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Financial and Fiscal Shocks in the Great Recession and Recovery of the Spanish Economy

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Abstract

In this paper we develop and estimate a new Bayesian DSGE model for the Spanish economy that has been designed to evaluate different structural reforms. The small open economy model incorporates a banking sector, consumers and entrepreneurs who accumulate debt, and a rich fiscal structure and monopolistic competition in products and labor markets, for a country in a currency union, with no independent monetary policy. The model can be used to evaluate ex-ante and ex-post policies and structural reforms and to decompose the evolution of macroeconomic aggregates according to different shocks. In particular, we estimate the contribution of financial and fiscal shocks to both the crisis of the Great Recession and the recovery of the Spanish economy.

Keywords: collateral constraints, banks, bank capital, fiscal policy, sticky interest rates.

JEL Classification: E30, E32, E43, E51, E52, E62.

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1 Introduction

During the Great Recession there was a very intense debate about the effects of financial and fiscal shocks and structural reforms on economic activity, particularly in peripheral European countries. Although some of these questions may be partially addressed with previous macroeconomic models for the Spanish economy, none of them is able to simultaneously analyze the quantitative relevance of these factors and their contributions to the fall and recovery of output and employment.[1]

In this paper we propose a DSGE model for the Spanish economy that estimates the contribution of different real and financial shocks to economic activity. We extend Gerali et al.'s (2010) model with financial frictions and an imperfectly competitive banking sector to a small open economy with a public sector and a rich detail of fiscal variables, in the spirit of the rational expectations model (REMS) proposed by Boscá et al. (2010). Like REMS, our model incorporates different nominal, real and financial frictions, and wages and price rigidities in non-competitive labor and product markets; whereas fiscal variables include different taxes on consumption, labor and capital incomes, and expenditures on public consumption and investment. We expand REMS in two main directions of interest given the recent economic crisis. First, we include a financial sector in which banks operate in monopolistically competitive markets, managing their capital position while counting on the monetary authority to fully allot their funding requirements at the current policy rate. Second, we estimate the parameters and the shocks that explain the dynamics of the main macroeconomic aggregates of the Spanish economy from 1992 to 2016.

The estimation of the model allows us to decompose output and other variables in terms of the shocks that have driven the cycle, improving our understanding of the factors behind the crisis and the recent recovery. In particular, this exercise is very illustrative of the real effects of financial and fiscal shocks. Our results show that favorable financial conditions from 2003 to 2007 explain partially output growth and excessive debt accumulation, which allowed for the intertemporal substitution of growth from the future to the present. During the first recession that followed 2008, we identify a financial and trade crisis, partly offset by an expansionary fiscal policy. Nevertheless, the expansionary demand policy increased current activity but at the cost of future lower growth. Additionally, the negative wage shock made the recession worse. The second recession during the sovereign debt crisis implied higher financial tensions and a significant fiscal adjustment due to the unsustainability of public finances. The latter recovery after 2013 shows an intense improvement of activity given the positive contribution of financial, fiscal and wage shocks, despite some unfavorable external

[1] See, for example, Boscá et al. (2010), Andrés et al. (2010), and Burriel et al. (2010). In all of these models there is no detailed financial sector.

trade conditions at the beggining of the recovery.

The estimation of our model is also useful to assess the effects of some of the structural reforms undertaken by the Spanish economy during the crisis. This is a relevant exercise because there has been an intense debate about the effects of structural reforms when economies are near the zero lower bound (ZLB). Some economists (e.g., Krugman (2014) or Eggertsson et al. (2014)) have claimed that when the nominal interest rate is close to the ZLB, structural reforms to regain competitiveness (reducing production costs and prices) increase real interest rates and real debt, and depress aggregate demand in a deflationary spiral, intensifying the fall of output and the destruction of employment in the short run. Similarly, Galí (2013) has shown that in currency unions or in economies in which interest rates are at the ZLB, a wage cut may have contractionary effects on aggregate demand and employment if it triggers expectations of lower inflation and induces higher real interest rates. This result has been extended to open economies by Galí and Monacelli (2016), who find that wage adjustments have small effects on employment in economies under an exchange rate peg. These results in favor of postponing structural reforms during economic recessions have been recently questioned by some authors, such as Vogel (2017) or Andrés et al. (2017), who show that the negative short-run effects of structural reforms in a deflationary environment when economies are at the ZLB are small, short-lived and do not support the proposal of delaying structural reforms to the future.

We present evidence that the Spanish banking restructuring process, the labor market reform and wage moderation (among other structural reforms and the easing of monetary policy by the ECB) have contributed to the improvement of output growth. Our results show that the effects of these reforms on output and employment have been positive, despite the potential deflationary effects of some of them. The interaction between reforms and the expansionary monetary policies of the ECB has been mutually reinforcing and has crucially reduced the risk premia, therefore supporting the argument that monetary policies and measures oriented to reduce financial tensions in Europe, as Figure 1 illustrates, have also been decisive in increasing the beneficial effects of structural reforms in the case of Spain.

The structure of this paper is as follows. In the second section we present the details of the small open economy DSGE model with financial frictions, a banking sector, staggered prices and wage setting. In the third section, we discuss the model estimation and its results. Thus, we present the decomposition of output growth into the contribution of the main shocks and, for comparability with REMS, we analyze the properties of the estimated model also in terms of impulse response functions to some common shocks. Finally, the last section presents the main conclusions of the paper.

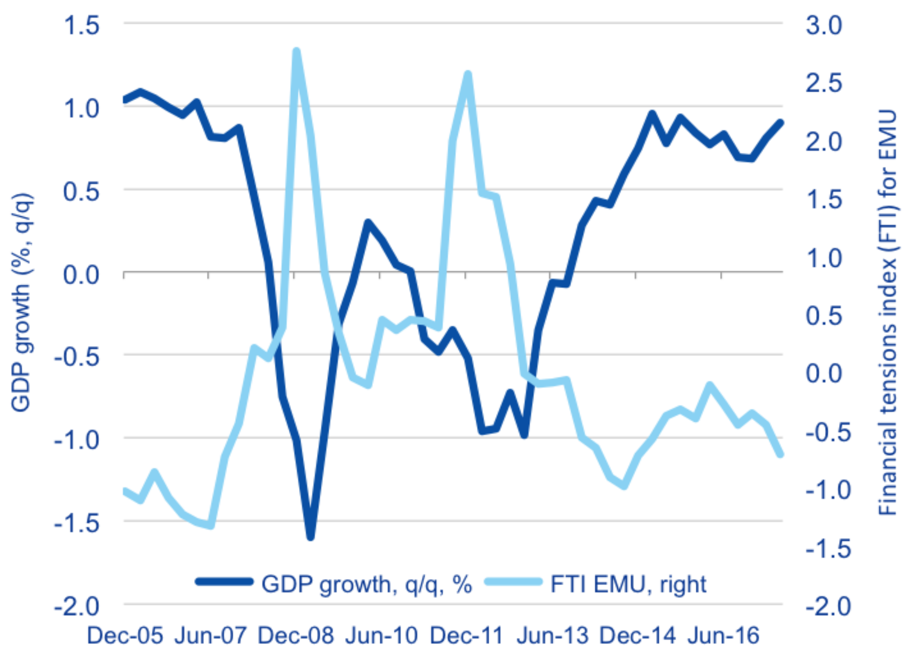

Figure 1: *Financial Tensions Index for EMU and Spanish output growth, 2005-2017. Source: INE and BBVA Research.*

2 Model Description

The model represents a small open economy (Spain) that belongs to a trade and monetary union (EMU) along with a supra-national central bank (ECB) controlling the reference interest rate according to a Taylor rule linked to the aggregate inflation and output growth of the whole union, both taken as exogenous to the model (that is, the effect of the home economy on the rest of the union is negligible, as in Monacelli (2004) and Galí and Monacelli (2005)).

The home economy is populated by four types of consumers (patient households, impatient households, hand-to-mouth households and entrepreneurs), a centralized government, three types of non-financial firms (intermediate good producers, capital producers and retailers), banks organized as holdings with lending and deposit branches, labor unions (one for each type of household) and, as a convenient way to incorporate monopolistic competition, "packagers" with monopolistic power who play an intermediary role in goods, labor and banking services markets.

Patient households get utility from the consumption goods and housing services they buy with the wage income received in exchange for the differentiated labor supplied to labor unions and past deposit yields, and these households can even afford to save part of this income in additional bank deposits. Impatient households behave similarly except that they can't afford to save and even need to take bank loans to finance their purchases. Hand-to-mouth households get utility only from the consumption goods they can afford to buy spending all their wage income, because they don't have access to credit and they don't have enough income (and/or patience) to save.

Labor unions buy differentiated labor from households in competitive markets and re-sell it to monopolistic labor packagers which, in turn, re-sell it (after bundling it in to a single homogeneous type of labor for each type of household) to intermediate good producers in competitive markets. Intermediate good producers combine the three types of labor bought with the capital rented from entrepreneurs and public capital (freely available) to produce differentiated intermediate goods that are sold to retailers. Retailers re-label (at no cost) and re-sell these differentiated intermediate goods to monopolistic packagers that (after bundling them into a single homogeneous type of final good) re-sell them to consumers for direct consumption, and to capital producers, who transform them in to capital goods to be sold to entrepreneurs under competitive conditions.

Each bank holding comprises a wholesale branch, a deposit branch and a lending branch. The wholesale branch accumulates capital and makes loans to the lending branch from the resources accumulated in the past as capital and loans taken from the deposit branch and the rest of the world. The deposit branch gets its resources (which it lends to the wholesale branch) from households through the intermediation of monopolistic deposit packagers; specifically, the deposit branch sells differentiated "deposits" (saving products) to packagers that bundle them into a single homogeneous type of "deposit," which is sold to patient households in a competitive market. The lending branch gets resources by taking loans from the wholesale unit under competitive conditions and lends them to households through the intermediation of monopolistic loan packagers; specifically, the lending branch sells differentiated "loans" (i.e, bonds or other financing products) to packagers that re-sell them to impatient households and entrepreneurs (after bundling them into a single homogeneous type of bond).

The government or "fiscal authority" levies taxes and takes on debt (selling bonds to domestic banks, domestic households and the rest of the world) and spends its resources in buying final goods for transferring them in a lump-sum way to households and accumulating public capital. And, finally, although implicitly there is at the union level a monetary authority that fixes the one-period nominal interest rate using a Taylor rule and supplies full-allotment refinancing to wholesale banks, following Schmitt-Grohe and Uribe (2003), to ensure the stationarity of equilibrium we assume that banks pay a risk premium that increases with the country's net foreign asset position. Thus, we close the model by assuming that the foreign borrowing interest rate is equal to an exogenous interest rate multiplied by a risk premium. Finally, there is a fiscal authority that consumes, invests, borrows or lends, sets lump-sum taxes, and taxes consumption, housing services, labor earnings, capital earnings, bond holdings, and deposits.

2.1 Patient households

There is a continuum of patient households in the economy indexed by j, with mass γ_p, whose utility depends on consumption, $c^p_{j,t}$; housing services, $h^p_{j,t}$; and hours worked, $\ell^p_{j,t}$ and has the following form:

$$E_0 \sum_{t=0}^{+\infty} \beta_p^t \left[(1-a_{cp})\varepsilon_t^z log(c^p_{j,t} - a_{cp}c^p_{t-1}) + a_{hp}\varepsilon_t^h log(h^p_{j,t}) - \frac{a_{\ell p}{\ell^p_{j,t}}^{1+\phi}}{1+\phi} \right],$$

where c^p_t denotes the average patient household's consumption, $c^p_t = \gamma_p^{-1}\left(\int_0^{\gamma_p} c^p_{j,t}dj\right)$, ε^z_t is a shock to the consumption preferences of all households with the law of motion:

$$\log\, \varepsilon_t^z = (1-\rho_z)\log\, \varepsilon_{ss}^z + \rho_z \log\, \varepsilon_{t-1}^z + \sigma_z e_t^z \quad \text{where } e_t^z \sim \mathcal{N}(0,1) \tag{i}$$

and ε^h_t is a shock to the housing preferences of all households with the law of motion:

$$\log\, \varepsilon_t^h = (1-\rho_h)\log\, \varepsilon_{ss}^h + \rho_h \log\, \varepsilon_{t-1}^h + \sigma_h e_t^h \quad \text{where } e_t^h \sim \mathcal{N}(0,1) \tag{ii}$$

The jth patient household is subject to the following budget constraint (expressed in terms of final goods):

$$\begin{aligned}
&(1+\tau_t^c)c^p_{j,t} + (1+\tau_t^h)q_t^h \Delta h^p_{j,t} + (1+\tau_t^{fd})d^p_{j,t} + \frac{\alpha_{RW}(1-\alpha_{B_g})Bg_t}{\gamma_p} - \frac{(1-\alpha_{ED})B_t^*}{\gamma_p} = \\
&(1-\tau_t^w)w^p_{j,t}\ell^p_{j,t} + \left[\frac{1+(1-\tau_t^d)r^d_{t-1}}{\pi_t} + \tau_t^{fd}\right] d^p_{j,t-1} + \frac{(1-\omega_b)J^b_{t-1}}{\gamma_p} - \frac{T_t^{up}}{\gamma_p} - \frac{T_t^g}{\gamma_p+\gamma_i+\gamma_e+\gamma_m} + \\
&\frac{\alpha_{RW}(1-\alpha_{B_g})(1+r_t^d)Bg_{t-1}}{\gamma_p} - \frac{(1-\alpha_{ED})(1+r_t^d)B^*_{t-1}}{\gamma_p},
\end{aligned} \tag{1}$$

where $\pi_t = \frac{P_t}{P_{t-1}}$ is gross inflation of the consumption good, with P_t denoting the price of the consumption good and the variables, τ_t^w, τ_t^c, τ_t^h, τ_t^d and τ_t^{fd} denoting taxes on labor income, consumption, accumulation of housing services, interest income from deposits and variation of deposits respectively; q_t^h is the price of housing services in terms of the consumption good; $w^p_{j,t}$ is the real wage in terms of the consumption good; and r^d_{t-1} is the nominal interest rate on deposits.

The flow of expenses, expressed in terms of the consumption good, is consumption (plus consumption taxes), $(1+\tau_t^c)c^p_{j,t}$; accumulation of housing services (plus taxes on housing services), $(1+\tau_t^h)q_t^h\Delta h^p_{j,t}$; current deposits (plus deposit taxes), $(1+\tau_t^d)d^p_{j,t}$, government bonds $\frac{\alpha_{RW}(1-\alpha_{B_g})Bg_t}{\gamma_p}$, and international bonds $\frac{(1-\alpha_{ED})B_t^*}{\gamma_p}$. The sources of income, also expressed in terms of the consumption good, are after-tax labor income , $(1-\tau_t^w)w_{j,t}^p\ell_{j,t}^p$; after-tax deposits gross return from the previous period, $\left[\frac{1+(1-\tau_t^d)r_{t-1}^d}{\pi_t}+\tau_t^d\right]d_{j,t-1}^p$; dividends from the banking sector, $\frac{(1-\omega_b)J_{t-1}^b}{\gamma_p}$ (where ω_b is the share of benefits that the banking sector does not distribute as dividends), the cost of participating in the labor union paid to the unions, $\frac{T_t^{up}}{\gamma_p}$; lump-sum taxes paid to the government, $\frac{T_t^g}{\gamma_p+\gamma_i+\gamma_e+\gamma_m}$, payments on government bonds $\frac{\alpha_{RW}(1-\alpha_{B_g})(1+r_t^d)Bg_{t-1}}{\gamma_p}$ and payments on international bonds $\frac{(1-\alpha_{ED})(1+r_t^d)B_{t-1}^*}{\gamma_p}$, where γ_i, γ_e, and γ_m represent the mass of the rest of consumers in the model (impatient, hand-to-mouth and entrepreneurs), α_{RW} is the share of public debt in the hands of resident agents (that is, "domestic" public debt) from which a share α_{B_g} is in the hands of banks and $(1-\alpha_{B_g})$ in the hands of patient households; similarly, α_{ED} and $(1-\alpha_{ED})$ are the share of external debt in the hands of banks and patient households respectively.[2] Clearly, q_t^h is the price of housing services in terms of consumption goods.

The patient household chooses $c_{j,t}^p$, $d_{j,t}^p$, $h_{j,t}^p$ (decision on $w_{j,t}^p$ and $l_{j,t}^p$ is delegated to a "labor union" whose decision is described below) in order to maximize utility subject to the budget constraint. The corresponding FOCs are:

$$\lambda_t^p(1+\tau_c)-\frac{(1-a_{cp})\varepsilon_t^z}{c_t^p-a_{cp}c_{t-1}^p} = 0, \tag{2}$$

$$\frac{a_{hp}\varepsilon_t^h}{h_t^p}-\lambda_t^p(1+\tau_h)q_t^h+\beta_pE_t\left\{\lambda_{t+1}^p(1+\tau_h)q_{t+1}^h\right\} = 0, \text{ and} \tag{3}$$

$$\text{and } \lambda_t^p(1+\tau_d)-\beta_pE_t\left\{\lambda_{t+1}^p\left[\frac{1+(1-\tau_d)r_t^d}{\pi_{t+1}}+\tau_{fd}\right]\right\} = 0, \tag{4}$$

where we focus on symmetric equilibrium.

2.2 Impatient households

There is a continuum of impatient households in the economy indexed by j, with mass γ_i, whose utility depends on consumption $c_{j,t}^i$, housing services $h_{j,t}^i$ and hours worked $\ell_{j,t}^i$, and has the following form:

$$E_0\sum_{t=0}^{+\infty}\beta_i^t\left[(1-a_{ci})\varepsilon_t^z log(c_{j,t}^i-a_{ci}c_{t-1}^i)+a_{hi}\varepsilon_t^h log(h_{j,t}^i)-\frac{a_{\ell i}\ell_{j,t}^{i\,1+\phi}}{1+\phi}\right]$$

where c_t^i denotes the average patient household's consumption, $c_t^i=\gamma_i^{-1}\left(\int_0^{\gamma_i}c_{j,t}^i dj\right)$ and ε_t^z and ε_t^h are defined as in the patient household's problem above. The jth impatient household budget constraint, expressed in

[2]Households have access to a Arrow-Debreu securities. We do not write the whole set of possible Arrow-Debreu securities in the budget constraint to save on notation. Since their net supply is zero, they are not traded in equilibrium. However, households could trade and price any of these securities. This will be true for all types of households we consider in this paper.

terms of final goods, is given by:

$$(1+\tau_t^c)c_{j,t}^i + (1+\tau_t^h)q_t^h \Delta h_{j,t}^i + \left(\frac{1+r_{t-1}^{bi}}{\pi_t} - \tau_t^{fb}\right) b_{j,t-1}^i =$$
$$(1-\tau_t^w)w_{j,t}^i \ell_{j,t}^i + (1-\tau_t^{fb})b_{j,t}^i - \frac{T_t^{ui}}{\gamma_i} - \frac{T_t^g}{\gamma_p+\gamma_i+\gamma_e+\gamma_m}, \tag{5}$$

where τ_t^{fb} denotes taxes on the variation of loans, $w_{j,t}^i$ is the real wage in term of the consumption good, and r_{t-1}^{bi} is the nominal interest rate on loans.

This budget constraint reflects the fact that impatient households do not receive any dividend. Having said that, the expenses and incomes are similar to the ones described for patient households. The main difference is $b_{j,t}^i$, which represents bank loans. In addition, impatient households face a borrowing constraint. In terms of final goods, they cannot borrow more than a certain proportion of the expected value in period t of the value in period $t+1$ of their housing stock at period t discounted by $(1+r_t^{bi})$:

$$(1+r_t^{bi})b_{j,t}^i \leq m_t^i E_t \left\{ q_{t+1}^h h_{j,t}^i \pi_{t+1} \right\},$$

where m_t^i is the stochastic loan-to-value ratio for all impatient households' mortgages with the law of motion:

$$\log\, m_t^i = (1-\rho_{mi})\log\, m_{ss}^i + \rho_{mi}\log m_{t-1}^i + \sigma_{mi}e_t^{mi} \quad \text{where } e_t^{mi} \sim \mathcal{N}(0,1) \tag{iii}$$

We assume that the shocks in the model are small enough so that we can solve the model imposing the condition that the borrowing constraint always binds, as in Iacoviello (2005).

The impatient household chooses $c_{j,t}^i$, $d_{j,t}^i$, $h_{j,t}^i$ (decision on $w_{j,t}^i$ and $l_{j,t}^i$ is delegated to a "labor union" whose decision is described below) in order to maximize utility subject to thge budget constraint. The corresponding FOCs are:

$$\lambda_t^i(1+\tau_c) - \frac{(1-a^{ci})\varepsilon_t^z}{c_t^i - a^{ci}c_{t-1}^i} = 0, \tag{6}$$

$$\frac{a^{hi}\varepsilon_t^h}{h_t^i} - \lambda_t^i(1+\tau_h)q_t^h + \xi_t^i m_t^i E_t\left\{q_{t+1}^h \pi_{t+1}\right\} + \beta_i E_t\left\{\lambda_{t+1}^i(1+\tau_h)q_{t+1}^h\right\} = 0, \text{ and} \tag{7}$$

$$\text{and } \lambda_t^i(1-\tau_b) - \beta_i E_t\left\{\lambda_{t+1}^i\left(\frac{1+r_t^{bi}}{\pi_{t+1}} - \tau_b\right)\right\} - \xi_t^i(1+r_t^{bi}) = 0 \tag{8}$$

where we focus on symmetric equilibrium again. Also, the binding borrowing constraint can be written as:

$$(1 + r_t^{bi})b_t^i = m_t^i E_t \left\{ q_{t+1}^h h_t^i \pi_{t+1} \right\}. \tag{9}$$

2.3 Hand-to-mouth households

There is a continuum of hand-to-mouth households in the economy indexed by j, with mass γ_m, whose utility function depends on consumption $c_{j,t}^m$ and hours worked $\ell_{j,t}^i$, and has the following form:

$$E_0 \sum_{t=0}^{+\infty} \beta_m^t \left[(1 - a_{cm}) \varepsilon_t^z log(c_{j,t}^m - a_{cm} c_{t-1}^m) - \frac{a_{\ell m} \ell_{j,t}^{m^{1+\phi}}}{1+\phi} \right].$$

where c_t^m denotes the average hand-to-mouth household's consumption, $c_t^m = \gamma_m^{-1} \left(\int_0^{\gamma_m} c_{j,t}^m dj \right)$ and ε_t^z and ε_t^h are defined as in the patient household's problem above. The jth hand-to-mouth household budget constraint is given by:

$$(1 + \tau_t^c) c_{j,t}^m = (1 - \tau_t^w) w_{j,t}^m \ell_{j,t}^m - \frac{T_t^{um}}{\gamma_m} - \frac{T_t^g}{\gamma_p + \gamma_i + \gamma_e + \gamma_m} \tag{10}$$

where $w_{j,t}^m$ is the real wage in terms of the consumption good.

This budget constraint reflects the fact that hand-to-mouth households do not receive any dividend. Having said that, the only expense of hand-to-mouth households is after-tax consumption. The sources of income are labor income net of the cost of participating in the labor union paid to the unions and the lump-sum taxes paid to the government. Hand-to-mouth households do not have bank deposits or bank loans.

The hand-to-mouth household chooses $c_{j,t}^m$ (decision on $w_{j,t}^m$ and $l_{j,t}^m$ is delegated to a "labor union" whose decision is described below) in order to maximize utility subject to thebudget constraint. But not having alternative uses for its income, the only condition for maximizing the hand-to-mouth household's utility is spending it all, i.e, satisfying its binding budget constraint.

2.4 Labor unions and labor packers

There are three types of labor unions and three types of "labor packer," one for each type of household. Given the similarity of the problem of choosing wages and labor supply for the three types of households, we present a general derivation of the problem using the super-index s to denote patient households, $s = p$; impatient households, $s = i$; and hand-to-mouth households, $s = m$.

There is a continuum of labor unions of each type in the economy indexed by j. Each household (j, s) delegates its labor decision to labor unions (j, s). The labor union (j, s) sells labor in a monopolistically competitive market to the "labor packer" of type s. The labor packer of type s sells bundled labor in a competitive market to intermediate good producers. The labor packer of type s uses the following production function to bundle labor:

$$\ell_t^s = \left(\int_0^{\gamma_s} \left(\ell_{j,t}^s\right)^{\frac{\varepsilon_t^\ell - 1}{\varepsilon_t^\ell}} dj \right)^{\frac{\varepsilon_t^\ell}{\varepsilon_t^\ell - 1}},$$

where ℓ_t^s is labor from households of type s and ε_t^ℓ is the elasticity of substitution among different types of labor, which is stochastic and follows the law of motion:

$$\log \varepsilon_t^\ell = (1-\rho_\ell)\log \varepsilon_{ss}^\ell + \rho_\ell \log \varepsilon_{t-1}^\ell + \sigma_\ell e_t^\ell \quad \text{where } e_t^\ell \sim \mathcal{N}(0,1) \tag{iv}$$

The labor packer of type s chooses $l_{j,t}^s$ for all j in order to maximize:

$$w_t^s \ell_t^s - \int_0^{\gamma_s} w_{j,t}^s \ell_{j,t}^s dj.$$

subject to the production function and taking as given all wages. Both, $w_{j,t}^s$ and w_t^s refer to real wages in terms of the consumption good. The corresponding FOC is:

$$w_t^s \frac{\varepsilon_t^\ell}{\varepsilon_t^\ell - 1} \left(\int_0^{\gamma_s} \left(\ell_{j,t}^s\right)^{\frac{\varepsilon_t^\ell - 1}{\varepsilon_t^\ell}} \right)^{\frac{\varepsilon_t^\ell}{\varepsilon_t^\ell - 1} - 1} \frac{\varepsilon_t^\ell - 1}{\varepsilon_t^\ell} \left(\ell_{j,t}^s\right)^{\frac{\varepsilon_t^\ell - 1}{\varepsilon_t^\ell} - 1} - w_{j,t}^s = 0.$$

Dividing the FOCs for two members of the s-type household group, we obtain:

$$w_{j,t}^s = \left(\frac{\ell_{i,t}^s}{\ell_{j,t}^s} \right)^{\frac{1}{\varepsilon_t^\ell}} w_{i,t}^s.$$

Using the zero profits condition of labor packers implied by perfect competition, $w_t^s \ell_t^s = \int_0^{\gamma_s} w_{j,t}^s \ell_{j,t}^s dj$, we get the input demand functions associated with this problem:

$$\ell_{j,t}^s = \left(\frac{w_{j,t}^s}{w_t^s} \right)^{-\varepsilon_t^\ell} \ell_t^s.$$

To find the aggregate real wage for each type of labor we use again the zero profit condition and the demand functions to obtain:

$$w_t^s = \left(\int_0^{\gamma_s} w_{j,t}^{1-\varepsilon_t^\ell} dj \right)^{\frac{1}{1-\varepsilon_t^\ell}}.$$

The labor union of type (s,j) sets the nominal wage, $W_{j,t}^s$, by maximizing the following objective function, which represents the utility of the household supplying the labor from the resulting wage income net of a quadratic cost for adjusting the nominal wage:

$$E_0 \sum_{t=0}^{+\infty} \beta_s^t \left\{ U^s_{c,j,t} \theta_t^{wc} \left[w^s_{j,t} \ell^s_{j,t} - \frac{\eta_w}{2} \left(\pi^{ws}_{j,t} \theta^w_t - \pi^{\iota_w}_{t-1} \pi^{1-\iota_w} \theta^c_{t-1} \right)^2 w^s_t \right] - \frac{a_{\ell s} \ell^{s\,1+\phi}_{j,t}}{1+\phi} \right\}$$

subject to:

$$\ell^s_{j,t} = \left(\frac{w^s_{j,t}}{w^s_t} \right)^{-\varepsilon^\ell_t} \ell^s_t, \text{ and } w^s_{j,t} \equiv \frac{W^s_{j,t}}{P_t}$$

where:

$$\pi^{ws}_{j,t} \equiv \left(\frac{w^s_{j,t}}{w^s_{j,t-1}} \right) \pi_t, \tag{11}$$

and $\theta^{wc}_t \equiv \left(\frac{1-\tau^w_t}{1+\tau^c_t} \right)$, $\theta^w_t \equiv \left(\frac{1-\tau^w_t}{1-\tau^w_{t-1}} \right)$, $\theta^c_t \equiv \left(\frac{1+\tau^c_t}{1+\tau^c_{t-1}} \right)$ and $U^s_{c,j,t}$ represents the instantaneous marginal utility of the household taken as given by unions. Denoting $U^s_{j,t}$ as the instantaneous utility function, we have that:

$$U^s_{j,t} \equiv \begin{cases} (1-a_{cs}) \varepsilon^z_t log(c^s_{j,t} - a_{cs} c^s_{t-1}) + a_{hs} \varepsilon^z_t log(h^s_{j,t}) - \frac{a_{\ell s} \ell^{s\,1+\phi}_{j,t}}{1+\phi} \text{ for } s = p, i \\ \\ (1-a_{cs}) \varepsilon^z_t log(c^s_{j,t} - a_{cs} c^s_{t-1}) - \frac{a_{\ell s} \ell^{s\,1+\phi}_{j,t}}{1+\phi} \text{ for } s = m. \end{cases}$$

Thus, we have that:

$$U^s_{c,j,t} \equiv \frac{\partial U^s_{j,t}}{\partial c^s_{j,t}} = \frac{(1-a_{cs}) \varepsilon^z_t}{c^s_{j,t} - a_{cs} c^s_{t-1}}. \tag{12}$$

In equilibrium $U^s_{c,j,t} = (1+\tau^c_t) \lambda^s_{j,t}$ for $s = p, i$. Hence, when we focus on symmetric equilibrium, the FOC of the labor union of type $s = p, i$ with respect to the nominal wage is:

$$\begin{aligned} &\left[(1-\varepsilon^\ell_t) \ell^s_t - \eta_w \left(\pi^{ws}_t - \pi^{\iota^w}_{t-1} \pi^{1-\iota^w} \right) \pi^{ws}_t \right] + \frac{a^{\ell s} \varepsilon^\ell_t \ell^{s\,1+\phi}_t}{\lambda^s_t (1-\tau^w_t) w^s_t} + \\ &\beta_s E_t \left\{ \frac{\lambda^s_{t+1}}{\lambda^s_t} \left[\eta_w \left(\pi^{ws}_{t+1} - \pi^{\iota^w}_t \pi^{1-\iota^w} \right) \frac{\pi^{ws^2}_{t+1}}{\pi_{t+1}} \right] \right\} = 0. \end{aligned} \tag{13}$$

In the case of the labor union of type hand-to-mouth we have:

$$\begin{aligned} &\left(\frac{1-\tau_w}{1+\tau_c} \right) \left[(1-\varepsilon^\ell_t) \ell^m_t - \eta_w \left(\pi^{wm}_t - \pi^{\iota^w}_{t-1} \pi^{1-\iota^w} \right) \pi^{wm}_t \right] + \frac{a^{\ell m} \varepsilon^\ell_t \ell^{m\,1+\phi}_t}{U^m_{c,t} w^m_t} + \\ &\beta_m E_t \left\{ \frac{U^m_{c,t+1}}{U^m_{c,t}} \left[\eta_w \left(\frac{1-\tau_w}{1+\tau_c} \right) \left(\pi^{wm}_{t+1} - \pi^{\iota^w}_t \pi^{1-\iota^w} \right) \frac{\pi^{wm^2}_{t+1}}{\pi_{t+1}} \right] \right\} = 0. \end{aligned} \tag{14}$$

This implies that:

$$\ell_t^s = \left(\int_0^{\gamma_s} \left(\ell_{j,t}^s\right)^{\frac{\varepsilon_t^\ell - 1}{\varepsilon_t^\ell}} dj \right)^{\frac{\varepsilon_t^\ell}{\varepsilon_t^\ell - 1}} = \ell_{j,t}^s$$

for $s = p, i, m$. Finally, the cost of participating in the labor union is equal to the quadratic cost of changing the wage:

$$T_t^{us} = \gamma_p \frac{\eta_w}{2} \left(\pi_t^{ws}\theta_t^w - \pi_{t-1}^{\iota_w}\pi^{1-\iota_w}\theta_{t-1}^c\right)^2 w_t^s \tag{15}$$

for all types of households.

2.5 Entrepreneurs

There is a continuum of entrepreneurs in the economy indexed by j, with mass γ_e, whose utility function depends on consumption $c_{j,t}^e$, and has the following form:

$$E_0 \sum_{t=0}^{+\infty} \beta_e^t (1 - a_{ce}) log(c_{j,t}^e - a_{ce} c_{t-1}^e).$$

where c_t^e denotesthe average entrepreneur's consumption, $c_t^e = \gamma_e^{-1} \left(\int_0^{\gamma_e} c_{j,t}^e dj \right)$. The jth entrepreneur's budget constraint is given by:

$$\begin{aligned} &(1 + \tau_t^c) c_{j,t}^e + \left(\frac{1 + r_{t-1}^{be}}{\pi_t} - \tau_t^{fb} \right) b_{j,t-1}^e + q_t^k k_{j,t}^e = \\ &(1 - \tau_t^k) r_t^k k_{j,t}^e + q_t^k (1 - \delta) k_{j,t-1}^e + (1 - \tau_t^{fb}) b_{j,t}^e + \frac{J_t^R}{\gamma_e} + \frac{J_t^x}{\gamma_e} + \frac{J_t^k}{\gamma_e} - \frac{T_t^g}{\gamma_p + \gamma_i + \gamma_e + \gamma_m}. \end{aligned} \tag{16}$$

where τ_t^k denotes taxes on returns on capital, q_t^k is the price of the capital good in terms of the consumption good, r_t^k is the return on capital in terms of the consumption good, and r_{t-1}^{be} is the nominal interest rate on loans.

Entrepreneurs buy/sell the capital good from the capital good producers and rent it to the intermediate good producers. They also own the intermediate good producers' firms and the capital good producers' firms and have bank loans. The flow of expenses of entrepreneurs is given by consumption (plus consumption taxes) $(1 + \tau_t^c) c_{j,t}^e$, capital purchases $q_t^k k_{j,t}^e$, and interest plus principal of loans taken out during the previous period $\left(\frac{1 + r_{t-1}^{be}}{\pi_t} - \tau_t^{fb} \right) b_{j,t-1}^e$. The sources of income are rental capital (minus capital taxes), $(1 - \tau_t^k) r_t^k k_{j,t}^e$; loans (minus taxes on lending transactions), $(1 - \tau_t^{fb}) b_{j,t}^e$; capital from the previous period $q_t^k (1 - \delta) k_{j,t-1}^e$; dividends from the retail firms, $\frac{J_t^R}{\gamma_e}$; dividends from intermediate good producers $\frac{J_t^x}{\gamma_e}$, and dividends from capital good producers, $\frac{J_t^k}{\gamma_e}$, net of lump-sum taxes paid to the government, $\frac{T_t^g}{\gamma_p + \gamma_i + \gamma_p}$.

In addition, impatient entrepreneurs face a borrowing constraint. In terms of final goods, they cannot borrow more than a certain proportion of the expected value in period t of the value in period $t+1$ of their capital stock in period $t+1$ discounted by $(1+r_t^{be})$:

$$(1+r_t^{be})b_{j,t}^e \leq m_t^e E_t \left\{ q_{t+1}^k \pi_{t+1}(1-\delta)k_{j,t}^e \right\},$$

where m_t^e is the stochastic loan-to-value ratio for capital with the law of motion:

$$\log\, m_t^e = (1-\rho_{me})\log\, m_{ss}^e + \rho_{me}\log m_{t-1}^e + \sigma_{me}e_t^{me} \quad \text{where } e_t^{me} \sim \mathcal{N}(0,1) \tag{v}$$

As in the case of impatient households, we assume that the shocks in the model are small enough so that we can solve the model imposing the condition that the borrowing constraint always binds, as in Iacoviello (2005). The entrepreneur chooses $c_{j,t}^e$, $k_{j,t}^e$, and $b_{j,t}^e$. The corresponding FOC are:

$$\lambda_t^e(1+\tau_c) - \frac{1-a_{ce}}{c_t^e - a_{ce}c_{t-1}^e} = 0, \tag{17}$$

$$q_t^k - (1-\tau_k)r_t^k - \beta_e E_t \left\{ \frac{\lambda_{t+1}^e}{\lambda_t^e} \left[q_{t+1}^k(1-\delta) \right] \right\} - \left(\frac{\xi_t^e}{\lambda_t^e} \right) m_t^e E_t \left\{ q_{t+1}^k(1-\delta)\pi_{t+1} \right\} = 0 \tag{18}$$

$$\lambda_t^e(1-\tau_b) - \xi_t^e(1+r_t^{be}) - \beta_e E_t \left\{ \lambda_{t+1}^e \left(\frac{1+r_t^{be}}{\pi_{t+1}} - \tau_b \right) \right\} = 0, \tag{19}$$

where we focus on symmetric equilibrium again. Also, the binding borrowing constraint can be written as:

$$(1+r_t^{be})b_t^e = m_t^e E_t \left\{ q_{t+1}^k \pi_{t+1}(1-\delta)k_t^e \right\}. \tag{20}$$

2.6 Intermediate good producers

There is a continuum of competitive intermediate good producers in the economy indexed by j, with mass γ_x. Intermediate good producers sell intermediate goods in a competitive market to retailers.

The jth intermediate good producer has access to a technology represented by a production function:

$$y_{j,t}^x = A_t \left(k_{j,t-1}^{ee} u_j \right)^\alpha \left[\left(\ell_{j,t}^{pp} \right)^{\mu_p} \left(\ell_{j,t}^{ii} \right)^{\mu_i} \left(\ell_{j,t}^{mm} \right)^{\mu_m} \right]^{1-\alpha} \left(\frac{K_{t-1}^g}{\gamma_x} \right)^{\alpha_g},$$

where $k_{j,t-1}^{ee}$ is the capital rented by the firm from entrepreneurs, u_j is the capital utilization rate that we consider exogenous, $\ell_{j,t}^{pp}$ is the amount of "packed" patient labor input rented by the firm, $\ell_{j,t}^{ii}$ is the amount of "packed" impatient labor input rented by the firm, $\ell^{mm}_{j,t}$ is the amount of "packed" hand-to-mouth labor input rented by the firm, and K^g_{t-1} is the amount of public capital controlled by the government. A_t denotes an aggregate productivity shock with the law of motion:

$$\log A_t = (1-\rho_A)\log A_{ss} + \rho_A \log A_{t-1} + \sigma_A e^A_t \text{ where } e^A_t \sim \mathcal{N}(0,1) \tag{vi}$$

In addition to the cost of the inputs required for production, the intermediate good producers face a fixed cost of production, Φ_x, which guarantees that the economic profits are roughly equal to zero in the steady-state, to be consistent with the additional assumption of no entry and exit of intermediate good producers and a cost of utilization of capital equal to

$$\left[\psi_{u_1}(u_j-1) + \frac{\psi_{u_1}}{2}(u_j-1)^2\right] k^{ee}_{j,t-1}.$$

Intermediate good producers choose $k^{ee}_{j,t-1}$, $\ell^{pp}_{j,t}$, $\ell^{ii}_{j,t}$, and $\ell^{mm}_{j,t}$ to maximize profits taken all prices as given. The FOCs are:

$$w^p_t = \frac{\mu^p(1-\alpha)}{x_t}\frac{y^x_{j,t}}{\ell^{pp}_{j,t}}, \tag{21}$$

$$w^i_t = \frac{\mu^i(1-\alpha)}{x_t}\frac{y^x_{j,t}}{\ell^{ii}_{j,t}}, \tag{22}$$

$$w^m_t = \frac{\mu^m(1-\alpha)}{x_t}\frac{y^x_{j,t}}{\ell^{mm}_{j,t}}, \tag{23}$$

$$r^k_t = \alpha\frac{y^x_{j,t}}{x_t k^{ee}_{j,t-1}} - \left[\psi_{u_1}(u_j-1) + \frac{\psi_{u_1}}{2}(u_j-1)^2\right], \tag{24}$$

where x_t is the inverse of the of price intermediate goods in terms of the consumption good.

After integrating out both sides of Equations (21)-(23) with respect to j we get:

$$w^p_t = \frac{\mu^p(1-\alpha)}{x_t}\frac{y^x_t}{\ell^{pp}_t},$$

$$w^i_t = \frac{\mu^i(1-\alpha)}{x_t}\frac{y^x_t}{\ell^{ii}_t},$$

$$w^m_t = \frac{\mu^m(1-\alpha)}{x_t}\frac{y^x_t}{\ell^{mm}_t},$$

where $y^x_t = \int_0^{\gamma_x} y^x_{j,t}dj$ and $\ell^{ss}_t = \int_0^{\gamma_x} \ell^{ss}_{j,t}dj$ for all $s \in \{p,i,m\}$. It also follows that the ratio of capital to labor is independent of j:

$$\frac{k^{ee}_{j,t-1}}{\ell^{pp}_{j,t}} = \frac{\alpha}{(1-\alpha)}\frac{1}{\mu^p}\frac{w^p_t}{\left(r^k_t + \left[\psi_{u_1}(u_j-1) + \frac{\psi_{u_1}}{2}(u_j-1)^2\right]\right)} \equiv \frac{1}{\kappa_{p,t}},$$
$$\frac{k^{ee}_{j,t-1}}{\ell^{ii}_{j,t}} = \frac{\alpha}{(1-\alpha)}\frac{1}{\mu^i}\frac{w^i_t}{\left(r^k_t + \left[\psi_{u_1}(u_j-1) + \frac{\psi_{u_1}}{2}(u_j-1)^2\right]\right)} \equiv \frac{1}{\kappa_{i,t}}, \text{ and}$$
$$\frac{k^{ee}_{j,t-1}}{\ell^{mm}_{j,t}} = \frac{\alpha}{(1-\alpha)}\frac{1}{\mu^m}\frac{w^m_t}{\left(r^k_t + \left[\psi_{u_1}(u_j-1) + \frac{\psi_{u_1}}{2}(u_j-1)^2\right]\right)} \equiv \frac{1}{\kappa_{m,t}}.$$

These equations also imply that:

$$\frac{k^{ee}_{t-1}}{\ell^{pp}_{t}} = \frac{1}{\kappa_{p,t}},$$
$$\frac{k^{ee}_{t-1}}{\ell^{ii}_{t}} = \frac{1}{\kappa_{i,t}}, \text{ and}$$
$$\frac{k^{ee}_{t-1}}{\ell^{mm}_{t}} = \frac{1}{\kappa_{m,t}},$$

where $k^{ee}_t = \int_0^{\gamma_x} k^{ee}_{j,t} dj$. Substituting these ratios into the production function yields:

$$\begin{aligned}
y^x_{j,t} &= A_t\left(k^{ee}_{j,t-1}u_j\right)^{\alpha}\left[\left(k^{ee}_{j,t-1}\kappa_{p,t}\right)^{\mu_p}\left(k^{ee}_{j,t-1}\kappa_{i,t}\right)^{\mu_i}\left(k^{ee}_{j,t-1}\kappa_{m,t}\right)^{\mu_m}\right]^{1-\alpha}\left(\frac{K^g_{t-1}}{\gamma_x}\right)^{\alpha_g} \\
&= A_t\left(k^{ee}_{j,t-1}u_j\right)^{\alpha}\left(k^{ee}_{j,t-1}\right)^{(1-\alpha)(\mu_p+\mu_i+\mu_m)}\left[\left(\kappa_{p,t}\right)^{\mu_p}\left(\kappa_{i,t}\right)^{\mu_i}\left(\kappa_{m,t}\right)^{\mu_m}\right]^{1-\alpha}\left(\frac{K^g_{t-1}}{\gamma_x}\right)^{\alpha_g} \\
&= k^{ee}_{j,t-1}A_t\left(u_j\right)^{\alpha}\left(k^{ee}_{j,t-1}\right)^{-(1-\alpha)+(1-\alpha)(\mu_p+\mu_i+\mu_m)}\left[\left(\kappa_{p,t}\right)^{\mu_p}\left(\kappa_{i,t}\right)^{\mu_i}\left(\kappa_{m,t}\right)^{\mu_m}\right]^{1-\alpha}\left(\frac{K^g_{t-1}}{\gamma_x}\right)^{\alpha_g} \\
&= k^{ee}_{j,t-1}A_t\left(u_j\right)^{\alpha}\frac{1}{\left(k^{ee}_{j,t-1}\right)^{(1-\alpha)(1-(\mu_p+\mu_i+\mu_m))}}\left[\left(\kappa_{p,t}\right)^{\mu_p}\left(\kappa_{i,t}\right)^{\mu_i}\left(\kappa_{m,t}\right)^{\mu_m}\right]^{1-\alpha}\left(\frac{K^g_{t-1}}{\gamma_x}\right)^{\alpha_g} \\
&= k^{ee}_{j,t-1}A_t\left(u_j\right)^{\alpha}\frac{\left(k^{ee}_{j,t-1}\right)^{\alpha_g}}{\left(k^{ee}_{j,t-1}\right)^{(1-\alpha)(1-(\mu_p+\mu_i+\mu_m))}}\left[\left(\kappa_{p,t}\right)^{\mu_p}\left(\kappa_{i,t}\right)^{\mu_i}\left(\kappa_{m,t}\right)^{\mu_m}\right]^{1-\alpha}\left(\frac{K^g_{t-1}}{k^{ee}_{j,t-1}\gamma_x}\right)^{\alpha_g}
\end{aligned}$$

After some algebra, this implies that:

$$y^x_t = A_t\left(k^{ee}_{t-1}u\right)^{\alpha}\left[\left(\ell^{pp}_t\right)^{\mu_p}\left(\ell^{ii}_t\right)^{\mu_i}\left(\ell^{mm}_t\right)^{\mu_m}\right]^{1-\alpha}\left(\frac{K^g_{t-1}}{k^{ee}_{j,t-1}\gamma_x}\right)^{\alpha_g}, \tag{25}$$

where we have imposed that

$$u_j = u. \tag{26}$$

Finally, the profits of the individual intermediate good producers are:

$$\frac{J_t^x}{\gamma_x} = \frac{y_t^x}{x_t} - w_t^p \ell_t^{pp} - w_t^i \ell_t^{ii} - w_t^m \ell_t^{mm} - r_t^k k_{t-1}^{ee} - \Phi_x - \left[\psi_{u_1}(u_j - 1) + \frac{\psi_{u_1}}{2}(u_j - 1)^2\right] k_{j,t-1}^{ee}. \tag{27}$$

2.7 Capital good producers

There is a continuum of capital goods producers in the economy indexed by j, with mass γ_k. Capital goods producers sell new capital goods, $k_{j,t}$, in a competitive market, to entrepreneurs.

The jth capital goods producer produces these new capital goods out of the non-depreciated portion of old capital goods, $(1-\delta)k_{j,t-1}$, bought from entrepreneurs at price q_t^k, and of gross investment goods, $i_{j,t}^z$, bought from investment good packers at price p_t^I. However, whereas old non-depreciated capital goods can be converted one to one to new capital, gross investment goods are subject to non-linear adjustment costs, which causes a one to less than one conversion, such that, all in all, the amount of new capital goods evolves according to the following law of motion,

$$k_{j,t} = (1-\delta)k_{j,t-1} + i_{j,t}\varepsilon_t^k.$$

where $i_{j,t}$ is *effective* investment, which is related to investment (*gross of adjustment costs*) through the following expression,

$$i_{j,t}^z = i_{j,t}\left[1 + \frac{\eta_i}{2}\frac{i_{j,t}}{k_{j,t-1}}\right] \tag{28}$$

so that $i_{j,t} \leq i_{j,t}^z$, and ε_t^k is an investment-specific productivity shock with the law of motion,

$$\log \varepsilon_t^k = (1-\rho_k)\log \varepsilon_{ss}^k + \rho_k \log \varepsilon_{t-1}^k + \sigma_k e_t^k \quad e_t^k \sim \mathcal{N}(0,1) \tag{vii}$$

Then, each capital good producer chooses $k_{j,t}$ and $i_{j,t}$ in order to maximize profit subject to the law of motion for capital. The corresponding FOCs are reduced to:

$$q_t^k \varepsilon_t^k - p_t^I\left(1 + \frac{\eta_j i_{j,t}}{k_{j,t-1}}\right) = 0$$

Because of complete markets we get $i_{j,t} = i_t$ and hence:

$$q_t^k \varepsilon_t^k - p_t^I\left(1 + \frac{\eta_i i_t}{k_{t-1}}\right) = 0 \tag{29}$$

and

$$k_t = (1-\delta)k_{t-1} + i_t\varepsilon_t^k \tag{30}$$

Finally, the profits of the representative capital good producer are:

$$\frac{J_t^k}{\gamma_k} = \left[q_t^k\varepsilon_t^k - p_t^I\left(1+\frac{\eta_i}{2}\frac{\imath_t}{k_{t-1}}\right)\right]i_t. \tag{31}$$

2.8 Retailers

There is a continuum of retailers indexed by j, with mass γ. Each retailer buys the intermediate good from intermediate goods producers, differentiates it and sells the resulting varieties of intermediate goods, in a monopolistically competitive market, to goods packers, who, in turn, bundle the varieties together into a domestic good and sell it, in a competitive market, to consumption and investment goods packers that bundle home and imported production.

We assume that retail prices are indexed by a combination of past and steady-state inflation of retail prices with relative weights parameterized by ι_p. In addition, retailers are subject to quadratic price adjustment costs, where η_p controls the size of these costs.

Then, each retailer chooses the nominal price for its differentiated good, $P_{j,t}^H$ to maximize:

$$E_0\sum_{t=0}^{+\infty}\beta_p^t\lambda_{j,t}^p\left[p_t^H\frac{P_{j,t}^H y_{j,t}}{P_t^H} - \frac{y_{j,t}^{xx}}{x_t} - \frac{\eta_p}{2}\left(\frac{P_{j,t}^H}{P_{j,t-1}^H} - \left(\pi_{t-1}^H\right)^{\iota_p}\left(\pi_{ss}^H\right)^{1-\iota_p}\right)^2 y_t\right]$$

subject to:

$$\begin{aligned} y_{j,t} &= y_{j,t}^{xx} \\ y_{j,t} &= \left(\frac{P_{j,t}^H}{P_t^H}\right)^{-\varepsilon_t^y} y_t, \end{aligned}$$

here we have used $\lambda_{j,t}^p$ because capital good producers are owned by patient households, $p_t^H = \frac{P_t^H}{P_t}$, $\pi_t^H = \frac{P_t^H}{P_{t-1}^H}$, and ε_t^y is the elasticity of substitution, which follows an AR(1) process with the law of motion:

$$\log\,\varepsilon_t^y = (1-\rho_y)\log\,\varepsilon_{ss}^y + \rho_y\log\,\varepsilon_{t-1}^y + \sigma_y e_t^y \quad e_t^y \sim \mathcal{N}(0,1) \tag{viii}$$

The demand faced by retailers is derived from the optimization problem solved by goods packers, left implicit.

The FOC of retailers is:

$$p_t^H\left(1-\varepsilon_t^y\right)+\frac{\varepsilon_t^y}{x_t}-\eta_p\pi_t^H\left(\pi_t^H-\left(\pi_{t-1}^H\right)^{\iota_p}\left(\pi_{ss}^H\right)^{1-\iota_p}\right)+$$
$$\beta_p E_t\left\{\frac{\lambda_{t+1}^p}{\lambda_t^p}\left[\left(\pi_{t+1}^H\right)\left(\frac{Y_{t+1}}{Y_t}\right)\eta_p\left(\pi_{t+1}^H-\left(\pi_t^H\right)^{\iota_p}\left(\pi_{ss}^H\right)^{1-\iota_p}\right)\right]\right\}=0, \tag{32}$$

where we have omitted the sub-indexes j in the FOC because of complete markets and the construction of a symmetric equilibrium, which also implies that $\lambda_{j,t}^p=\lambda_t^p$ and $P_{j,t}^H=P_t^H$. Hence we have that:

$$y_t=\left(\int_0^\gamma y_{j,t}^{\frac{\varepsilon_t^y}{1-\varepsilon_t^y}}dj\right)^{\frac{1-\varepsilon_t^y}{\varepsilon_t^y}}=y_{j,t}.$$

Finally, the individual retailer's profits are:

$$\frac{J_t^R}{\gamma}=y_t\left[1-\frac{1}{x_t}-\frac{\eta_p}{2}\left(\pi_t^H-\left(\pi_{t-1}^H\right)^{\iota_p}\left(\pi_{ss}^H\right)^{1-\iota_p}\right)^2\right]. \tag{33}$$

2.9 Banks

There is a continuum of bank branches with mass γ_b. Each bank branch is composed of three units: a wholesale unit and two retail units. The two retail units are responsible for selling differentiated loans and differentiated deposits, in monopolistically competitive markets, to loan and deposit packers. The wholesale unit manages the capital position of the bank, receives loans from abroad, and raises wholesale domestic loans and deposits. The loan-retailing unit also gives loans to the government in a competitive market.

2.9.1 Wholesale unit

The wholesale unit of branch j combines bank capital, $k_{j,t}^b$, wholesale deposits, $d_{j,t}^b$, and foreign borrowing, $-\frac{B_{j,t}^*}{\gamma_b}$, in order to issue wholesale domestic loans, $b_{j,t}^b$, in a competitive market and everything expressed in terms of consumption goods. Thus, the balance sheet of the wholesale unit of branch j is:

$$b_{j,t}^b=d_{j,t}^b-\frac{B_{j,t}^*}{\gamma_b}+k_{j,t}^b.$$

The wholesale units pay a quadratic cost whenever the capital-to-assets ratio $\frac{k^b_{j,t}}{b^b_{j,t}}$ deviates from an exogenously given target, η_b. Finally, bank capital, in nominal terms, $\hat{k}^b_j$ evolves according to the following law of motion:

$$\hat{k}^b_{j,t} = \frac{(1-\delta_b)}{\varepsilon^{kb}_t}\hat{k}^b_{j,t-1} + \omega_b \hat{j}^b_{j,t-1},$$

where ε^{kb}_t is a shock to the bank capital management and $\hat{j}^b_{j,t}$ represents the profits of the bank in nominal terms. In terms of $k^b_{j,t} \equiv \frac{\hat{k}^b_{j,t}}{P_t}$ and $j^b_{j,t} \equiv \frac{\hat{j}^b_{j,t}}{P_t}$ the latter expression becomes:

$$P_t k^b_{j,t} = \frac{(1-\delta_b)}{\varepsilon^{kb}_t} P_{t-1} k^b_{j,t-1} + \omega_b P_t j^b_{j,t-1},$$

or equivalently:

$$\pi_t k^b_{j,t} = \frac{(1-\delta_b)}{\varepsilon^{kb}_t} k^b_{j,t-1} + \omega_b \pi_t j^b_{j,t-1}.$$

Finally ε^{kb}_t follows the following law of motion:

$$\log\,\varepsilon^{kb}_t = (1-\rho_{kb})\log\,\varepsilon^{kb}_{ss} + \rho_{kb}\log\,\varepsilon^{kb}_{t-1} + \sigma_{kb} e^{kb}_t \text{ with } e^{kb}_t \sim \mathcal{N}(0,1) \tag{ix}$$

Given these definitions, the problem of the wholesale unit of branch j is to choose the amount of wholesale loans, $b^b_{j,t}$, and wholesale deposits, $d^b_{j,t}$, and foreign borrowing, B^*_t, in order to maximize cash flows:

$$\max_{b^b_{j,t}, d^b_{j,t}, B^*_{j,t}} r^b_t b^b_{j,t} - r_t d^b_{j,t} + r^*_t \frac{B^*_{j,t}}{\gamma_b} - \frac{\eta_b}{2}\left(\frac{k^b_{j,t}}{b^b_{j,t}} - \nu_b\right)^2 k^b_{j,t},$$

where r^b_t, r_t, and r^*_t are the gross real interest rates for wholesale lending, wholesale deposits, and foreign borrowing respectively, all of them taken as given and in terms of the consumption goods. The rate r_t is the monetary policy rate that follows from the assumption that wholesale units can obtain funds from the monetary authority at that rate. The FOC displays the following results:

$$(r^b_t - r^*_t) = -\eta_b\left(\frac{k^b_t}{b^b_t} - \nu_b\right)\left(\frac{k^b_t}{b^b_t}\right)^2. \tag{34}$$

We can drop the sub-index j from the FOCs because we focus on a symmetric equilibrium where each wholesale bank unit decides its optimal capital-to-loans ratio, taking as given the capital-to-loans ratios of other banks.

Accordingly, we can drop the sub-index from the law of motion for bank capital:

$$\pi_t k_t^b = \frac{(1-\delta_b)}{\varepsilon_t^{kb}} k_{t-1}^b + \omega_b \left(\frac{\pi_t J_{t-1}^b}{\gamma_b} \right), \tag{35}$$

and the balance-sheet equation of each wholesale unit:

$$b_t^b = d_t^b - \frac{\alpha_{ED} B_t^*}{\gamma_b} + k_t^b. \tag{36}$$

Following Schmitt-Grohe and Uribe (2003), to ensure the stationarity of equilibrium we assume that:

$$r_t^* = \phi_t r_t, \tag{37}$$

where the risk premium ϕ_t increases with the external debt according to the expression

$$\log \phi_t = -\widetilde{\phi} \left(\exp\left(B_t^*\right) - 1 \right) + \theta_t^{rp} \tag{38}$$

and the shock θ_t^{rp} obeys the following law of motion:

$$\theta_t^{rp} = (1-\rho_{rp})\theta_{ss}^{rp} + \rho_{rp}\theta_{t-1}^{rp} + \sigma_{rp}\, e_t^{rp} \text{ with } e_t^{rp} \sim \mathcal{N}(0,1) \tag{x}$$

2.9.2 Deposit-retailing unit

The deposit-retailing unit of branch j combines bank capital and sells a differentiated type of deposit, $d_{j,t}^{pp}$, in a monopolistically competitive market, to deposit packers, who bundle the varieties together and sell the packed deposits, in a competitive market, to patient households, d_t^{pp}. Finally, each deposit-retailing unit uses its resources to buy $d_{j,t}^b$ from the wholesale banks. Thus, the balance sheet of the deposit-retailing unit of branch j is:

$$d_{j,t}^b = d_{j,t}^{pp}.$$

The deposit-retailing unit of branch j chooses the real gross interest rate paid by its type of deposit, $r_{j,t}^d$ in order to maximize:

$$E_0 \sum_{t=0}^{+\infty} \beta_p^t \lambda_t^p \left[r_t d_{j,t}^b - r_{j,t}^d d_{j,t}^{pp} - \frac{\eta_d}{2} \left(\frac{r_{j,t}^d}{r_{j,t-1}^d} - 1 \right)^2 r_t^d d_t^{pp} \right]$$

subject to:

$$d^b_{j,t} = d^{pp}_{j,t},$$
$$d^{pp}_{j,t} = \left(\frac{r^d_{j,t}}{r^d_t}\right)^{-\varepsilon^d_t} d^{pp}_t,$$

where we have used $\lambda^p_{j,t}$ because capital good producers are owned by patient households, and ε^d_t is the elasticity of substitution between types of deposits. In practice, we re-parameterize this elasticity as $\varepsilon^d_t \equiv \left(\frac{\theta^d_t}{\theta^d_t - 1}\right)$ with θ^d_t, obeying the following law of motion:

$$\log\,\theta^d_t = (1-\rho_d)\log\,\theta^d_{ss} + \rho_d \log\,\theta^d_{t-1} + \sigma_d e^d_t \text{ with } e^d_t \sim \mathcal{N}(0,1) \tag{xi}$$

The demand faced by deposit-retailing units is derived from the optimization problem solved by deposits packer, left implicit. The FOCs of deposit-retailing units are:

$$1 + \frac{r_t}{r^d_t}\left(\frac{\theta^d_t}{\theta^d_t - 1}\right) - \left(\frac{\theta^d_t}{\theta^d_t - 1}\right) + \eta_d \left(\frac{r^d_t}{r^d_{t-1}} - 1\right)\frac{r^d_t}{r^d_{t-1}}$$
$$-\beta_p E_t \left\{ \frac{\lambda^p_{t+1}}{\lambda^p_t}\left[\eta_d \left(\frac{r^d_{t+1}}{r^d_t} - 1\right)\left(\frac{r^d_{t+1}}{r^d_t}\right)^2 \frac{d^{pp}_{t+1}}{d^{pp}_t}\right]\right\} = 0, \tag{39}$$

where we have omitted the subindexes j in the FOC because of complete markets and the construction of a symmetric equilibrium, which also implies that $\lambda^p_{j,t} = \lambda^p_t$ and $r^d_{j,t} = r^d_t$. Hence we have that:

$$d^{pp}_t = \left(\int_0^\gamma \left(d^{pp}_{j,t}\right)^{\frac{\varepsilon^d_t}{1-\varepsilon^d_t}} dj\right)^{\frac{1-\varepsilon^d_t}{\varepsilon^d_t}} = d^{pp}_{j,t}$$

and:

$$d^b_t = d^{pp}_t. \tag{40}$$

2.9.3 Loan-retailing unit

The loan-retailing unit of branch j borrows from the wholesale unit, $b^b_{j,t}$, creates differentiated loans and sells the resulting loan, in a monopolistically competitive market, to loan packers, who sell the packed loans to impatient households, $b^{ii}_{j,t}$ and entrepreneurs, $b^{ee}_{j,t}$. Each loan-retailing unit also lends to the government, B^g_t, in a competitive market at a rate $\theta^g_{ss} r^b_t$, i.e., charging a mark-up over the cost of the funds, but taking both the mark-up and the cost of the funds as given. Thus, the balance-sheet of the loan-retailing unit of branch j is:

$$b^{ii}_{j,t} + b^{ee}_{j,t} + \frac{\alpha_{B_g}\alpha_{RW}B^g_t}{\gamma_b} = b^b_{j,t}.$$

The loan-retailing unit of branch j chooses the real gross interest rates for its loans to impatient households, $r^{bi}_{j,t}$, and entrepreneurs, $r^{be}_{j,t}$, in order to maximize profits subject to:

$$b^{ii}_{j,t} + b^{ee}_{j,t} + \frac{\alpha_{B_g}\alpha_{RW}B^g_t}{\gamma_b} = b^b_{j,t}, \tag{41}$$

$$b^{ii}_{j,t} = \left(\frac{r^{bi}_{j,t}}{r^{bi}_t}\right)^{-\varepsilon^{bi}_t} b^{ii}_t, \tag{42}$$

$$b^{ee}_{j,t} = \left(\frac{r^{be}_{j,t}}{r^{be}_t}\right)^{-\varepsilon^{be}_t} b^{ee}_t, \tag{43}$$

where we have used $\lambda^p_{j,t}$ because capital good producers are owned by patient households, ε^{bi}_t and ε^{be}_t are the elasticities of substitution between types of loans for impatient households and for entrepreneurs, respectively. In practice, we re-parameterize these elasticities as $\varepsilon^{bs}_t \equiv \left(\frac{\theta^{bs}_t}{\theta^{bs}_t - 1}\right)$ for $s = i, e$ with θ^{bs}_t, obeying the following law of motion:

$$\log\,\theta^{bs}_t = (1-\rho_{bs})\log\,\theta^d_{ss} + \rho_{bs}\log\,\theta^{bs}_{t-1} + \sigma_{bs}e^{bs}_t \text{ with } e^{bs}_t \sim \mathcal{N}(0,1) \tag{xii - xiii}$$

The demand faced by the loan-retailing unit in Equations (42) and (43) is derived from the optimization problem solved by loan packers, left implicit. The FOCs for this problem are:

$$1 + \frac{r^b_t}{r^{bi}_t}\left(\frac{\theta^{bi}_t}{\theta^{bi}_t - 1}\right) - \left(\frac{\theta^{bi}_t}{\theta^{bi}_t - 1}\right) - \eta_{bi}\left(\frac{r^{bi}_t}{r^{bi}_{t-1}} - 1\right)\frac{r^{bi}_t}{r^{bi}_{t-1}} + \\ \beta_p E_t\left\{\frac{\lambda^p_{t+1}}{\lambda^p_t}\left[\eta_{bi}\left(\frac{r^{bi}_{t+1}}{r^{bi}_t} - 1\right)\left(\frac{r^{bi}_{t+1}}{r^{bi}_t}\right)^2\frac{b^{ii}_{t+1}}{b^{ii}_t}\right]\right\} = 0 \text{ and} \tag{44}$$

$$1 + \frac{r^b_t}{r^{be}_t}\left(\frac{\theta^{be}_t}{\theta^{be}_t - 1}\right) - \left(\frac{\theta^{be}_t}{\theta^{be}_t - 1}\right) - \eta_{be}\left(\frac{r^{be}_t}{r^{be}_{t-1}} - 1\right)\frac{r^{be}_t}{r^{be}_{t-1}} + \\ \beta_p E_t\left\{\frac{\lambda^p_{t+1}}{\lambda^p_t}\left[\eta_{be}\left(\frac{r^{be}_{t+1}}{r^{be}_t} - 1\right)\left(\frac{r^{be}_{t+1}}{r^{be}_t}\right)^2\frac{b^{ee}_{t+1}}{b^{ee}_t}\right]\right\} = 0 \tag{45}$$

where again we drop the sub-index j for of the reasons mentioned above, which also implies that $r_{j,t}^{bi} = r_t^{bi}$ and $r_{j,t}^{be} = r_t^{be}$. Hence we have that:

$$b_t^{ii} = \left(\int_0^\gamma \left(b_{j,t}^{ii}\right)^{\frac{\varepsilon_t^{bi}}{1-\varepsilon_t^{bi}}} dj\right)^{\frac{1-\varepsilon_t^{bi}}{\varepsilon_t^{bi}}} = b_{j,t}^{ii} \text{ and}$$

$$b_t^{ee} = \left(\int_0^\gamma \left(b_{j,t}^{ee}\right)^{\frac{\varepsilon_t^{be}}{1-\varepsilon_t^{be}}} dj\right)^{\frac{1-\varepsilon_t^{be}}{\varepsilon_t^{be}}} = b_{j,t}^{ee}.$$

It also allows us to write:

$$b_t^{ii} + b_t^{ee} + \frac{\alpha_{B_g}\alpha_{RW} B_t^g}{\gamma_b} = b_t^b. \tag{46}$$

2.9.4 Profits

The profit of the bank branch j in terms of consumption good units is given by:

$$\begin{aligned} j_t^b = {} & r_t^{bi} b_t^{ii} + r_t^{be} b_t^{ee} + \theta_{ss}^g r_t^b \left(\alpha_{RW} \frac{B_t^g}{\gamma_b}\right) - r_t^d d_t^{pp} + r_t^* \alpha_{ED} \frac{B_t^*}{\gamma_b} - \frac{\eta_b}{2}\left(\frac{k_t^b}{b_t^b} - \nu_b\right)^2 k_t^b \\ & - \frac{\eta_d}{2}\left(\frac{r_t^d}{r_{t-1}^d} - 1\right)^2 r_t^d d_t - \frac{\eta_{bi}}{2}\left(\frac{r_t^{bi}}{r_{t-1}^{bi}} - 1\right)^2 r_t^{bi} b_t^{ii} - \frac{\eta_{be}}{2}\left(\frac{r_t^{be}}{r_{t-1}^{be}} - 1\right)^2 r_t^{be} b_t^{ee}, \end{aligned} \tag{47}$$

where again we drop the sub-index j for the reasons mentioned above.

2.10 External sector

We consider a world of two asymmetric countries in which the home country is small relative to the other (the rest of the world), whose equilibrium is taken as exogenous (see Monacelli (2004) and Galí and Monacelli (2005)).

2.10.1 Imports

There is a continuum of consumption good packers in the economy indexed by j with mass γ_c that buy domestic goods from good packers, $c_{j,t}^h$, and import foreign goods, $c_{j,t}^f$, pack them and sell the bundle, in a competitive market, to households and entrepreneurs for consumption. The packing technology is expressed by the following CES composite baskets of home- and foreign-produced goods:

$$c_{j,t}^c = \left((1-\omega^c \varepsilon_t^{\omega d})^{\frac{1}{\sigma_c}} \left(c_{j,t}^h\right)^{\frac{\sigma_c - 1}{\sigma_c}} + (\omega^c \varepsilon_t^{\omega d})^{\frac{1}{\sigma_c}} \left(c_{j,t}^f\right)^{\frac{\sigma_c-1}{\sigma_c}}\right)^{\frac{\sigma_c}{\sigma_c - 1}}.$$

There is also a continuum of investment good packers in the economy indexed by j with mass γ_z that buy domestic goods from good packers, $i^h_{j,t}$, and import foreign goods, $i^f_{j,t}$, pack them and sell the bundle, in a competitive market, to capital producers. The technology is given by

$$i^z_{j,t} = \left((1-\omega^i \varepsilon^{\omega d}_t)^{\frac{1}{\sigma_i}} \left(i^h_{j,t}\right)^{\frac{\sigma_i - 1}{\sigma_i}} + (\omega^i \varepsilon^{\omega d}_t)^{\frac{1}{\sigma_i}} \left(i^f_{j,t}\right)^{\frac{\sigma_i - 1}{\sigma_i}} \right)^{\frac{\sigma_i}{\sigma_i - 1}},$$

where σ_c and σ_i are the consumption and investment elasticities of substitution between domestic and foreign goods and, ω^c and ω^i, are inversely related to the degree of home bias and, therefore, directly with openness. These parameters are assumed to be affected by the same shock, $\varepsilon^{\omega d}_t$, which evolves over time according to the following expressions:

$$\log \varepsilon^{\omega d}_t = (1-\rho_{\omega d})\log \varepsilon^{\omega d}_{ss} + \rho_{\omega d}\log \varepsilon^{\omega d}_{t-1} + \sigma_{\omega d} e^{\omega d}_t \text{ with } e^{\omega d}_t \sim \mathcal{N}(0,1) \tag{xiv}$$

Each period, the consumption goods packer chooses $c^h_{j,t}$ and $c^f_{j,t}$ to minimize production costs subject to the technological constraint. The FOCs are:

$$c^h_{j,t} = (1-\omega^c \varepsilon^{\omega d}_t) \left(p^H_t\right)^{-\sigma_c} c^c_{j,t},$$
$$c^f_{j,t} = (\omega^c \varepsilon^{\omega d}_t) \left(p^M_t\right)^{-\sigma_c} c^c_{j,t},$$

where p^H_t is the price of domestic goods relative to consumption goods and p^M_t is the price of imported goods relative to consumption goods. Similarly, the FOCs for the investment goods packer are:

$$i^h_{j,t} = (1-\omega^i \varepsilon^{\omega d}_t) \left(\frac{p^H_t}{p^I_t}\right)^{-\sigma_i} i^z_{j,t},$$
$$i^f_{j,t} = (\omega^i \varepsilon^{\omega d}_t) \left(\frac{p^M_t}{p^I_t}\right)^{-\sigma_i} i^z_{j,t},$$

where p^I_t is the price of investment goods relative to consumption goods.

By assuming a symmetric equilibrium we can drop the sub-index j to get:

$$c_t^h = (1 - \omega^c \varepsilon_t^{\omega d}) \left(p_t^H\right)^{-\sigma_c} c_t^c, \tag{48}$$

$$c_t^f = (\omega^c \varepsilon_t^{\omega d}) \left(p_t^M\right)^{-\sigma_c} c_t^c, \tag{49}$$

$$i_t^h = (1 - \omega^i \varepsilon_t^{\omega d}) \left(\frac{p_t^H}{p_t^I}\right)^{-\sigma_i} i_t^z, \tag{50}$$

$$i_t^f = (\omega^i \varepsilon_t^{\omega d}) \left(\frac{p_t^M}{p_t^I}\right)^{-\sigma_i} i_t^z. \tag{51}$$

Because profits have to be zero, we have the following relationships:

$$1 = \left((1 - \omega^c \varepsilon_t^{\omega d}) \left(p_t^H\right)^{1-\sigma_c} + (\omega^c \varepsilon_t^{\omega d}) \left(p_t^M\right)^{1-\sigma_c}\right)^{\frac{1}{1-\sigma_c}}, \tag{52}$$

$$p_t^I = \left((1 - \omega^i \varepsilon_t^{\omega d}) \left(p_t^H\right)^{1-\sigma_i} + (\omega^i \varepsilon_t^{\omega d}) \left(p_t^M\right)^{1-\sigma_i}\right)^{\frac{1}{1-\sigma_i}}. \tag{53}$$

Given the small open economy assumption, the price of imports in domestic currency is defined as:

$$p_t^M = er_t(1 + \tau_t^m), \tag{54}$$

where er_t is the real exchange rate (and ER_t the nominal exchange rate), i.e., $er_t = \frac{ER_t P_t^*}{P_t}$, τ_t^m represents the import tariff, and P_t^* stands for the exogenous world price index.[3]

Some definitions follow from the previous equations:

$$C_t = \gamma_c c_t^c, \tag{55}$$

$$C_t^h = \gamma_c c_t^h, \tag{56}$$

$$I_t = \gamma_z i_t^z, \text{ and} \tag{57}$$

$$I_t^h = \gamma_z i_t^h, \tag{58}$$

where C_t is aggregate consumption and I_t is aggregate investment. Aggregate imports are:

$$IM_t = \gamma_c c_t^f + \gamma_z i_t^f = C_t^f + I_t^f. \tag{59}$$

[3] In a full monetary union the tariff rate is zero.

Therefore, the following equalities hold in aggregate:

$$C_t = \gamma_c c_t^c = p_t^H \gamma_c c_t^h + p_t^M \gamma_c c_t^f = \gamma_p c_t^p + \gamma_i c_t^i + \gamma_e c_t^e + \gamma_m c_t^m,$$
$$I_t = \gamma_z i_t^z = \frac{p_t^H}{p_t^I} \gamma_z i_t^h + \frac{p_t^M}{p_t^I} \gamma_z i_t^f = \gamma_k i_t.$$

2.10.2 Exports

Good packers are the ones that export. We assume that there is some degree of imperfect exchange rate pass through. To make this assumption operational, we consider a fraction $(1 - ptm)$ of good packers whose prices at home and abroad differ. The remaining fraction of good packers, ptm, sets a unified price across countries (i.e., the law of one price holds). Thus, the export price deflator relative to consumption goods, p_t^{EX}, is defined as:

$$p_t^{EX} = (1 - \tau_t^x) p_t^{H(1-ptm)} (er_t)^{ptm}, \tag{60}$$

where τ_t^x is an export subsidy and the parameter ptm determines the degree of pass through.

There is a continuum of foreign consumers and investors with mass γ^* whose demands for domestic goods from good packers are given by:

$$c_t^{*f} = \omega_t^f \left(\frac{p_t^{EX}}{er_t} \right)^{-\sigma_c^*} c_t^*, \tag{61}$$

$$i_t^{*f} = \omega_t^f \left(\frac{p_t^{EX}}{er_t} \right)^{-\sigma_c^*} i_t^*, \tag{62}$$

where c_t^* and i_t^* represent the (exogenous) aggregate consumption and investment demand in the rest of the world, and ω_t^f captures the impact of factors other than prices affecting Spanish exports that is assumed to obey the following law of motion:

$$\omega_t^f = (1 - \rho_{\omega f}) \omega_{ss}^f + \rho_{\omega f} \omega_{t-1}^f + \sigma_{\omega f}\, e_t^{\omega f} \text{ with } e_t^{\omega f} \sim \mathcal{N}(0,1) \tag{xv}$$

Therefore, exports of the home economy $ex_t = c_t^{*f} + i_t^{*f}$ can be written as:

$$ex_t = \omega_t^f \left(\frac{p_t^{EX}}{er_t} \right)^{-\sigma_c^*} (c_t^* + i_t^*). \tag{63}$$

Plugging (60) into (63) yields:

$$ex_t = \omega_t^f \left((1-\tau_t^x) \left(\frac{p_t^H}{er_t} \right)^{(1-ptm)} \right)^{-\sigma_c^*} (c_t^* + i_t^*).$$

Finally, we can define aggregate exports as:

$$EX_t = \gamma^* ex_t. \tag{64}$$

2.10.3 Accumulation of foreign assets

The net foreign asset position B_t^* evolves according to the following expression (denominated in the home currency):

$$B_t^* = \frac{(1+r_{t-1}^*)}{\pi_t} B_{t-1}^* + \left[p_t^{EX} \gamma^* ex_t - p_t^M \left(\gamma_c c_t^f + \gamma_z i_t^f \right) \right] \tag{65}$$

where a negative/positive sign for B_t^* implies a borrowing/lending position for the domestic economy with respect to the rest of the world and r_t^* stands for the interest rate paid/received for borrowing/lending abroad. Also, trade balance TB_t is defined as:

$$TB_t = p_t^{EX} \gamma^* ex_t - p_t^M \left(\gamma_c c_t^f + \gamma_z i_t^f \right). \tag{66}$$

2.11 Prices in the model

Prices in the model are written relative to before-consumption-tax CPI. Thus, the numeraire is P_t. Here we establish some relationships between prices and inflation rates, where P_t^H is the (absolute) price of domestic-produced output and $p_t^H = \frac{P_t^H}{P_t}$ is the corresponding relative price. Also, π_t^H, the gross inflation rate that appears in the New Phillips curve, is defined as $\frac{P_t^H}{P_{t-1}^H}$. Correspondingly, the gross inflation rate for the relative price is:

$$\widetilde{\pi}_t^H = \frac{p_t^H}{p_{t-1}^H}. \tag{67}$$

Notice that both π_t^H and $\widetilde{\pi}_t^H$ are identified in the equations of the model, the former in the New Phillips curve and the latter because we write some equations in terms of p_t^H. However, we cannot identify P_t^H or P_t. The inflation rate considered by the central bank in the Taylor rule is π_t' (the post-consumption-tax gross inflation rate). We cannot obtain π_t' directly from P_t, because it is not identified, but we can recover it from

π_t^H and $\widetilde{\pi}_t^H$ as

$$\pi_t' = \frac{P_t}{P_{t-1}} \frac{1+\tau_t^c}{1+\tau_{t-1}^c} = \frac{\frac{P_t}{P_t^H}}{\frac{P_{t-1}}{P_{t-1}^H}} \frac{P_t^H}{P_{t-1}^H} \frac{1+\tau_t^c}{1+\tau_{t-1}^c} = \frac{\pi_t^H}{\widetilde{\pi}_t^H} \frac{1+\tau_t^c}{1+\tau_{t-1}^c}, \tag{68}$$

and the before-consumption-tax inflation rate as

$$\pi_t = \frac{\pi_t^H}{\widetilde{\pi}_t^H}. \tag{69}$$

2.12 Monetary authority

The domestic economy belongs to a monetary union (say, the EMU), and monetary policy is managed by the central bank (say, the ECB) through the following Taylor rule that sets the nominal area-wide reference interest rate allowing for some smoothness of the interest rate's response to inflation and output:

$$(1+r_t) = (1+r_{ss})^{(1-\phi_r)}(1+r_{t-1})^{\phi_r} \left(\frac{\pi_t^{emu}}{\pi_{ss}^{emu}}\right)^{\phi_\pi(1-\phi_r)} \left(\frac{y_t^{emu}}{y_{t-1}^{emu}}\right)^{\phi_y(1-\phi_r)} (1+e_t^r), \tag{70}$$

where π_t^{emu} is EMU inflation as measured in terms of the consumption price deflator and $\frac{y_t^{emu}}{y_{t-1}^{emu}}$ measures the gross rate of growth of EMU output. There is also some inertia in setting the nominal interest rate, and the shock to the central bank interest rate is characterized by:

$$e_t^r \sim \mathcal{N}(0, \sigma_r) \tag{xvi}$$

The domestic economy contributes to EMU inflation and output growth according to its economic size in the Eurozone, ω_{Sp}:

$$\pi_t^{emu} = (1-\omega_{Sp})\left(\overline{\pi_t^{remu}}\right) + \omega_{Sp}\pi_t' \text{ and} \tag{71}$$

$$\frac{y_t^{emu}}{y_{t-1}^{emu}} = (1-\omega_{Sp})\left(\overline{\left(\frac{y_t^{remu}}{y_{t-1}^{remu}}\right)}\right) + \omega_{Sp}\frac{y_t}{y_{t-1}} \tag{72}$$

where $\overline{\pi_t^{remu}}$ and $\overline{\left(\frac{y_t^{remu}}{y_{t-1}^{remu}}\right)}$ are average (exogenous) inflation and output growth in the rest of the Eurozone.

The real exchange rate is given by the ratio of relative prices between the domestic economy and the remaining EMU members, so real appreciation/depreciation developments are driven by the inflation differential of the domestic economy vis-à-vis the euro area:

$$\frac{er_t}{er_{t-1}} = \frac{\overline{\pi_t^{remu}}}{\pi_t}. \tag{73}$$

2.13 Fiscal authority

There is also a fiscal authority with a flow of expenses determined by government consumption, government investment, and interest plus principal borrowed during the previous period. The fiscal authority collects revenues with new debt, lump-sum taxes, and distortionary taxation on consumption, housing services, labor income, loans, and deposits. Hence, we have:

$$
\begin{aligned}
& C_t^g + I_t^g + \left(\frac{1+\theta_{ss}^b r_{t-1}^b}{\pi_t}\right) B_{t-1}^g = B_t^g + T_t^g + \tau_t^c\left(\gamma_p c_t^p + \gamma_i c_t^i + \gamma_e c_t^e + \gamma_m c_t^m\right) + \\
& \frac{\tau_t^m}{1+\tau_t^m} p_t^M IM_t - \frac{\tau_t^x}{1-\tau_t^x} p_t^{EX} EX_t + \\
& \tau_t^h q_t^h \left(\gamma_p \Delta h_{j,t}^p + \gamma_i \Delta h_{j,t}^i\right) + \tau_t^w\left(w_t^p \gamma_p \ell_t^p + w_t^i \gamma_i \ell_t^i + w_t^m \gamma_m \ell_t^m\right) + \tau_t^k r_t^k K_t + \\
& \tau_t^{fb}\left(\gamma_i \Delta b_t^i + \gamma_e \Delta b_t^e\right) + \tau_t^{fd} \gamma_p \Delta d_t^p + \tau_t^d \left(\frac{r_{t-1}^d}{\pi_t}\right) \gamma_p d_{t-1}^p. \qquad (74)
\end{aligned}
$$

Tax rates are constant:

$$\tau_t^s = \tau^s \text{ for } s = c, h, w, d, fd, fb, k, m, x.$$

Government consumption and investment are considered to be random proportions of potential GDP. Given that this model does not feature growth in the variables, this is equivalent to saying that both public consumption and public investment move randomly along a constant, i.e.,

$$C_t^g = \psi^{cg} \varepsilon_t^{cg} \qquad (75)$$

$$I_t^g = \psi^{ig} \varepsilon_t^{ig} \qquad (76)$$

where ψ^{cg} and ψ^{ig} are two parameters and both ε_t^{cg} and ε_t^{ig} are shocks that move according to the following law of motion

$$\log\, \varepsilon_t^{cg} = (1-\rho_{cg})\log\, \varepsilon_{ss}^{cg} + \rho_{cg}\log\, \varepsilon_{t-1}^{cg} + \sigma_{cg} e_t^{cg} \text{ such that } e_t^{cg} \sim \mathcal{N}(0,1) \qquad \text{(xvii)}$$

$$\log\, \varepsilon_t^{ig} = (1-\rho_{ig})\log\, \varepsilon_{ss}^{ig} + \rho_{ig}\log\, \varepsilon_{t-1}^{ig} + \sigma_{ig} e_t^{ig} \text{ such that } e_t^{ig} \sim \mathcal{N}(0,1) \qquad \text{(xviii)}$$

Lump-sum taxes adjust to guarantee the non-explosiveness of government debt according to the following rule,

$$T_t^g = T_{t-1}^g + \rho_{tgb1}\left(\psi_t^{bg} - \psi_{ss}^{bg}\right) + \rho_{tgb2}\left(\psi_t^{bg} - \psi_{t-1}^{bg}\right), \tag{77}$$

where ψ_t^{bg} represents the proportion of public debt over aggregate output, namely,

$$\psi_t^{bg} = \frac{B_t^g}{Y_t} \tag{78}$$

and ψ_{ss}^{bg} refers to its steady-state objective value. In turn, public debt adjusts to satisfy the budget constraint given the above levels of C_t^g, I_t^g and T_t^g.

Finally, public capital evolves with investment according to the law of motion:

$$K_t^g = (1-\delta_g)K_{t-1}^g + I_t^g. \tag{79}$$

2.14 Aggregation and market clearing in equilibrium

The supply of labor equals the corresponding demand for the three types of households:

$$\int_0^{\gamma_p} \ell_{j,t}^p dj = \int_0^{\gamma_x} \ell_{j,t}^{pp} dj \Rightarrow \gamma_p \ell_t^p = \gamma_x \ell_t^{pp}, \tag{80}$$

$$\int_0^{\gamma_i} \ell_{j,t}^i dj = \int_0^{\gamma_x} \ell_{j,t}^{ii} dj \Rightarrow \gamma_i \ell_t^{ii} = \gamma_x \ell_t^{ii}, \text{ and} \tag{81}$$

$$\int_0^{\gamma_m} \ell_{j,t}^m dj = \int_0^{\gamma_x} \ell_{j,t}^{mm} dj \Rightarrow \gamma_{mm} \ell_t^m = \gamma_x \ell_t^{mm}. \tag{82}$$

The supply of capital by capital producers equals the corresponding demand by entrepreneurs, while the supply of capital services by the latter equals the demand of these services by intermediate good producers:

$$\int_0^{\gamma_e} k_{j,t}^e dj = \int_0^{\gamma_k} k_{j,t} dj \Rightarrow \gamma_e k_t^e = \gamma_k k_t \text{ and} \tag{83}$$

$$\int_0^{\gamma_x} k_{j,t}^{ee} dj = \int_0^{\gamma_e} k_{j,t}^e dj \Rightarrow \gamma_x k_t^{ee} = \gamma_e k_t^e. \tag{84}$$

2.14.1 Housing market

The demand for houses by households equals a perfectly inelastic supply of houses:

$$\int_0^{\gamma_x} h_{j,t}^i dj + \int_0^{\gamma_x} h_{j,t}^p dj = H \Rightarrow \gamma_p h_t^p + \gamma_i h_t^i = H, \tag{85}$$

2.14.2 Intermediate goods

The demand for intermediate goods by retailers equals the supply of them by intermediate good producers:

$$\int_0^{\gamma_x} y^x_{j,t} dj = \int_0^{\gamma} y^{xx}_{j,t} dj \Rightarrow \gamma_x y^x_t = \gamma y_t, \tag{86}$$

where the last equality follows from the production function for final goods, $y_{j,t} = y^{xx}_{j,t}$.

2.14.3 Labor market

We can define real wage as

$$w_t = \gamma_p w^p_t + \gamma_i w^i_t + \gamma_m w^m_t$$

Thus, the quarter-on-quarter rate of growth of the aggregate real wage is:

$$\pi^w_t = \frac{w_t}{w_{t-1}} \tag{87}$$

2.14.4 Loan and deposits

The loan demand by impatient households and entrepreneurs equals the corresponding supply by loan-retailing units:

$$\int_0^{\gamma_i} b^i_{j,t} dj = \int_0^{\gamma_b} b^{ii}_{j,t} dj \Rightarrow \gamma_i b^i_t = \gamma_b b^{ii}_t \text{ and} \tag{88}$$

$$\int_0^{\gamma_e} b^e_{j,t} dj = \int_0^{\gamma_b} b^{ee}_{j,t} dj \Rightarrow \gamma_e b^e_t = \gamma_b b^{ee}_t. \tag{89}$$

The demand for deposits by patient households equals the deposit supply by deposit-retailing banks:

$$\int_0^{\gamma_p} d^p_{j,t} dj = \int_0^{\gamma_b} d^{pp}_{j,t} dj \Rightarrow \gamma_p d^p_t = \gamma_b d^{pp}_t. \tag{90}$$

2.14.5 Consumption and investment goods

The demand for consumption goods by households and entrepreneurs and investment goods by capital producers equals the supply of them by consumption and investment goods packers:

$$\int_0^{\gamma_c} c_t^c dj = \gamma_c c_t^c = \gamma_p c_t^p + \gamma_i c_t^i + \gamma_e c_t^e + \gamma_m c_t^m,$$
$$\int_0^{\gamma_z} i_t^z dj = \gamma_z i_t^z = \gamma_k i_t^h$$

By aggregating the budget constraints of households and plugging in the market clearing conditions, we can derive the following expression for the effective aggregate demand for final goods in equilibrium:

$$\begin{aligned}
p_t^H Y_t &= C_t + p_t^I I_t + p_t^H C_t^g + p_t^H I_t^g + p_t^{EX} EX_t - p_t^M IM_t \\
&+ \left[\psi_{u_1}(u_t - 1) + \tfrac{\psi_{u_2}}{2}(u_t - 1)^2\right] K_{t-1} + \delta_b \tfrac{K_{t-1}^b}{\pi_t} + \tfrac{\eta_p}{2}\left(\pi_t - \pi_{t-1}^{\iota_p}\pi^{1-\iota_p}\right)^2 Y_t \\
&+ \tfrac{1}{\pi_t}\left[\tfrac{\eta_d}{2}\left(\tfrac{r_{t-1}^d}{r_{t-2}^d} - 1\right)^2 r_{t-1}^p D_{t-1} + \tfrac{\eta_i}{2}\left(\tfrac{r_{t-1}^{bi}}{r_{t-2}^{bi}} - 1\right)^2 r_{t-1}^{bi} B_{t-1}^i + \tfrac{\eta_e}{2}\left(\tfrac{r_t^{be}}{r_{t-2}^{be}} - 1\right)^2 r_{t-1}^{be} B_{t-1}^e\right] \\
&+ \tfrac{\eta_b}{2}\left(\tfrac{K_{t-1}^b}{B_{t-1}} - \nu_b\right)^2 \tfrac{K_{t-1}^b}{\pi_t} + \tfrac{\gamma_p\eta_w}{2}\left(\pi_t^{wp} - \pi_{t-1}^{\iota_w}\pi^{1-\iota_w}\right)^2 w_t^p + \tfrac{\gamma_i\eta_w}{2}\left(\pi_t^{wi} - \pi_{t-1}^{\iota_w}\pi^{1-\iota_w}\right)^2 w_t^i \\
&+ \tfrac{\gamma_m\eta_w}{2}\left(\pi_t^{wm} - \pi_{t-1}^{\iota_w}\pi^{1-\iota_w}\right)^2 w_t^m,
\end{aligned}$$

where

$$Y_t = \gamma y_t = \gamma_x y_t^x, \tag{91}$$

$$C_t = \gamma_p c_t^p + \gamma_i c_t^i + \gamma_m c_t^m + \gamma_e c_t^e = p_t^H C_{ht} + p_t^M C_{ft}, \tag{92}$$

$$I_t = \gamma_k i_t^z = \frac{p_t^H}{p_t^I} I_{ht} + \frac{p_t^M}{p_t^I} I_{ft}, \tag{93}$$

$$K_{t-1} = \gamma_k k_{t-1} = \gamma k_{t-1}, \tag{94}$$

$$K_{t-1}^b = \gamma_b k_{t-1}^b, \tag{95}$$

$$D_t = \gamma_p d_t^b, \tag{96}$$

$$B_t^i = \gamma_i b_t^i, \tag{97}$$

$$B_t^e = \gamma_e b_t^e, \text{ and} \tag{98}$$

$$B_t = B_t^e + B_t^i + B_t^g. \tag{99}$$

Finally, GDP, Y_t^1, can be defined as:

$$\begin{aligned} p_t^H Y_t^1 &= C_t + p_t^I I_t + p_t^H C_t^g + p_t^H I_t^g + p_t^{EX} EX_t - p_t^M IM_t = \\ &= p_t^H C_{ht} + p_t^H I_{ht} + p_t^H C_t^g + p_t^H I_t^g + p_t^{EX} EX_t \end{aligned} \tag{100}$$

3 Model Parameters

There are a large number of structural parameters in the model, including those controlling the behavior of the 18 structural shocks. All the structural parameters related to technology and preferences are calibrated. We divide the calibration into three blocks. The parameters in the first block are set following the related literature. The ones in the second block are obtained from setting steady-state conditions to match some moment conditions. The third block is calibrated using direct information contained in REMSDB, the database of the Spanish Ministry of Finance, which was created to serve as a consistent framework for REMS calibration.[4] Only the 36 parameters corresponding to the structural shocks (two for each shock) are estimated by means of Bayesian inference using the Metropolis-Hastings algorithm implemented in Dynare 4.5.1.

3.1 Calibration

Tables 1-7 present the calibrated structural parameters and show the value assigned to each one. As a general principle, we use the Gerali et al. (2010) calibration approach. When necessary, we adapt it to the features of our model and to the singularities of the Spanish economy. When possible, we stick as close as possible to parameters calibrated in the REMS model, which has exhibited an excellent performance in the last ten years.

The preference parameters reported in Table 1 come from Gerali et al. (2010), although slightly modified to capture our prior about the steady-state relative consumption among our four household types. We assume that patient households' discount factor is higher than that of the impatient household and of the entrepreneurs.

Weights reported in Table 2 are also similar to those inGerali et al. (2010) except for household weights. Given that we have one more category of households (hand-to-mouth consumers), we have approximately split the Gerali et al. (2010) impatient households group into our hand-to-mouth and impatient groups.

The calibrations related to adjustment costs reported in Table 3 are also consistent with Gerali et al.'s (2010) priors and estimations. In particular, parameters linked with interest rate adjustment costs are set at values between 3 and 10. However, in our case these values come from a Bayesian estimation of a closed economy version of the model. The same is true for the rest of the parameters in this block, except for the one governing the cost for banks, which deviates from the targeted capital-to-assets ratio. In this case we prefer to calibrate a value of 60, which lies in between the posterior mean in Gerali et al. (2010) and the value considered in some counterfactual experiments that yielded impulse response functions more consistent with the ones produced with REMS.

As regards production and fiscal policy parameters, reported in Tables 4 and 5, some of them have been

[4] See Boscá et al. (2007) for details.

recovered by estimating some of the equations of the model using Spanish data in REMSDB. Others, like tax rates and government expenditure ratios, are simple averages over the last 25 years. Monetary policy parameters have been borrowed from a closed economy version of the model estimated for the Eurozone.

To obtain the external sector parameters in Table 6 we have used the same methodology employed in the calibration of REMS (see Boscá et al., 2010), although we use the updated information in REMSDB. Finally, we think that the Spanish banking sector is, on average, more competitive than in the rest of the Eurozone and, thus, we slightly lower the values of mark-ups, mark-downs, and the bank capital depreciation rate with respect to their counterparts in Gerali et al. (2010). The banking sector parameters are in Table 7.

TABLE 1: Preferences Parameters

Parameter	Description	Value
β_p	Discount factor patients	0.995
β_i	Discount factor impatients	0.975
β_e	Discount factor entrepreneurs	0.980
β_m	Discount factor HtM	0.975
a_{cp}	Habits in consumption patients	0.856
a_{ci}	Habits in consumption impatients	0.856
a_{ce}	Habits in consumption entrepreneurs	0.856
a_{cm}	Habits in consumption HtM	0.856
a_{lp}	Disutility labor patients	1.000
a_{li}	Disutility labor impatients	1.000
a_{lm}	Disutility labor HtM	1.000
a_{hp}	Utility housing patients	0.210
a_{hi}	Utility housing impatients	0.210
ϕ	Frisch elasticity (inverse)	1.000

TABLE 2: Weight Parameters

Parameter	Description	Value
γ_p	Patients over total households	0.350
γ_i	Impatients over total households	0.200
γ_e	Entrepreneurs over total households	0.280
γ_m	HtM over total households	0.170
γ_x	Intermediate good producers	1.000
γ_k	Capital good producers	1.000
γ	Retailers	1.000
γ_b	Banks	1.000
γ_c	Consumption good packers	1.000
γ_z	Investment good packers	1.000
γ^*	Foreign consumers and investors	1.000

Table 3: Adjustment Cost Parameters

Parameter	Description	Value
η_b	Target bank capital	60.00
η_d	Interest rate deposits	3.503
η_{be}	Interest rate loans entrepreneurs	9.364
η_{bi}	Interest rate loans impatients	10.09
η_i	Investment	0.200
ψ_{u1}	Capital utilization	0.045
ψ_{u2}	Capital utilization	0.005

Table 4: Production Parameters

Parameter	Description	Value
α	Elasticity physical capital	0.426
α_g	Elasticity public capital	0.060
μ_p	Elasticity patients in labor composite	0.350
μ_i	Elasticity impatients in labor composite	0.350
μ_m	Elasticity HtM in labor composite	0.300
δ	Depreciation rate physical capital	0.025
δ_g	Depreciation rate public capital	0.016
H	Housing supply	4.139
A_{ss}	Average TFP	1.000
ε_{ss}^{y}	Elasticity of substitution between goods	6.000
ε_{ss}^{l}	Elasticity of substitution between labor types	5.000
ϕ_x	Fixed costs	0.000

Table 5: Fiscal and Monetary Policy Parameters

Parameter	Description	Value
τ^c	Consumption tax	0.110
τ^h	Housing tax	0.075
τ^w	Labor income tax	0.330
τ^{fd}	Tax on bank deposits accumulation	0.000
τ^{fb}	Tax on bank loans accumulation	0.000
τ^d	Tax on interest rates on bank deposits	0.000
τ^k	Tax on capital returns	0.220
τ^m	Import tariff	0.000
τ^x	Export subsidy	0.000
θ_{ss}^{g}	Mark-up over loan-rate for public debt	1.517
ρ_{tgb1}	Adjustment to debt/GDP (transfer rule)	0.100
ρ_{tgb2}	Adjustment to debt growth (transfer rule)	0.200
Ψ_{ss}^{cg}	Government spending over GDP	0.175
Ψ_{ss}^{ig}	Government investment over GDP	0.035
ϕ_π	Inflation weight	1.982
ϕ_y	Output weight	0.346
ϕ_r	Interest rate persistence	0.769
$\overline{\pi^{remu}}$	Gross average inflation rest Eurozone	1.000

Table 6: External Sector Parameters

Parameter	Description	Value
ω^c	Weight foreign cons. goods in consumption pack	0.280
σ^c	Elasticity substitution domestic/foreign cons. goods	0.857
ω^i	Weight foreign invest. goods in consumption pack	0.523
σ^i	Elasticity substitution domestic/foreign invest. goods	1.016
ptm	Degree of pass-through	0.741
ω^f	Scale factor exports function	0.023
σ^{c*}	Price elasticity of exports	0.651
c^*	Exogenous aggregate consump. demand in RoW	6.480
i^*	Exogenous aggregate investment demand in RoW	3.240
$\widetilde{\phi}$	Risk premium response to external debt	0.300
α_{RW}	Share of public debt in foreigners' hands	0.667

Table 7: Banking Sector Parameters

Parameter	Description	Value
δ_b	Bank capital depreciation rate	0.059
ω_b	Share of non-distributed bank profits	0.800
ν_b	Target capital-to-assets ratio	0.090
m^i_{ss}	Impatients loan-to-value	0.700
m^e_{ss}	Entrepreneurs loan-to-value	0.150
θ^d_{ss}	Mark-down deposits	0.614
θ^{be}_{ss}	Mark-up loans entrepreneurs	1.157
θ^{bi}_{ss}	Mark-up loans impatient households	1.317
ε^{kb}_{ss}	Bank capital shock	1.000
α_{Bg}	Share of domestic public debt in banks' hands	0.750
α_{ED}	Share of foreign debt in banks' hands	1.000

3.2 Estimation

We estimate all the parameters related to the 18 structural shocks, plus price and wage adjustment costs and indexation parameters. Specifically, using quarterly data for the Spanish economy for the period 1992Q4-2017Q4 (see the Appendix for a description of the data and their sources), we estimate a first-order approximation around the steady-state to the solution of the model taking as observables the demeaned interannual change of the following five variables: $r^{bi}_t, r^{be}_t, r^d_t, r_t, \phi_t$; plus the demeaned interannual logarithmic change of the following thirteen variables (the first ten in per capita terms): $C_t, Y^1_t, C^g_t, I^g_t, I_t, EX_t, IM_t, B^i_t, B^e_t, K^b_t, q^h_t, P^h_t$ and w_t. To deflate nominal variables we have used observed deflators consistent with prices in the model.

Our priors and posteriors are shown in Table 8 and Table 9. Starting with a very diffuse set of priors, as in Gerali et al. (2010) and Justiniano et al. (2010), we perform a preliminary shock decomposition exercise. Then, we modify some of the priors to produce a prior shock decomposition consistent with our beliefs about the direction and the relative size of the shocks hitting the Spanish economy. We will describe our beliefs when we report our results. Table 8 and Table 9 use 500,000 draws from the posterior. The "Prior" column describes the prior distribution and its mean and standard deviation (Std). Some of the priors have very low standard deviations, such as the ones for ρ_h, ρ_l, ρ_y, ρ_{rp}, $\rho_{\omega d}$, $\rho_{\omega f}$, σ_l, σ_A, σ_k, and σ_r. This is necessary to match our prior shock decomposition.

The "Posterior" column describes the mean of the posterior and the 90 percent highest posterior density interval (HPDI). As can be seen in the tables, the data have information about most of the estimated parameters. The exceptions seem to be ρ_l, ρ_{rp}, $\rho_{\omega d}$, $\rho_{\omega f}$, ρ_r, σ_l and σ_{cg} where priors and posteriors seem to be quite similar. From Table 8 one can see that the data seem to like persistent shocks. The only exception is the shock to the consumption preferences, which, it is estimated to have very low persistence.

TABLE 8: Prior and Posteriors

Parameter	Prior			Posterior	
	Distribution	Mean	Std	Mean	90 HPDI
ρ_z	*Beta*	0.40	0.080	0.245	[0.156; 0.331]
ρ_h	*Beta*	0.94	0.005	0.954	[0.950; 0.960]
ρ_{mi}	*Beta*	0.80	0.080	0.978	[0.969; 0.987]
ρ_{me}	*Beta*	0.80	0.080	0.976	[0.964; 0.990]
ρ_l	*Beta*	0.70	0.005	0.704	[0.698; 0.711]
ρ_A	*Beta*	0.80	0.080	0.686	[0.608; 0.765]
ρ_k	*Beta*	0.95	0.005	0.950	[0.941; 0.958]
ρ_y	*Beta*	0.90	0.080	0.630	[0.514; 0.744]
ρ_{kb}	*Beta*	0.80	0.080	0.496	[0.409; 0.585]
ρ_{rp}	*Beta*	0.66	0.005	0.666	[0.659; 0.675]
ρ_d	*Beta*	0.80	0.080	0.806	[0.744; 0.870]
ρ_{bi}	*Beta*	0.80	0.080	0.940	[0.897; 0.970]
ρ_{be}	*Beta*	0.80	0.080	0.934	[0.906; 0.974]
$\rho_{\omega d}$	*Beta*	0.80	0.005	0.805	[0.798; 0.813]
$\rho_{\omega f}$	*Beta*	0.99	0.005	0.977	[0.968; 0.985]
ρ_r	*Beta*	0.80	0.080	0.795	[0.720; 0.874]
ρ_{cg}	*Beta*	0.80	0.080	0.963	[0.945; 0.980]
ρ_{ig}	*Beta*	0.80	0.080	0.965	[0.947; 0.984]
η_p	*Gamma*	500	80	470.7	[361.7; 588.1]
ι_p	*Beta*	0.50	0.080	0.304	[0.199; 0.409]
η_w	*Gamma*	500	80	236.1	[209.2; 263.0]
ι_w	*Beta*	0.50	0.080	0.496	[0.368; 0.630]

Table 9: Prior and Posteriors

Parameter	Prior			Posterior	
	Distribution	Mean	Std	Mean	90 HPDI
σ_z	$Inv - Gamma$	0.010	0.15	0.256	[0.225; 0.288]
σ_h	$Inv - Gamma$	0.010	0.15	0.236	[0.193; 0.277]
σ_{mi}	$Inv - Gamma$	0.010	0.15	0.030	[0.026; 0.033]
σ_{me}	$Inv - Gamma$	0.010	0.15	0.025	[0.020; 0.029]
σ_l	$Inv - Gamma$	0.900	0.01	0.908	[0.893; 0.932]
σ_A	$Inv - Gamma$	0.012	0.01	0.029	[0.026; 0.033]
σ_k	$Inv - Gamma$	0.050	0.01	0.028	[0.024; 0.032]
σ_y	$Inv - Gamma$	0.010	0.15	0.955	[0.625; 1.291]
σ_{kb}	$Inv - Gamma$	0.010	0.15	0.043	[0.038; 0.049]
σ_{rp}	$Inv - Gamma$	0.010	0.15	0.002	[0.002; 0.002]
σ_d	$Inv - Gamma$	0.010	0.15	0.172	[0.149; 0.194]
σ_{bi}	$Inv - Gamma$	0.010	0.15	0.246	[0.211; 0.278]
σ_{be}	$Inv - Gamma$	0.010	0.15	0.238	[0.207; 0.267]
$\sigma_{\omega d}$	$Inv - Gamma$	0.010	0.15	0.024	[0.021; 0.027]
$\sigma_{\omega f}$	$Inv - Gamma$	0.010	0.15	0.031	[0.028; 0.035]
σ_r	$Inv - Gamma$	0.130	0.01	0.090	[0.085; 0.095]
σ_{cg}	$Inv - Gamma$	0.010	0.15	0.010	[0.009; 0.011]
σ_{ig}	$Inv - Gamma$	0.010	0.15	0.051	[0.045; 0.057]

4 Results

This section analyzes the results. We present the results in two steps. We first present some simulations associated with some fully anticipated shocks, and second, we analyze the contribution of each of the shocks to the observed movement in some variables of interest.

4.1 Simulations

This section shows some of the properties of the model when it is hit by shocks. To do so, we examine three standard simulations: a public consumption shock, a technology shock and a bank capital shock. The first two shocks are of a temporary nature and fully anticipated by economic agents, while the capital ratio shock is permanent.

4.1.1 A transitory public consumption shock

With a view to illustrating transmission channels in our model, this section discusses the effects of an exogenous transitory shock affecting the steady-state level of public consumption. The fiscal impulse amounts to 1 percent of baseline GDP (or 5.7 percent of C_t^g) and is assumed to follow a first-order autoregressive process with a persistence parameter of 0.9.

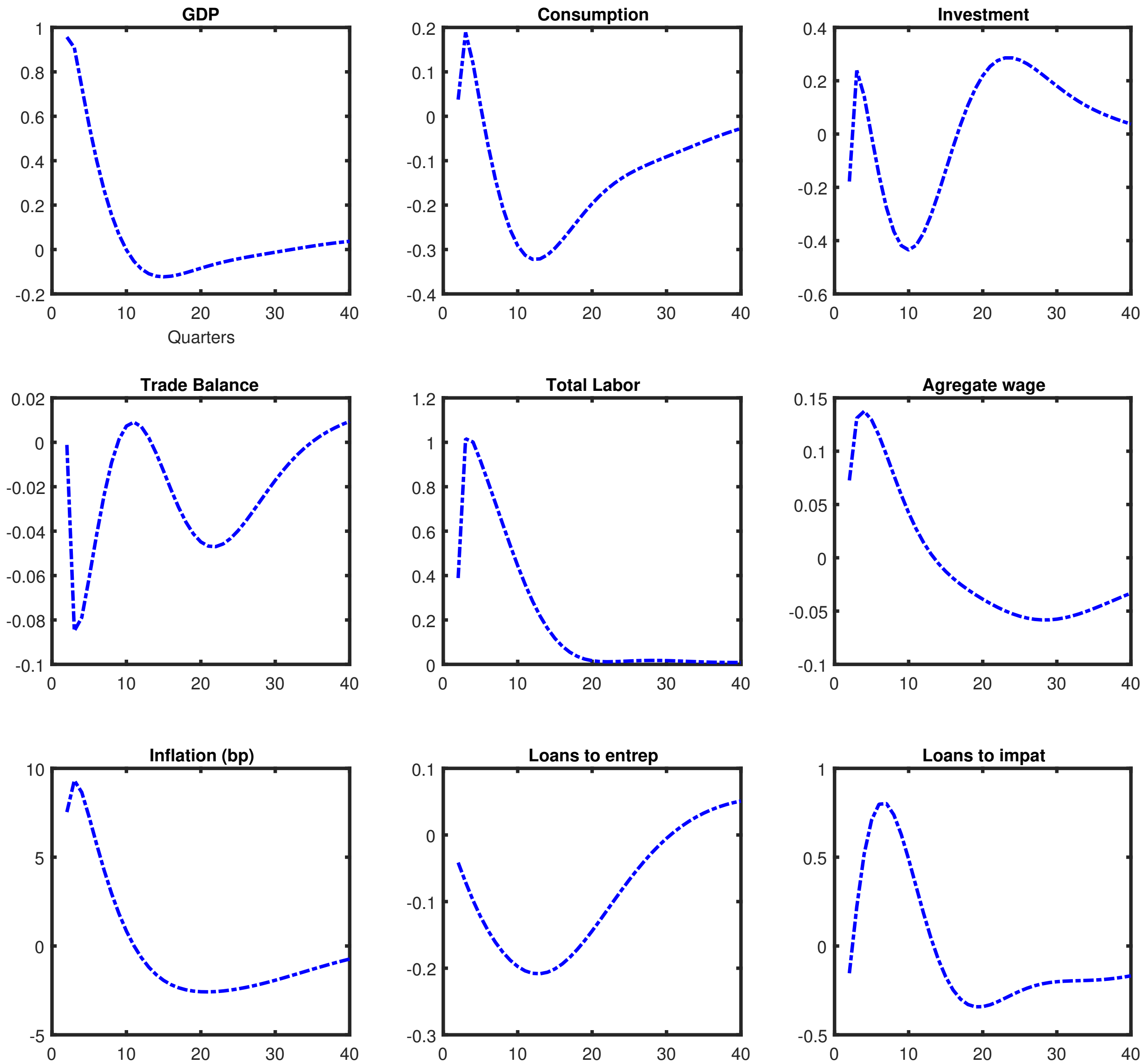

FIGURE 2: *Response to a 1 percent of GDP government consumption increase*

Figure 2 displays the quarterly dynamic responses of the main macroeconomic variables in the model. Simulation results are percentage deviations from the baseline, except for the trade-balance-to-GDP ratio (which is an absolute deviation) and GDP deflator inflation (which is expressed in basic points).

The multiplier on GDP ($\Delta GDP/\Delta C_t^g$) on impact is equal to 1, almost identical to the same multiplier in the REMS model (see Boscá et al. (2010)). A transitory impulse to public consumption leads to a significant initial increase in private consumption that peaks at 0.2 percentage points in the second quarter and lasts for

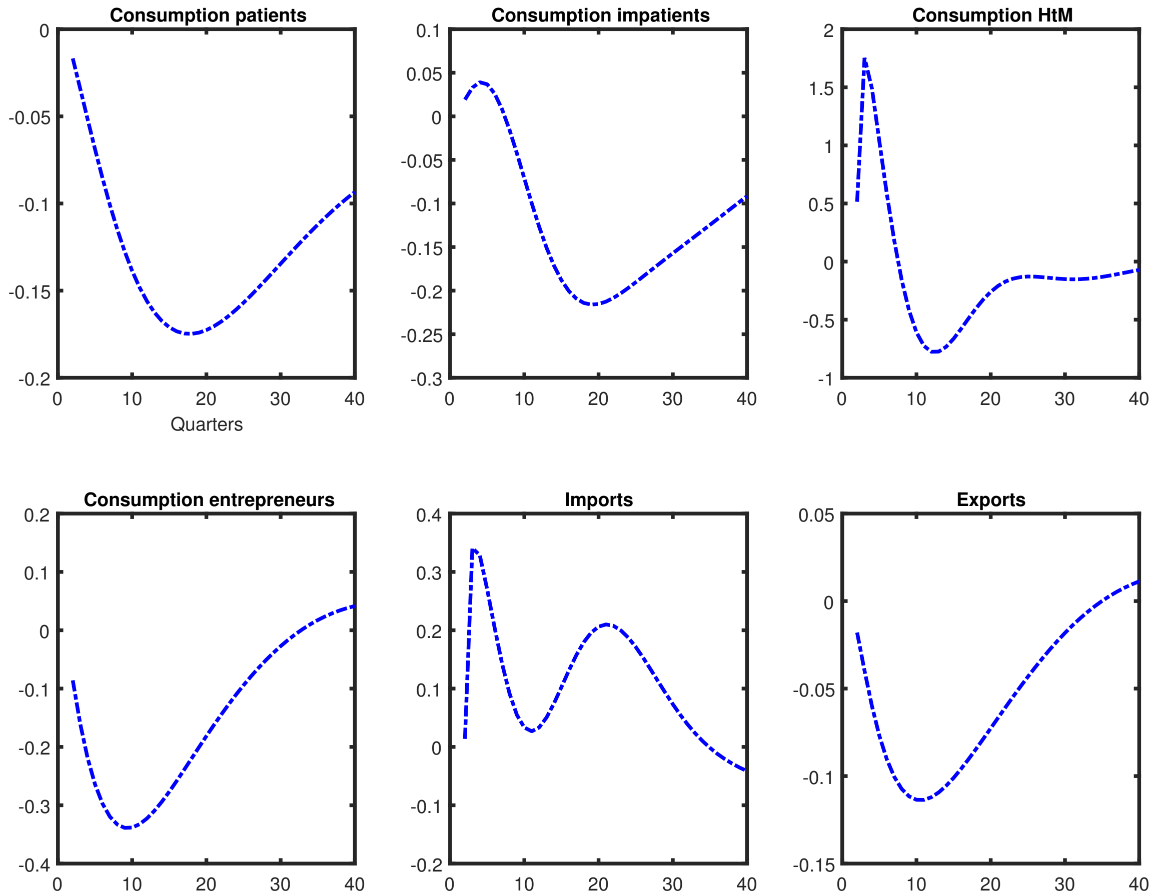

Figure 3: *Response to a 1 percent of GDP government consumption increase: consumption*

about three quarters. This initial positive effect on private consumption is typical in models that allow for rule-of-thumb individuals (see Blanchard and Galí (2006), Galí et al. (2007) and Boscá et al. (2010)).

As suggested by Figure 3, the dynamics of overall consumption are largely driven by the behavior of HtM households, whose consumption increases on impact by 0.5 percentage points and by more than 1.7 points in the second quarter. In contrast, optimizing households follow Ricardian equivalence, revising their current consumption downward to offset the effect of future tax increases to finance the fiscal stimulus. Also entrepreneurs and impatient consumers experience reductions in their consumption. In the short run the fiscal shock provokes a negative wealth effect and, simultaneously, loans going to these individuals are reduced. The reason for this fall in the amount of credit has to do with the fact that banks provide credit to both the private and the public sector. In our model banks finance a fixed share of public debt, so after the rise of public consumption, they divert part of the supply of credit from individuals and entrepreneurs to the government.

Banks may try to increase loans to the private sector, but in the short run, they have to fulfill the capital-assets requirements to avoid incurring a penalty. Given that increasing capital is difficult in the short run (capital increases with past profits), banks will end up diverting credit from the private sector to the government.

Private investment falls on impact but increases immediately after for approximately one year. Thus, in our model, there is no short-run crowding-out effect. As can be seen in the figure, investment increases in the short run despite, the fact that the amount of loans going to entrepreneurs is reduced in the quarters after the shock. These individuals, however, are the ones who more heavily reduce their consumption during the first two years after the government policy intervention. The increase in investment can be rationalized in terms of a rise in Tobin's q, due to the improvement of expectations about future demand.

Figure 2 also shows that employment increases right after the shock and then gradually returns to normal. Employment is enhanced by the positive short run responses of consumption and investment in the economy. Workers also benefit from the boost in the economy, due to the increase in real wages that lasts for more than two years. On the flip side the government consumption shock deteriorates the trade balance in the short run, because of the loss of competitiveness that inflation provokes.

4.1.2 A transitory technology shock

In this section an exogenous productivity improvement is implemented as a 1 percent increase in A_t. The technology shock is modeled as a first-order autoregressive process with a persistence parameter of 0.9, implying that the level of total factor productivity after five years is situated 0.2 percentage points above the steady-state level.

Figure 4 shows that GDP reacts on impact by approximately 0.6 percentage point. In addition, the GDP effect is long-lasting, reaching a maximum after ten quarters. As can be seen, the effects on consumption, investment, wages and bank loans are also positive and quite persistent. The shock leads to an increase in consumption, which peaks after four years. Hump-shaped consumption dynamics prevail for all types of consumers, with the exception of HtM households, which display a short run reduction in consumption which is relatively more volatile and less persistent compared with other types of consumers (see Figure 5).

Total labor in the economy suffers an important reduction on impact and then gradually returns to normal in approximately two years. This initial negative effect in the short run following a technology shock depends, first, on the extent of wage rigidity and wage indexation in the economy, second, on the degree of price stickiness and, third, on the complementarity between consumption and leisure. In our model the parameters capturing these issues imply relatively flexible wages, a moderate degree of price stickiness and a high complementarity

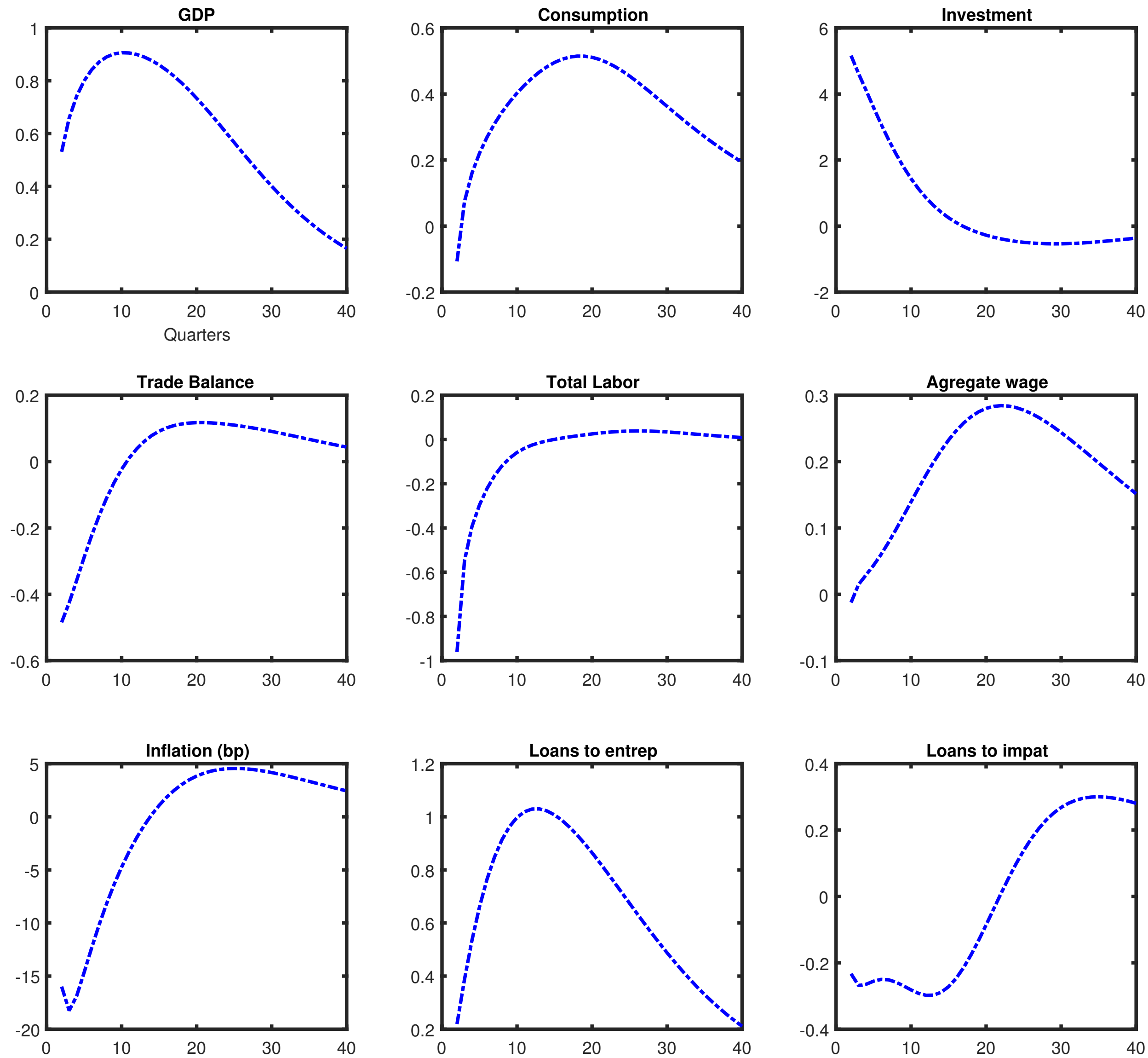

FIGURE 4: *Response to a 1 percent TFP increase*

of leisure and consumption. After the technological shock, consumption increases and individuals desire to increase leisure, thus reducing the supply of labor. The shock also produces an increase in labor demand that, nevertheless, is not capable of compensating for the negative labor supply effect on employment. Given the relative wage flexibility, in the short run we observe wages increasing, while total hours worked are reduced.

Finally, the technology shock has a sizable effect on goods mark-ups (not shown in the graph), i.e., the price of consumption goods in terms of intermediate goods. The mark-up increases on impact, thereby increasing

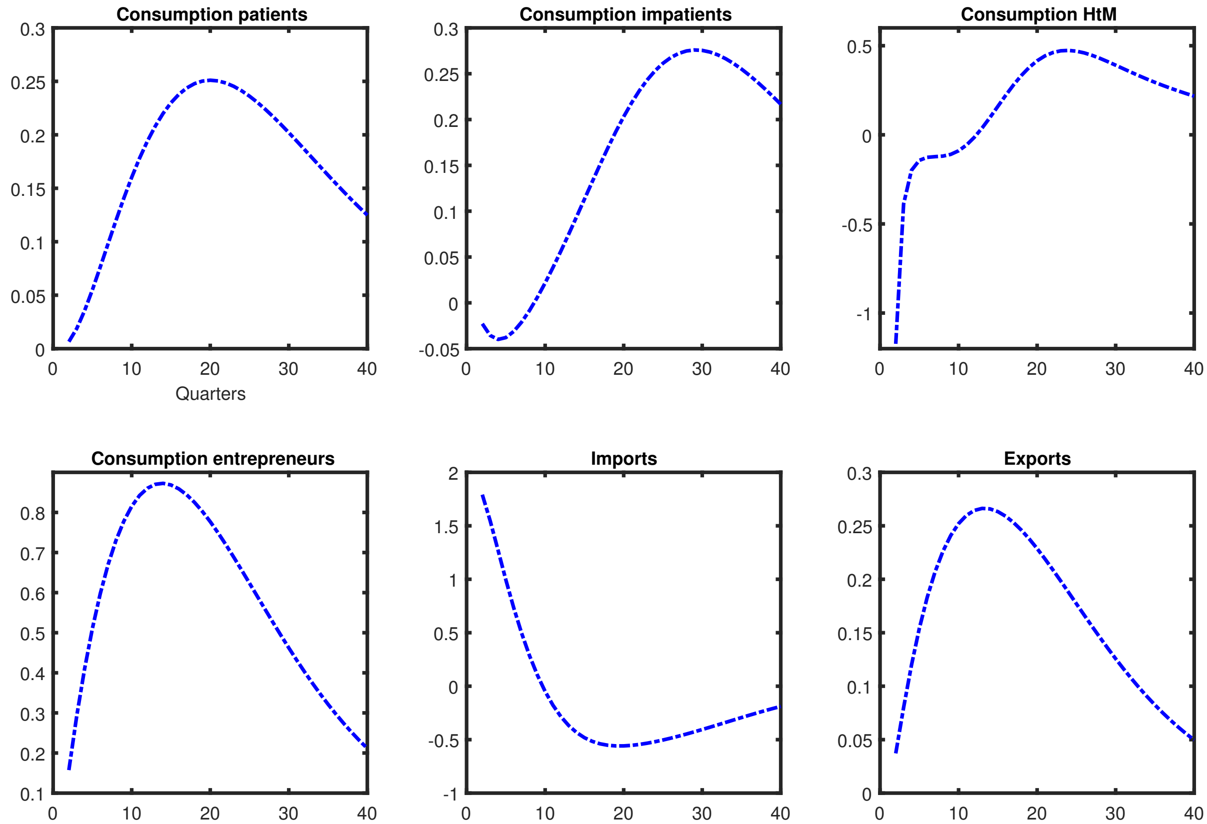

FIGURE 5: *Response to a 1 percent TFP increase*

Tobin's q and stimulating investment and capital accumulation. The reduction in marginal costs implied by the rise in mark-ups moderates inflation, improving price competitiveness and, thus, encouraging exports (see Figure 5). However, as can be seen, in the short run, the trade balance deteriorates due to the behavior of imports. These are accelerated because of the boom in domestic absorption than more that counteracts the positive effect of real depreciation on exports.

4.1.3 A permanent bank capital shock

In this section we assume that the supervisor unexpectedly increases the required bank capital-to-assets ratio from 9 to 10 percent and simulate its economic effects. This measure imposes a cost to the banks because the current ratio falls short of the target ratio. In other words, banks are too leveraged so that they start to adjust their balance sheets.

According to Figure 6 it takes eight periods to converge to the target ratio. In the process, banks try to increase capital by raising the interest rates on loans. As a consequence of this, we observe in Figure 7 a fall in

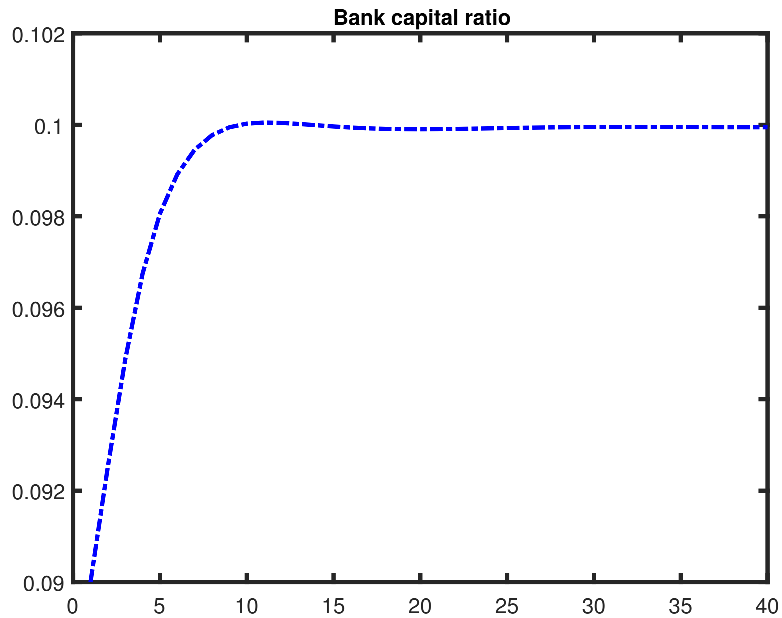

FIGURE 6: *Increase in the bank capital to assets ratio*

credit that negatively affects consumption and investment. This reduction is more pronounced for investment but more persistent for consumption. Investment falls on impact by 3.5 percentage points, but it recovers completely in approximately three years.

Aggregate wages are harmed in a long-lasting way because the reduction in consumption makes labor unions more willing to accept lower wages. The counterpart of this shift in labor supply is the increase in total hours, which is not able to fully compensate for the contraction in aggregate demand. The weakness of total absorption drives a drop in imports (Figure 8), which is reflected in the improvement in the trade balance. However, as the result of the tightened credit conditions provoked by the shock, GDP falls around 0.4 percentage points in the first three years. This effect slowly reverts over time, and after ten years, GDP is still 0.3 percentage points below its initial level.

4.2 Shock decomposition

Given that we have estimated 18 structural shocks in our model with 18 observables, we can proceed to analyze a shock decomposition of the variables used in the estimation. For space reasons, in this section we will present only the shock decomposition of the demeaned interannual logarithmic change of per capita GDP, from 1992:4 to 2017:4. For illustrative purposes we will not present all the shocks, but group them into sensible sets.

Figures 9 and 10 present the contributions of shocks that qualify as typically affecting the aggregate demand

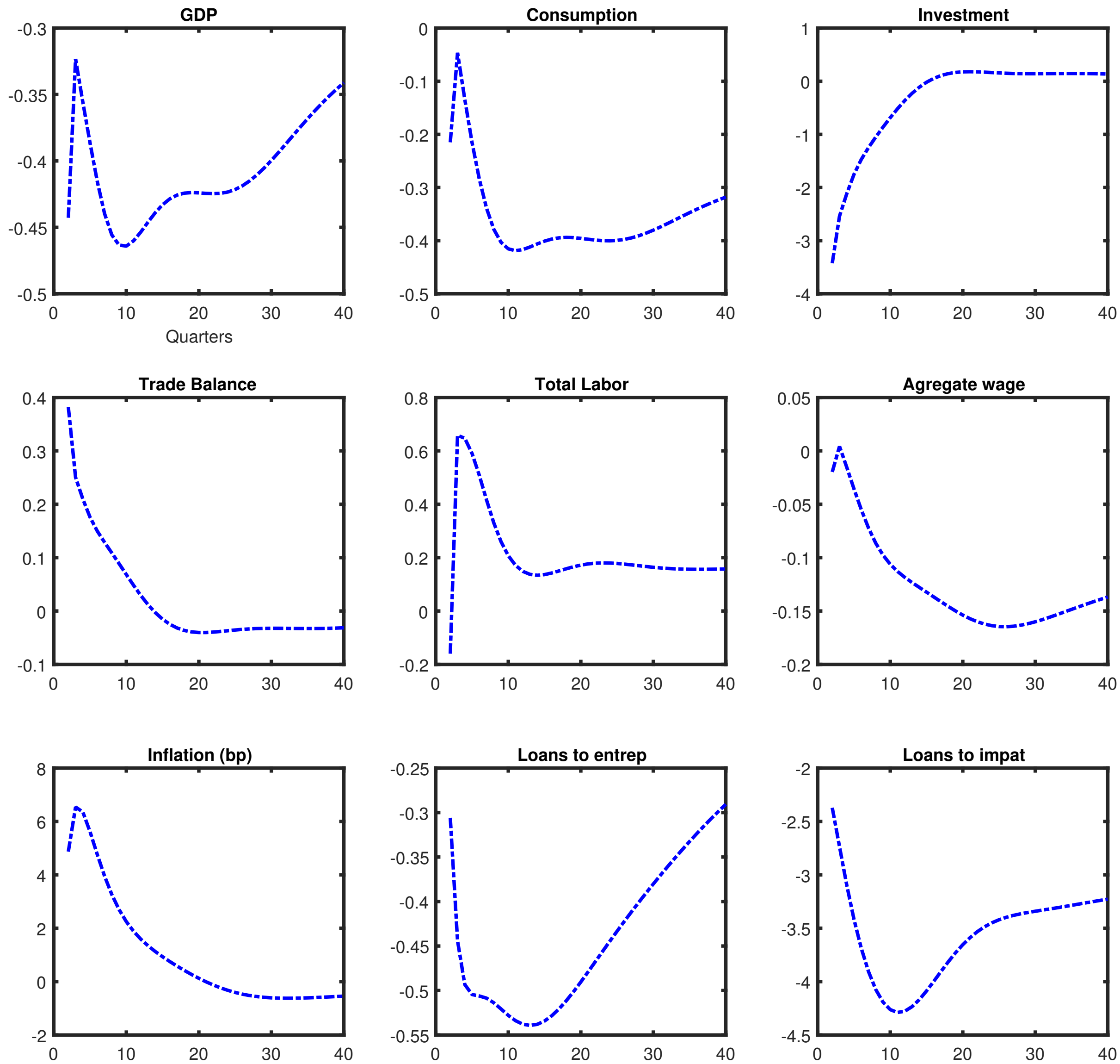

FIGURE 7: *Response to a permanent increase in the bank capital ratio*

and supply side of the economy. From Figure 9 it is clear that demand shocks affecting private consumption and housing demand, both of them very likely related to households' confidence and expectations, played a very important role in shaping GDP growth dynamics in the period of the economic boom and posterior sharp recession. In fact, from 2002 to 2007 the size of these shocks seems to have fueled the output growth in the pre-crisis expansionary period. The figure also shows that the loss of confidence and negative expectations were more important in the second part of the crisis - the sovereign debt crisis - than in the initial years, with

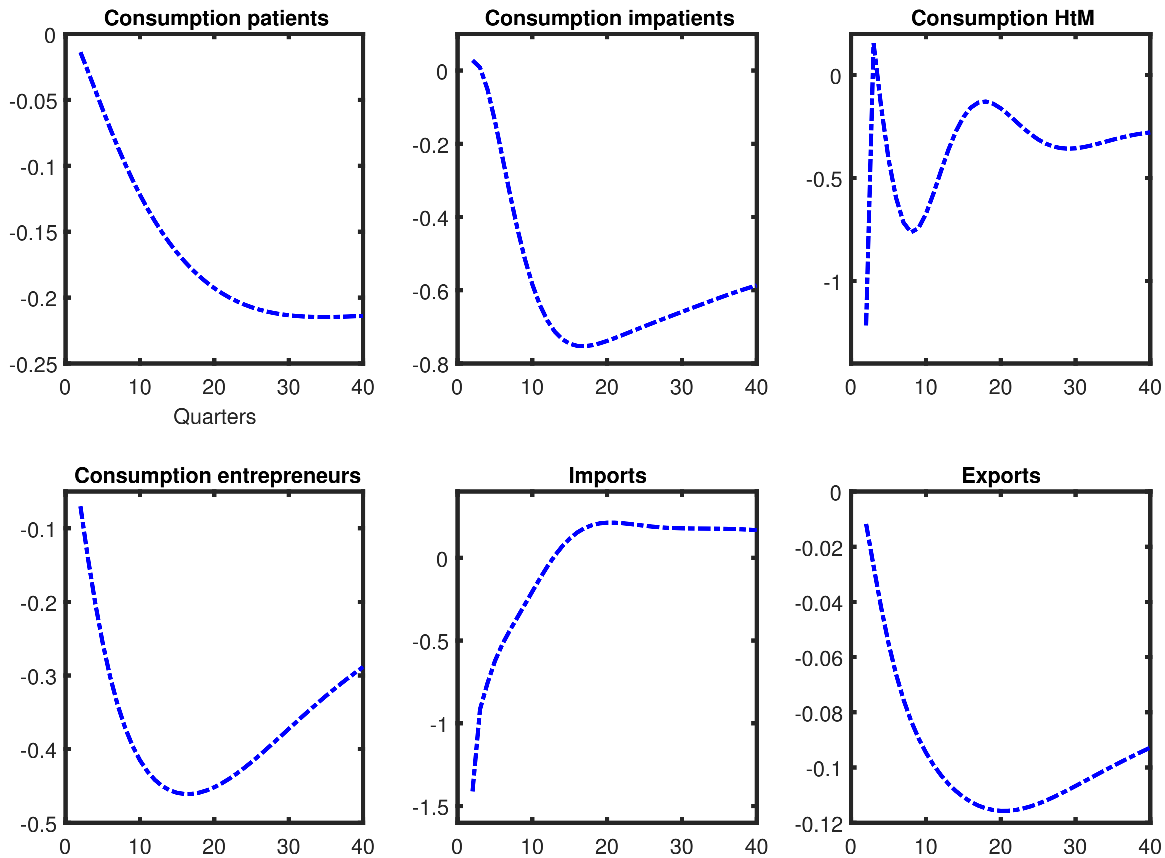

FIGURE 8: *Response to a permanent increase in the bank capital ratio*

a trough in September 2012 that would have accounted for a fall of 5 percentage points. A closer look at these shocks shows that housing demand shocks subtracted 1.25 percentage points of growth, on average between 2009 and 2015 (not shown here), to regain a positive influence only after the last quarter of 2015.

The blue bars in Figure 10 encompass price and wage mark-ups shocks, as well as shocks affecting the quality of capital and the TFP. Quite the opposite to what we observe with aggregate demand shocks, what the figure reveals is that supply shocks have displayed a countercyclical behavior in different periods. It was the case during the pre-crisis booming years. This pattern changed since the recent expansionary period, during which positive contributions of the supply shocks coexisted with positive economic growth. Interestingly, a more detailed inspection of the last shocks in the period under analysis reveals that mark-ups in prices and wages are the main source of the negative influence (not shown here). Their negative contribution is compensated by positive shocks due to the improvement in the quality of capital goods. Thus, aggregate supply shocks arise as the most important ingredient pulling up the economy, with an average positive contribution of

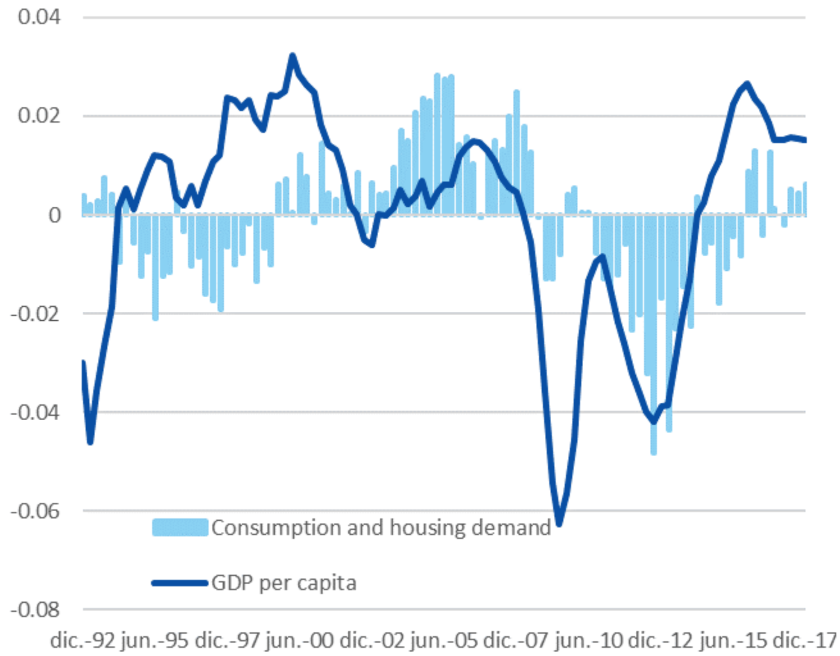

FIGURE 9: *GDP per capita growth in deviations from sample mean: consumption and housing demand shocks' contribution.*

2.1 percentage points to GDP growth since the sovereign debt crisis.

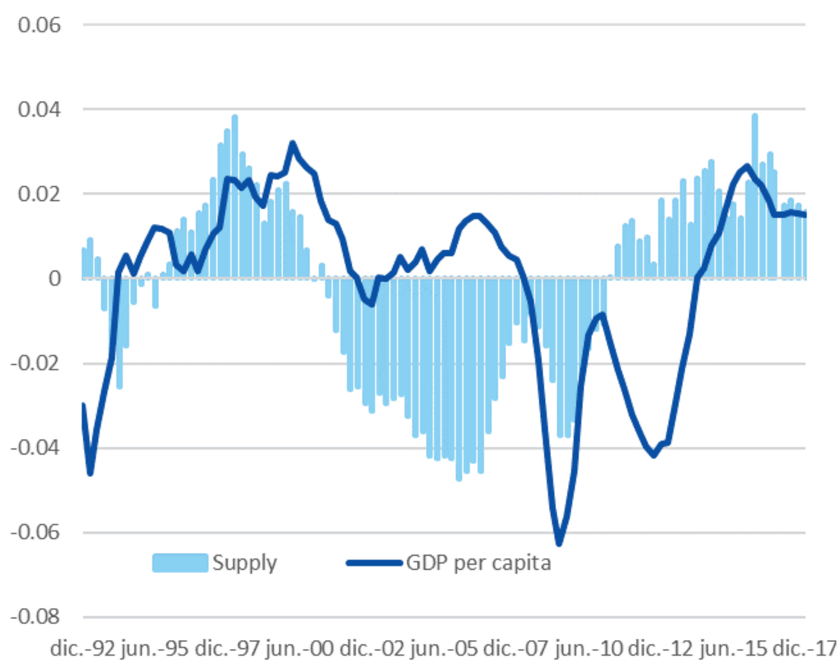

FIGURE 10: *GDP per capita growth in deviations from sample mean: mark-ups, capital and TFP shocks' contribution.*

In Figures 11 and 12 we present the contributions of those shocks more directly related with the financial market. Figure 11 aggregates shocks affecting the loan-to-value ratio of credit to households and firms that relates to their leverage ratio. This aggregate credit shock contributed positively, well above the GDP rate of growth, in the period previous to the crisis. Since then, its contribution has been negative and much more pronounced during the sovereign crisis than in the first stage of the international financial crisis. However, whereas in the first phase the behavior of the shock to households and firms was similar, after 2011 the perturbations associated with credit to firms are the main contributor. Actually, after 2014 negative shocks to households' credit start to decline or virtually disappear. That normalization in credit conditions was not observed for firms is probably due to a supplementary effort from their side to reduce the leverage ratio and improve their financial position.

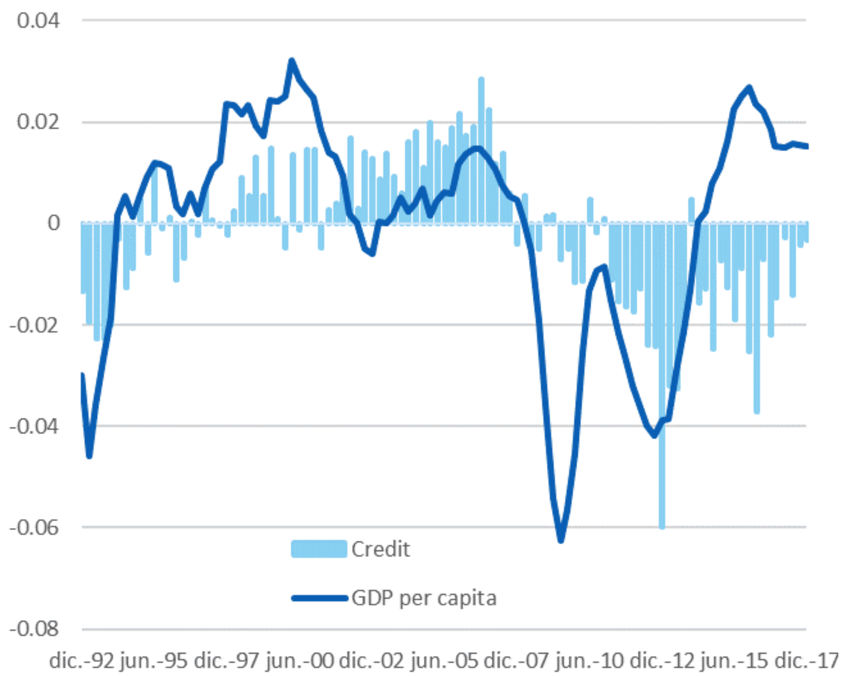

FIGURE 11: *GDP per capita growth in deviations from sample mean: loan-to-value shocks' contribution.*

Figure 12 captures the estimated aggregate shocks that include those affecting bank capital and interest rate mark-ups. Overall, their contribution was not negligible, fluctuating from positive to negative influences along the Great Recession times. Interestingly, after 2013 the effect has been always positive (on average 0.3 percentage points). The fall in the interest rate mark-ups, specially those for households, and the improvement in own resources during these years, are behind their positive effect on the economic recovery. Interest rate mark-ups and bank capital shocks affecting GDP in the same direction were not the norm previous to the sovereign crisis. Actually, for most of the boom period, they both contributed in different ways, offering an aggregate picture of a quite neutral influence during long intervals of the Spanish business cycle.

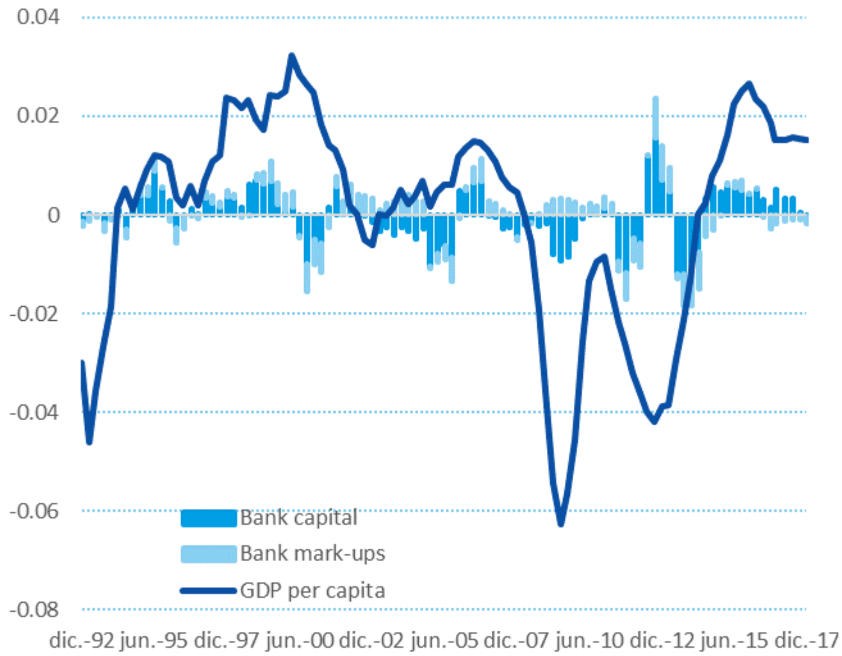

FIGURE 12: *GDP per capita growth in deviations from sample mean: bank capital and mark-ups' contribution.*

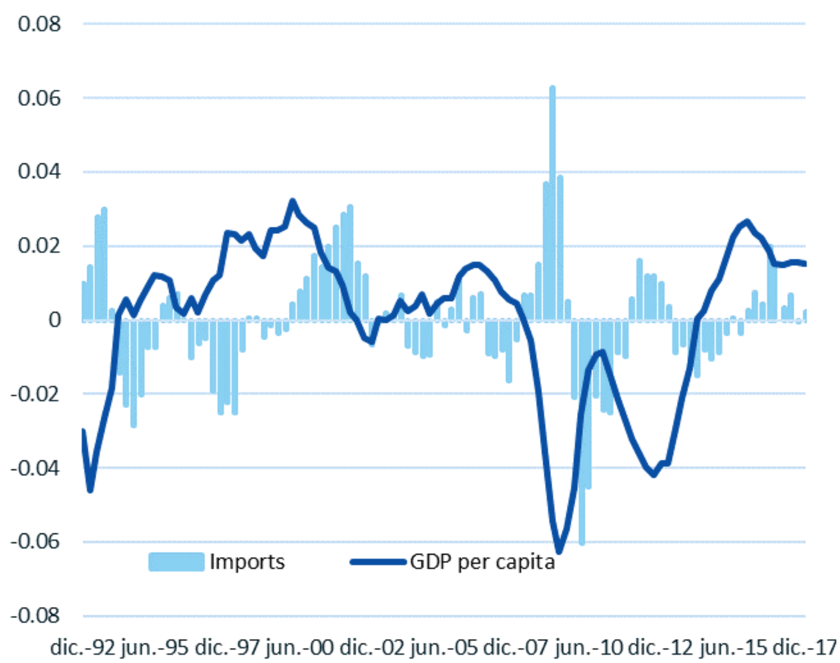

FIGURE 13: *GDP per capita growth in deviations from sample mean: imports.*

In Figures 13 and 14 we present the contribution of the external sector shocks, that is, the weight on GDP growth of shocks affecting imports and exports. To interpret results here it is important to remember that observables used to estimate the model are demeaned with respect to the rate of growth of each particular variable. That means that the model is not able to capture the contribution of the trade balance to growth due to different growth trends of exports and imports. Quite the opposite, what we are estimating are the effects on GDP owing to differences in changes in imports' and exports' rate of growth with respect to their own growth trend. With this caveat in mind, what we observe is that the contributions of import shocks were clearly countercyclical along the financial and sovereign debt recessions, but their contribution changed to positive in the first years of the recovery. Export shocks, on the other hand, detracted from the GDP rate of growth in the first part of the financial crisis. However, with the process of domestic devaluation that eventually took place in Spain, they have become an important factor offsetting the draining of aggregate production.

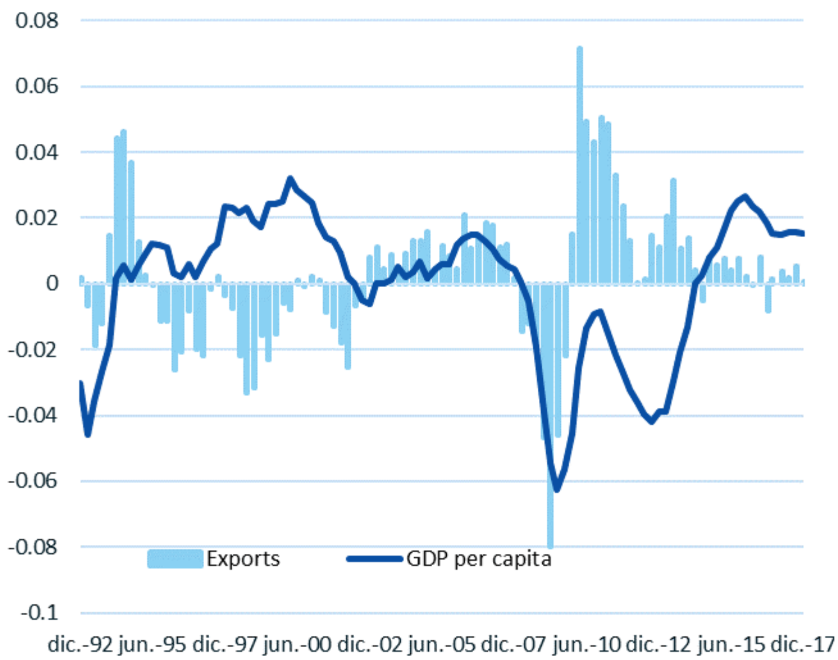

FIGURE 14: *GDP per capita growth in deviations from sample mean: exports.*

Figures 15 and 16 present the contribution of the shocks related to (conventional) monetary and fiscal policy, respectively. In Figure 15 we also present the role played by risk premium shocks, which could have been largely affected by non-conventional monetary measures. Risk premium shocks became a positive force before 2007, but soon after their influence turned negative, these shocks alone explaining more than half a percentage point of the reduction in per capita GDP growth at some moments of the economic crisis. During the first and more pronounced drop in economic activity, the European Central Bank succeeded in implementing an expansionary monetary policy by lowering the policy rate. This fact is captured by the model in the estimated positive contributions of the monetary shocks, which fully compensate for the negative effect due to the increase

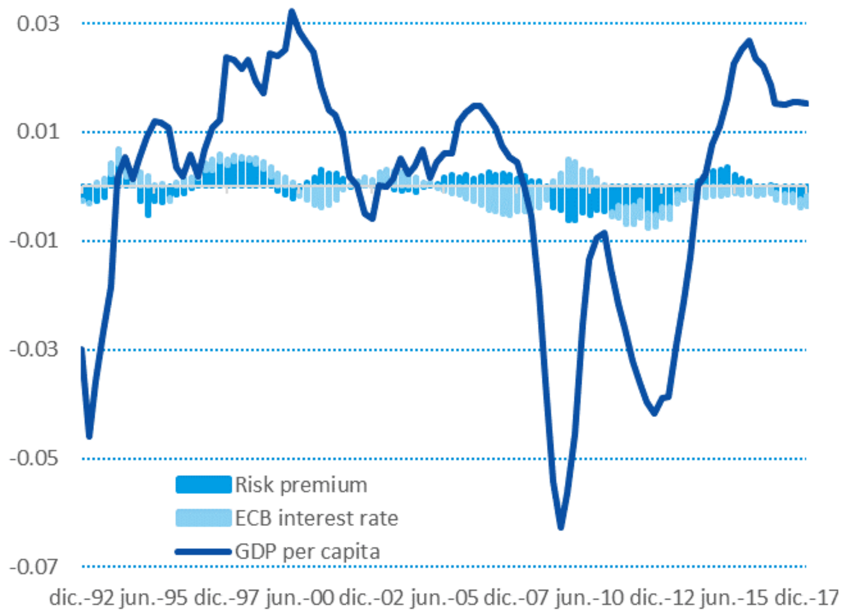

FIGURE 15: *GDP per capita growth in deviations from sample mean: risk premium and ECB's interest rate shocks' contribution.*

in the risk premium. However, once the zero lower bound was reached, the contribution of the policy rate to GDP growth was negative even during the sovereign debt crunch. The policy interest rate could not descend further to fight low inflation and weak economic activity, and this constraint is identified by the model as a perverse discretionary monetary policy.

Discretionary fiscal policy is represented in the model by the shocks affecting variables C_t^g and I_t^g. These shocks can be interpreted as perturbations that change the difference in the rate of growth of government consumption and investment with respect to potential GDP. This is so, because, at the steady-state, public spending in our model is growing at the same rate as GDP. A passive fiscal policy is then one that leaves unchanged the rate of growth of government purchases with respect to GDP, letting public consumption and investment grow more than observed output in economic recessions and less in good periods. Actually, this is the logic underlying the current fiscal rule in Spain. According to Figure 16, at the beginning of the crisis, the shock coming from an expansionary fiscal policy would have counteracted the fall in per capita GDP growth by little more than 0.5 percentage points. Nonetheless, the fast escalation in public deficits compelled the government to start a fiscal adjustment that subtracted an average of almost 1 percentage point from per capita output growth between the first quarter of 2010 and the last quarter of 2012, with a minimum of -1.6 percentage points in the third quarter of 2012. Starting at the beginning of 2013, government consumption

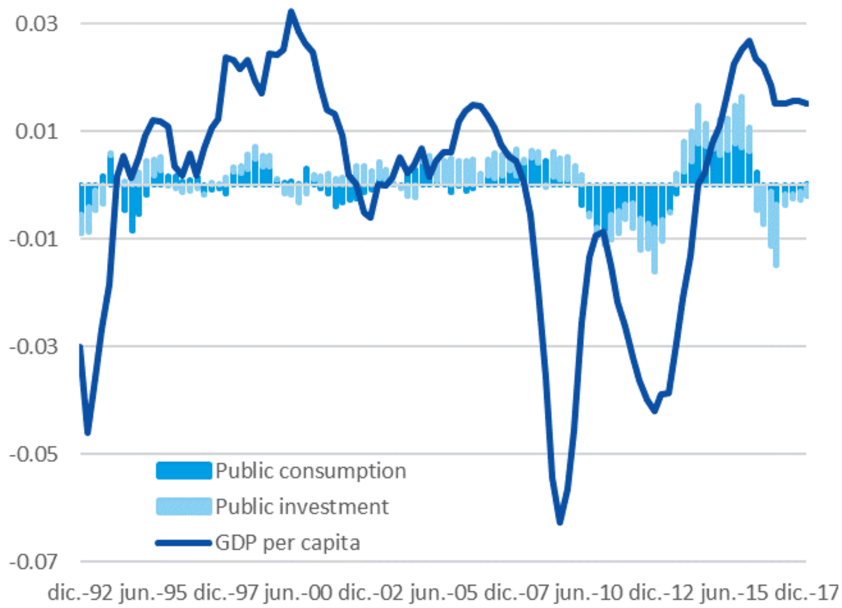

FIGURE 16: *GDP per capita growth in deviations from sample mean: public consumption and public investment shocks' contribution.*

and public investment had a positive weight in the economic recovery, pointing to a fiscal adjustment looser than the one that economic conditions would have allowed. Since 2016, fiscal policy, has again subtracted economic growth, mostly driven by the behavior of public investment.

5 Conclusions

In this paper we have developed a DSGE model of a small open economy within a monetary union with a banking sector and a rich representation of fiscal variables. We introduce banks following Gerali et al. (2010), who distinguish between a wholesale and a retail branch. Retail banks operate under monopolistic competition issuing colleteralized loans to impatient households and entrepreneurs. Banks also interact with the fiscal authority, buying part of the public debt. Interest rates in the retail sector change in a sticky way due to the presence of convex costs of adjustment. The wholesale branch collects deposits from domestic households and loans from the rest of the world, and manages bank capital, which increases with non-distributed profits. The interest rate for the wholesale branch is determined by the central bank policy rate augmented by a risk premium, which evolves according to the foreign position of the economy. Altogether, balance-sheet constraints, endogenous markups and staggered interest rates open a stimulating transmission mechanism through the banking sector for different shocks affecting the economy.

The model is specially designed to serve as a tool for the ex-ante evaluation of macroeconomic policies and to shed light on different shocks affecting the Spanish economy. After estimating the model by Bayesian techniques, we evaluate the response of macro variables to three shocks: a transitory increase in government consumption, a transitory increase in TFP and a permanent increase in banks' capital ratios. The impact of the fiscal multiplier on GDP is close to one and there is no short-run crowding-out effect on investment. The productivity shock produces a persistent hump-shaped reaction in GDP, which peaks after six quarters. A permanent increase in banks' capital ratios harms the amount of credit, consumption and investment with long-lasting effects. This result warns policymakers about the importance of carefully calibrating the trade-off between bank solvency and smoother credit conditions, which could enhance economic activity.

Our shock decomposition analysis highlights the fundamental role of financial conditions during the Great Recession and the subsequent recovery of the Spanish economy. Actually, shocks to loan-to-value ratios of households and firms and the implied deleverging process may explain almost entirely the observed reduction in GDP growth rates during the sovereign debt crisis. Quite differently, the nature of the shocks affecting bank capital and interest rate mark-ups is an important factor behind the recent recovery. Our results are also useful to quantify the contribution of discretionary fiscal policy to the business cycle. At the beginning of the crisis, the impact attributed to expansionary fiscal policies would have offset the fall in GDP growth by just under one percentage point. More recently, however, fiscal policy has been detrimental to economic growth, especially due to the low dynamism of public investment.

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Appendix: Data description and sources

The data used in the estimation of the model comprehend the (demeaned) interannual changes of the 18 quaterly time series enumerated below (after logged in the first 13 cases). For each variable we describe the economic indicators used in its construction along with their sources. The sample period is 1992Q4-2017Q4[1].

1. **Per capita households consumption** (C_t/γ^{all}): real private consumption divided by working-age population

    - **Real private consumption**: final consumption expenditure of households and non-profit institutions serving households at constant prices, seasonal and calendar effect adjusted (INE)
    - **Working-age population**: Population in family dwellings of 16 years old and over (INE)

2. **Per capita output** (Y_t^1/γ^{all}): real output divided by working-age population

    - **Real output**: gross domestic product at constant market prices, seasonal and calendar effect adjusted (INE)

3. **Per capita government consumption** (C_t^g/γ^{all}): nominal public consumption divided by GDP-deflator and additionally divided by working-age population

    - **Nominal public consumption**: final consumption expenditure of the Public Administrations at current prices, seasonal and calendar effect adjusted (INE)
    - **GDP-deflator**: Implicit deflator of gross domestic product. Seasonally adjusted by the authors.

4. **Per capita Government investment** (I_t^g/γ^{all}): nominal public investment divided by gdp-deflator and additionally divided by working-age population

    - **Nominal public investment**: General Government's gross fixed capital formation at current prices(INE). Seasonally adjusted by the authors.

5. **Per capita entrepreneurs' investment** (I_t/γ^{all}): nominal total investment minus nominal public investment, divided by total-investment-deflator and additionally divided by working-age population

[1]Recall that $\gamma^{all} = \gamma^p + \gamma^i + \gamma^m + \gamma^e$ denotes the total population of consumers (patient + impatient + hand-to-mouth+entrepreneurs).

- **Nominal total investment**: gross fixed capital formation at current prices, seasonal and calendar effect adjusted (INE)

- **Total investment deflator**: Implicit deflator of gross fixed capital formation, seasonal and calendar effect adjusted (INE)

6. **Per capita exports** (EX_t/γ^{pime}): real exports divided by working-age population

   - **Real exports**: Exports of goods and services at constant prices, seasonal and calendar effect adjusted (INE)

7. **Per capita imports** (IM_t/γ^{pime}): real imports divided by working-age population

   - **Real imports**: Imports of goods and services at constant prices, seasonal and calendar effect adjusted (INE)

8. **Per capita households lending** (B_t^i/γ^{pime}): households nominal lending (housing and non-housing) divided by the private-consumption-deflator and additionally divided by working-age population.

   - **Households nominal housing lending:**
     - ENTIDADES DE CRÉDITO Y EFC. OSR. Crédito para adquisición de vivienda propia (BdE Statistical Bulletin)
     - ENTIDADES DE CRÉDITO Y EFC. OSR. Crédito para rehabilitación de vivienda (BdE Statistical Bulletin)
     - ENTIDADES DE CRÉDITO RESIDENTES. Financiación a los hogares e instituciones sin fines de lucro que prestan servicios a los hogares. Préstamos titulizados fuera de balance para vivienda (BdE Economic Indicators)
   - **Households nominal non-housing lending:**
     - ENTIDADES DE CRÉDITO Y EFC. OSR. Crédito para adquisición de bienes de consumo duradero (BdE Statistical Bulletin)
     - ENTIDADES DE CRÉDITO Y EFC. OSR. Crédito para adquisición de bienes de consumo no duradero (BdE Statistical Bulletin)
     - OIFM. PRÉSTAMOS Y CRÉDITOS A LAS FAMILIAS. Resto de crédito excepto financiación actividades productivas (BdE Statistical Bulletin)

- ENTIDADES DE CRÉDITO RESIDENTES. Financiación a los hogares e instituciones sin fines de lucro que prestan servicios a los hogares. Préstamos titulizados fuera de balance distintos de vivienda (BdE Economic Indicators)

- **Private consumption deflator**: Implicit deflator of final consumption expenditure of households and non-profit institutions serving households(INE)

9. **Per capita entrepreneurs lending** (B_t^e/γ^{pime}): nominal entrepreneurs lending divided by the private-consumption-deflator and additionally divided by working-age population.

   - **Nominal entrepreneurs lending:**
     - ENTIDADES DE CRÉDITO Y EFC. OSR. Crédito para financiación de actividades productivas (BdE Statistical Bulletin)
     - ENTIDADES DE CRÉDITO Y EFC. OSR. Crédito para financiación a las sociedades no financieras. Préstamos titulizados fuera de balance (BdE Statistical Bulletin)

10. **Per capita banks capital** (K_t^b/γ^{pime}): nominal bank capital divided by private-consumption-deflator and additionally divided by working-age population.

    - **Nominal banks capital:** ENTIDADES DE CRÉDITO Y EFC. Capital y reservas. Patrimonio neto. Total fondos propios (BdE Statistical Bulletin).

11. **Housing price** (q_t^h): nominal housing price divided by private-consumption-deflator

    - **Nominal housing price**: Price m2 free housing (INE from Ministry of Development)

12. **GDP deflator** (P_t^h): GDP deflator (INE).

13. **Real wage** (w_t): ratio of the total remuneration of employees over the total number of wage earners, seasonal and calendar effect adjusted (INE), divided by the GDP deflator (INE).

14. **Interest rate for Households lending** (r_t^{bi}): it is the weighted average of the interest rates for housing loans and non-housing loans given, respectively, by the following two indicators:

    - **Interest rates for housing loans**: Tipo de interés (medias ponderadas). Nuevas operaciones. ENTIDADES DE CRÉDITO Y EFC. TEDR. A los hogares. Crédito a la vivienda (BdE Statistical Bulletin)

- **Interest rates for non-housing loans**: Tipo de interés (medias ponderadas). Nuevas operaciones.ENTIDADES DE CRÉDITO Y EFC. TEDR. A los hogares. Crédito al consumo (BdE Statistical Bulletin)

Weights are given by nominal households housing lending and nominal households non-housing lending respectively.

15. **Interest rate for Entrepreneurs lending** (r_t^{be}): Tipos de interés. Nuevas operaciones. ENTIDADES DE CRÉDITO Y EFC. TEDR. Crédito a sociedades no financieras.Descubiertos encuenta y créditos renovables (BdE Statistical Bulletin).

16. **Interest rate for deposits** (r_t^d): Tipos interés (medio ponderado). Nuevas operaciones. ENTIDADES DE CRÉDITO Y EFC. TEDR. Depósitos a plazo de los hogares (BdE Statistical Bulletin).

17. **Monetary policy interest rate** (r_t): EONIA (ECB)

18. **Risk premium on foreign lending** (ϕ_t): difference between sovereign-bond-yield and monetary policy interest rate, the former given by:

    - **Sovereign-bond-yield**: Spain: 10-Year Government Bond Yield, average, percentage (HAVER-EUDATA).

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