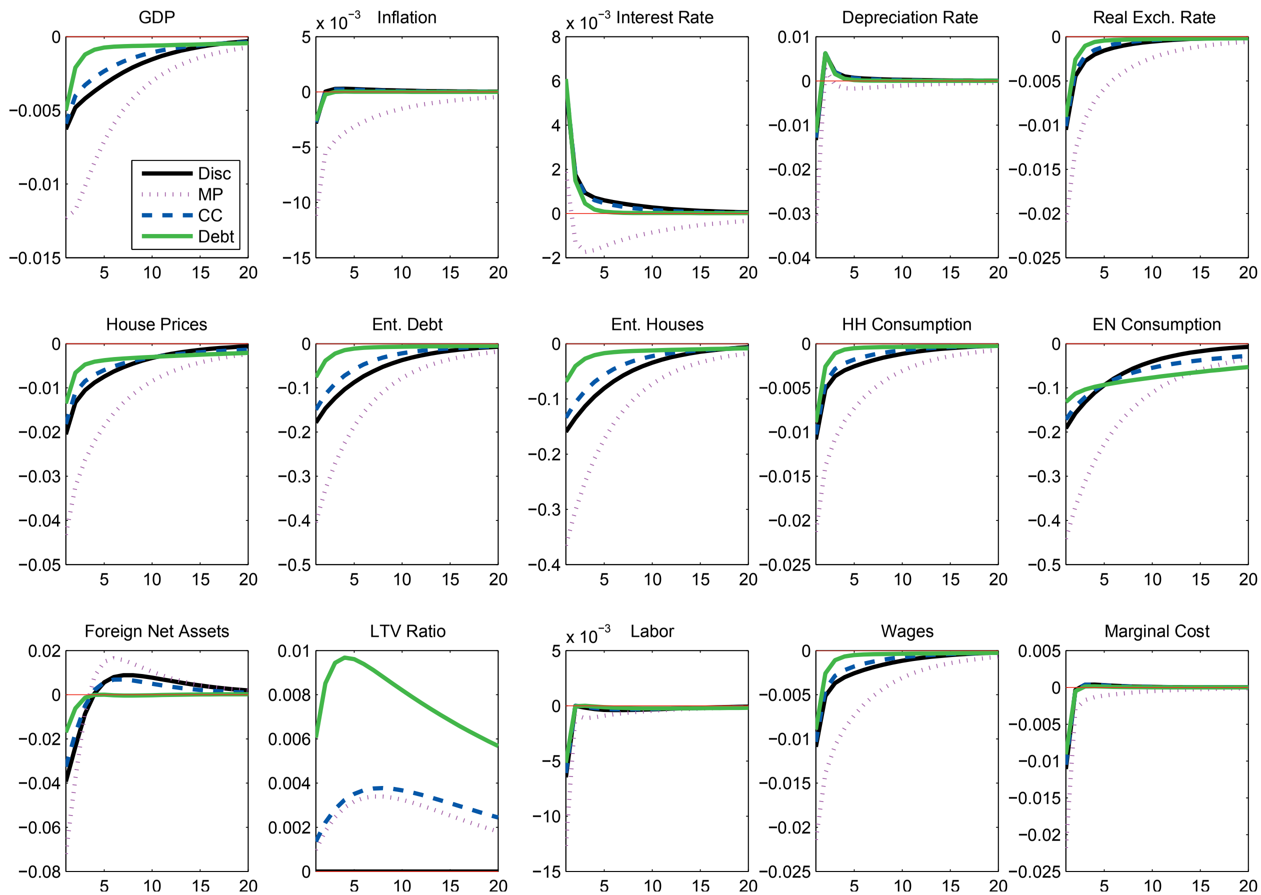
Source: Author's own calculations.

Figure 6.9 *Foreign interest rate shock: Monetary policy, purely countercyclical and debt rules*



Source: Author's own calculations.

Figure 6.10 *Monetary policy shock: Monetary policy, purely countercyclical and debt rules*



Source: Author's own calculations.

We have several results from this set of figures. First, that the monetary policy rule, where the central bank uses an interest rate rule that reacts to the price of assets, generates more volatility than using the LTV rules. Clearly, monetary policy faces a trade-off, and an increase in the interest rates to stabilize asset prices generates effects on the "real-side" of the economy. The second conclusion is that the debt-rule continues to appear more favorable in terms of the stabilization of the economy.

In order to obtain a metric related to these results, we define a loss function for the central bank:

$$\mathcal{L} = (\pi_t)^2 + (1/\theta_l)(y_t)^2$$

where the parameter θ_l measures the relative importance the central bank gives to inflation over output stabilization. We set this parameter at 6 for the following exercises.

The first exercise is to compare how much the central bank can gain by reacting to asset prices through an augmented Taylor rule. For this purpose, we use the optimal simple rule command in Dynare to compute the parameters that minimize the loss function specified above. Our findings are reported in Figure 6.11 for different levels of the steady state LTV (ζ). We report the percentage reduction in the minimal loss for using a Taylor type policy rule that includes housing prices. We observe that the gains range from 0.7 to 6.2 percent.

Alternatively, we endow the central bank with LTV rules, as in equation (6.39). For each type of rule, we search for the parameters of both the Taylor rule and LTV rule which minimize the central bank's loss function. We report the relative gain of using a macroprudential tool in comparison to the cases in which only a standard or augmented Taylor rule is implemented. Our results, displayed in Figure 6.12, show that in all four cases substantial gains are obtained from using an LTV rule, ranging from 35 to 42 percent of the loss associated with using a Taylor type rule.

This result supports the view that the central bank should use a separate tool to react to asset prices, as the gains from reacting with the monetary policy tool pale in comparison to the ones derived from using an alternative instrument. In this model, there are two reasons why the central bank would like to react to asset prices. First, we have introduced a financial conditions shock, which constitutes a source of instability. The presence of this type of shock is in line with the definition of financial (in)stability in Schinasi (2004), who stresses that the shocks emanating from the financial system are capable of greatly affecting the economy as a whole. The second motive is related to a pecuniary externality. When households face a negative income shock and lower their demand from housing services, they do not take into account the effect this has on tightening the borrowing constraints of entrepreneurs and, consequently, their wages. In this case the macroprudential instrument can serve as a mechanism to offset the effect of these externalities, as it may relax credit constraints when the economy is hit by negative shocks.

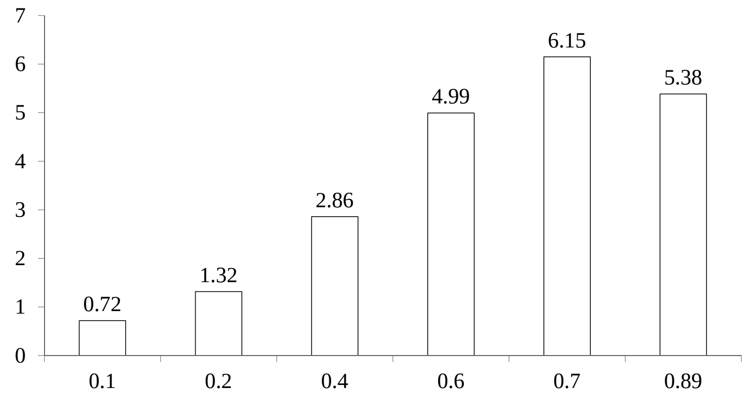
6.4 Conclusions

We present a new Keynesian open economy model that includes a housing market and credit constraints, in line with Iacoviello (2005). This setup allows us to study the effects of changes in credit conditions, represented by the share of capital that agents can use as collateral for loans, in the business cycle.

First, we show that, in general, the results of introducing credit constraints in a closed economy model remain valid for the open economy case. Then, we use the model to study the effects of easing credit conditions in a small open economy. This shock generates downward pressure on inflation, higher housing prices, GDP expansion and real exchange rate depreciation, consistent with lower prices for the non-tradable goods sector. Additionally, we analyze how the presence of credit constrained firms affect optimal monetary policy rules. In particular, we find that in the presence of shocks to credit conditions and the aforementioned pecuniary externalities, the central bank obtains relatively small gains for reacting to fluctuations in asset prices.

In contrast, the use of a different instrument that reacts to financial conditions can provide significant gains in stabilizing the economy. Although all of the instruments presented in our exercises help with stabilizing the economy, a LTV rule that reacts to deviations of debt from its stationary value is the preferred one. These results support the argument for using a different instrument for macroprudential purposes instead of relying on the central bank's reference rate.

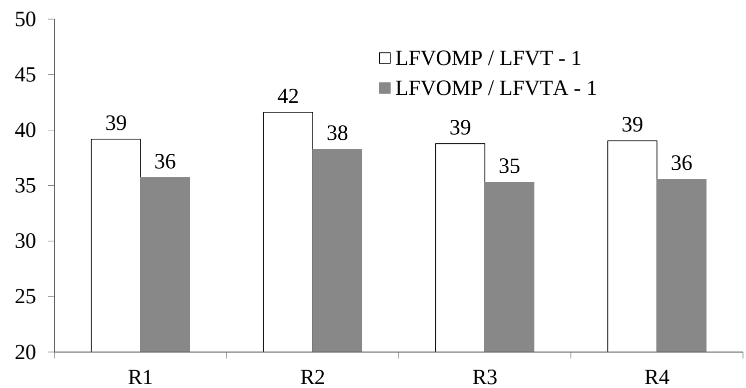
Figure 6.11 *Percentage gain relative to benchmark monetary policy loss*



Notes: The chart shows the percentage reduction in the minimal loss of the central bank for a Taylor-type policy rule that includes housing prices against a benchmark Taylor rule that only reacts to inflation and the output gap. In each case, we obtain the parameters that minimize the loss function for different levels of ζ (shown on the horizontal axis), the parameter representing the restrictiveness of credit conditions.

Source: Author's own calculations.

Figure 6.12 *Percentage gain from using a macroprudential tool*



Notes: The chart shows the percentage reduction in the minimal loss of the central bank for a Taylor-type policy rule and LTV rule (LFVOMP) against only using a Taylor-type rule (LFVT) or using an augmented Taylor-type rule (LFVTA). In each case, we obtain the parameters that minimize the loss function for different specifications of macroprudential rules. Namely, R1: reaction to current asset prices; R2: reaction to debt; R3: reaction to the business cycle; R4: reaction to expected asset prices.

Source: Author's own calculations.

References

Agenor, P.-R. and Pereira da Silva, L. A. (2009). Cyclical effects of bank capital requirements with imperfect credit markets. Policy Research Working Paper 5067, World Bank.

Angelini, P., Neri, S., and Panetta, F. (2011). Monetary and macroprudential policies. Temi di discussione (Economic Working Paper) 801, Bank of Italy.

Benigno, G., Chen, H., Otrok, C., Rebucci, A., and Young, E. R. (2013). Capital controls or exchange rate policy? A pecuniary externality perspective. Working Paper IDB-WP-393, InterAmerican Development Bank.

Benigno, P. and Woodford, M. (2005). Optimal taxation in an RBC model: A linear-quadratic approach. Working Paper 11029, National Bureau of Economic Research.

Borio, C. and Drehmann, M. (2009). Assessing the risk of banking crises - Revisited. *BIS Quarterly Review*, (March):29–46.

Calvo, G. A. (1983). Staggered prices in a utility-maximizing framework. *Journal of Monetary Economics*, 12(3):383–398.

Castillo, P., Montoro, C., and Tuesta, V. (2009). A dynamic stochastic general equilibrium model with dollarization for the Peruvian economy. Working Paper 2009-003, Banco Central de Reserva del Perú.

Christiano, L. J., Eichenbaum, M., and Evans, C. L. (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of Political Economy*, 113(1):1–45.

Galí, J. and Monacelli, T. (2005). Optimal monetary and fiscal policy in a currency union. Economics Working Paper 909, Department of Economics and Business, Universitat Pompeu Fabra.

Gerali, A., Neri, S., Sessa, L., and Signoretti, F. M. (2010). Credit and banking in a DSGE model of the Euro area. *Journal of Money, Credit and Banking*, 42(1):107–141.

Iacoviello, M. (2005). House prices, borrowing constraints, and monetary policy in the business cycle. *American Economic Review*, 95(3):739–764.

Kaminsky, G. L. and Reinhart, C. M. (1998). Financial crises in Asia and Latin America: Then and now. *American Economic Review*, 88(2):444–48.

Kiyotaki, N. and Moore, J. (1997). Credit cycles. *Journal of Political Economy*, 105(2):211–48.

Korajczyk, R. A. and Levy, A. (2003). Capital structure choice: Macroeconomic conditions and financial constraints. *Journal of Financial Economics*, 68(1):75–109.

Landvoigt, T., Piazzesi, M., and Schneider, M. (2012). The housing market(s) of San Diego. Working Paper 17723, National Bureau of Economic Research.

Obstfeld, M. and Rogoff, K. (1995). The intertemporal approach to the current account. In Grossman, G. M. and Rogoff, K., editors, *Handbook of International Economics*, volume 3, chapter 34, pages 1731–1799. Elsevier, 1 edition.

Orrego, F. (2014). Precios de viviendas en Lima. *Revista Estudios Económicos*, 28:47–59. Banco Central de Reserva del Perú.

Reinhart, C. and Rogoff, K. (2009). *This Time Is Different: Eight Centuries of Financial Folly*, volume 1. Princeton University Press.

Rodrigues Bastos, F., Kamil, H., and Sutton, B. (2015). Corporate financing trends and balance sheet risks in Latin America: Taking stock of the bon(d)anza. Working Paper 15/10, International Monetary Fund.

Samwick, A. A. (2003). Discount rate heterogeneity and social security reform. *Journal of Development Economics*, 61(1):163 – 185.

Schinasi, G. J. (2004). Defining financial stability. Working Paper 04/187, International Monetary Fund.

Schmitt-Grohé, S. and Uribe, M. (2003). Closing small open economy models. *Journal of International Economics*, 61(1):163 – 185.