# Imbalances and Rebalancing in an Estimated Structural Model for Spain*

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This paper uses an estimated DSGE model to analyze the factors behind the buildup of imbalances in the Spanish economy. Shock decompositions suggest that external imbalances have been able to build up mainly due to the reduction in real interest rates and easier access to credit following the elimination of the exchange rate risk premium. A rebalancing process in recent years with a sharp contraction in domestic demand has moved the trade balance back into surplus. The main driving factors were the collapse of the housing bubble and tightening of credit conditions.

JEL Codes: C54, E21, E62, F32.

## 1. Introduction

The existence of large internal and external imbalances in many European countries has become a major concern in the European Union. While the buildup of imbalances and growing current account deficits were recognized as one of the main challenges for adjustment in EMU early on (European Commission 2006, 2008), the financial and sovereign debt crises have exposed the serious vulnerabilities in some countries. In response, the European Union has created the

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macroeconomic imbalances procedure (MIP), which in its preventive arm tries to identify at an early stage the existence of internal and external imbalances relative to specific thresholds via a scoreboard. If imbalances are deemed to be harmful, a member state can be placed into an excessive imbalance position and corrective action can be demanded.[1] But this requires a thorough analysis of imbalances and underlines the importance of having a coherent framework to do this.

Current account deficits are not necessarily macroeconomic imbalances, but may reflect an appropriate allocation of savings, given different investment opportunities across countries. External borrowing allows countries to smooth consumption over time, and capital flows from core euro-area countries to the periphery could be a normal feature of savings looking for the highest returns. But distortions due to incorrect expectations of returns and mispricing of risks could lead to a misallocation of resources and a buildup of imbalances and vulnerabilities. As rising and persistent deficits translate into an accumulation of net foreign liabilities, the risk of being tipped into an external crisis becomes non-trivial and accelerates with further exposure. Catao and Milesi-Ferretti (2013) find that once economies' net foreign liabilities rise above 50 percent of GDP, the risk of crisis—defined as either an outright external default or the disbursement of a large multi-lateral financial support package—accelerates with further net liability exposure. Their model predicts Spain as a high-risk case, with signals flashing red since 2008.

The main contribution of our paper is to show how an estimated structural model can be used to examine the driving factors behind the buildup of imbalances in a country. We take the case of Spain and estimate our model over the period 1995–2012, including both the boom years and the subsequent bust, and use this to identify and measure the main shocks driving the Spanish economy. Large imbalances have built up in the Spanish economy since its accession to the euro area. With Spanish membership of EMU came the elimination of currency risk, and a sharp fall in interest rates, which spurred cross-border borrowing that fed a long-lasting housing and

[1] See http://ec.europa.eu/economy_finance/economic_governance/macroeconomic_imbalance_procedure/index_en.htm.

credit boom and large current account deficits and escalating external debt. A correction started in 2007, accelerated by the financial crisis, and the Spanish economy has since gone through a sharp adjustment, with unemployment soaring. But while there has been a significant improvement in the trade balance, Spain's net foreign liabilities remain above 90 percent of GDP, far exceeding euro-area averages and raising concerns about long-run sustainability. For the scoreboard used in the MIP, the "threshold" for the net international investment position is set at 35 percent of GDP, and for Spain this indicator would have been flashing since 2002. Given the stock nature of this indicator, it is unlikely this alert will stop flashing anytime soon.

Our model has some features which make it especially suitable to analyze the Spanish economy, namely residential investment and credit constraints as introduced by Kiyotaki and Moore (1997). Given the prominent role of residential investment and innovations in mortgage lending, we model housing investment explicitly and allow for collateral constraints; see, e.g., also Iacoviello (2005), Monacelli (2007), and Iacoviello and Neri (2010). This helps us in quantifying the extent to which financial innovations have contributed to the boom but also sheds light on the effects of a possible credit crunch in mortgage lending. For a historical decomposition, we use the fitted shocks of the model for a shock accounting exercise to decompose growth rates, domestic demand, and trade balance to GDP ratios to quantify the relative contributions of the different shocks. This allows us to identify the main driving factors behind the buildup of external imbalances and find policies which are most likely to be successful in rebalancing the economy. Possible causes are a loosening of credit growth; bubbles in asset markets, which may have driven up domestic demand; or loss of competitiveness because of insufficient adjustment of wages to productivity growth. By taking the model to the data, one can pinpoint certain developments in labor, housing, and credit markets.[2]

[2]Several papers have used estimated DSGE models to provide an additive decomposition of the data in terms of the estimated shocks. For the United States, Christiano, Motto, and Rostagno (2008) compares the monetary policy response to the 2001 recession in the United States and the euro area. In 't Veld et al. (2011) uses an estimated model to evaluate competing explanations about the boom-bust cycle in the United States.

Our shock decompositions suggest that one of the main factors behind the buildup of imbalances was low real interest rates and easier access to credit, linked to the inflow of cheap capital due to the disappearance of the risk premium and monetary policy set at the euro-area level. This conclusion is broadly in line with the findings in other studies. In a study on adjustment in a monetary union, the European Commission (2006) emphasized the role of the decline in the risk premium in explaining current account deficits in adjustment in a monetary union. Andres et al. (2010) also highlight the role of lower interest rates in Spain. Using an estimated structural model for Spain and comparing this with a version in which Spain is able to set its own monetary policy, they show that an independent monetary authority would have hypothetically pursued different output-inflation trade-offs for most of the sample period, and would have cooled down inflationary pressures at the cost of slightly slower economic growth (ibid., p. 93). Burriel, Fernández-Villaverde, and Rubio-Ramírez (2010) likewise refer to the adoption of the euro and the associated historically low real interest rates as a contributing factor to the long period of continuous real GDP growth since the mid-1990s. Jaumotte and Sodsriwiboon (2010) suggest other southern euro-area countries might also have benefited from a "euro bonus" in running larger deficits than sustainable. The euro helped these countries to maintain higher investment levels by improving their access to international savings, but investment took place in less productive non-tradable sectors, such as construction, and current account deficits now exceed their long-run fundamental "norms."

Our analysis indicates that the correction in the trade balance has been mainly driven by the collapse in the housing bubble and a tightening in credit conditions. The contraction in domestic demand is in line with historical evidence which suggests that current account adjustment in deficit countries has more typically relied on expenditure reduction than on expenditure switching (Lane and Milesi-Ferretti 2011). However, our results also show that the demand contraction has been accompanied by deflation and a decline in unit labor costs which has brought about some depreciation of the real effective exchange rate.

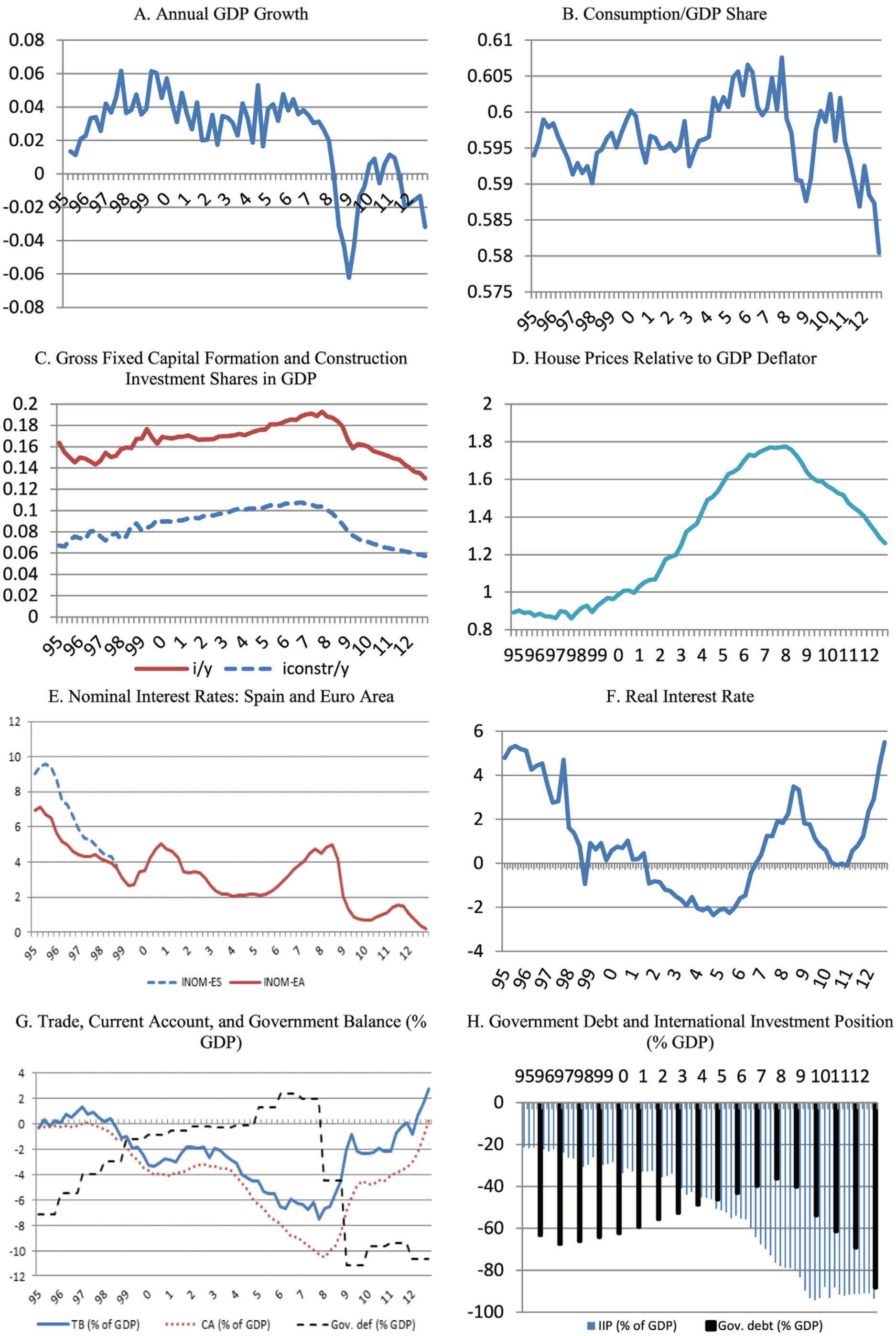
The remainder of the paper is structured as follows. The following section describes some of the main stylized facts of the Spanish economy since the adoption of the euro. Section 3 describes in detail the theoretical model; section 4 discusses the estimation and historical evolution of some of the main shocks. Section 5 discusses the shock decomposition of the main variables of interest to determine the underlying factors behind the buildup of imbalances. Section 6 concludes.

## 2. Some Stylized Facts of the Spanish Economy

For most of the decade up to 2007, GDP growth in Spain exceeded average growth in the euro area. But the financial and economic crisis hit Spain severely, with quarter-to-quarter annualized growth rates falling to almost −6 percent in the first quarter of 2009, a slower recovery in 2010–11 compared with the rest of the euro area, and a second-dip recession in 2012. While over the boom years all domestic demand components showed a trend increase in their share in GDP, this trend increase was most pronounced in investment, and in particular in residential construction (see figure 1). The Spanish consumption-to-GDP ratio remained relatively stable around 60 percent, about 4 percentage points higher than the euro-area average, but it had fallen to 58 percent by the end of 2012. On the other hand, investment-to-GDP and construction-investment-to-GDP ratios showed a strong positive trend from 1995 up to the last quarters of 2007 and then both dropped sharply in the crisis. This strong performance of investment (especially in the construction sector) relative to output in the 2000s, coupled with a substantial increase in house prices in this period, is suggestive of a housing bubble that developed in Spain prior to the crisis. It is noticeable that house prices in real terms have shown some correction since their peak in 2007, but were by 2012 only back at their 2003 levels.

Accession to EMU led to a gradual elimination of the risk premium on Spanish interest rates with a convergence of the policy rate towards the euro-area average by 1999. The reduction in nominal interest rates also led to a sharp reduction in the real interest rate and even negative rates between 2001 and 2006, but real rates rose sharply in 2012. The boom in domestic demand was accompanied by a strong deterioration in external balances. From the second half of the 1990s, the Spanish economy moved from small trade surpluses to a very large trade deficit of more than 7 percent by

**Figure 1. Spain: 1995:Q1–2012:Q4**



2007 and even larger current account deficits. The persistent trade deficits accumulated into an ever-increasing net foreign indebtedness, rising from around 20 percent of GDP in the late 1990s to more than 90 percent of GDP by 2009. Since the crisis, the Spanish trade deficit has shrunk considerably, to close to balance by the end of 2011, but its net international investment position remains around −90 percent of GDP. Spain's public finances were, up to the crisis, in better shape than the euro-area average. The Spanish government balance improved considerably between the mid-1990s and mid-2000s, even recording a surplus between 2005 and 2007.[3] Much of this improvement was not due to permanent factors but to increases in tax revenues associated with changes in the composition of GDP—in particular, transitory asset boom revenues (Martinez-Mongay, Maza Lasierra, and Yaniz Igal 2007). The crisis led to a sharp reversal of this trend, with the deficit peaking at 11 percent of GDP in 2009 and remaining persistently high since. This deterioration in the fiscal position reversed the trend decline in gross debt, which had fallen to 36 percent of GDP in 2007, but which increased rapidly to close to 90 percent of GDP by the end of 2012.

## 3. Model

We consider an open economy, which produces goods that are imperfect substitutes for goods produced in the rest of the world.[4] Households engage in international financial markets, and there is near-perfect international capital mobility. There are three production sectors, a final goods production sector as well as an investment-goods-producing sector and a construction sector. We distinguish between Ricardian households, which have full access to financial markets, and credit-constrained households facing a collateral constraint on their borrowing. The economy is part of a monetary union and faces an exogenous interest rate. There is a fiscal authority, which follows rules-based stabilization policies. Behavioral and

[3]In fact, the experience of Spain of fiscal and current account deficits moving in opposite directions appears to contradict the twin-deficit hypothesis.

[4]The model is an extension of the QUEST model estimated on euro-area data (Ratto, Roeger, and in 't Veld 2009) with a housing sector and collateral-constrained households. A similar version has been estimated on U.S. data (in 't Veld et al. 2011).

technological relationships can be subject to autocorrelated shocks denoted by $U_t^k$, where $k$ stands for the type of shock. The logarithm of $U_t^k$ will generally be autocorrelated with autocorrelation coefficient $\rho^k$ and innovation $\varepsilon_t^k$.[5]

## *3.1 Firms*

### *3.1.1 Final Goods Producers*

Firms operating in the final goods production sector are indexed by $j$. Each firm produces a variety of the domestic good which is an imperfect substitute for varieties produced by other firms. Because of imperfect substitutability, firms are monopolistically competitive in the goods market and face a demand function for goods. Domestic final goods producers sell goods and services to domestic and foreign households, investment and construction firms, and governments. Output is produced with a Cobb-Douglas production function using capital $K_t^{j,P}$ and production workers $L_t^j$ as inputs:

$$Y_t^j = (UCAP_t^j K_t^j)^{1-\alpha} L_t^{j\alpha} U_t^{Y\alpha}, \quad \text{with } L_t^j = \left[\int_0^1 L_t^{i,j\,\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}}. \tag{1}$$

Total employment of the firm $L_t^j$ is itself a constant elasticity of substitution (CES) aggregate of labor supplied by individual households $i$. The parameter $\theta > 1$ determines the degree of substitutability among different types of labor. Firms also decide about the degree of capacity utilization $(UCAP_t^j)$. There is an economy-wide technology shock $U_t^Y$ following a random-walk process plus drift. The objective of the firm is to maximize profits $Pr$,

$$\begin{aligned}\mathrm{Pr}_t^j = p_t^j Y_t^j - w_t L_t^j - i_t^K p_t^{K,j} K_t^j - (adj^P(P_t^j) + adj^L(L_t^j) \\ + adj^{UCAP}(UCAP_t^j)),\end{aligned} \tag{2}$$

where $i^K$ denotes the rental rate of capital. Firms also face technological and regulatory constraints which restrict their price-setting,

[5]Lowercase letters denote logarithms, i.e., $z_t = log(Z_t)$. Lowercase letters are also used for ratios and rates. In particular, we define $p_t^j = P_t^j / P_t^Y$ as the relative price of good $j$ with regard to the GDP deflator.

employment, and capacity-utilization decisions. Price-setting rigidities can be the result of the internal organization of the firm or specific customer-firm relationships associated with certain market structures. Costs of adjusting labor have a strong job-specific component (e.g., training costs), but higher employment adjustment costs may also arise in heavily regulated labor markets with search frictions. Costs associated with the utilization of capital can result from higher maintenance costs associated with a more intensive use of a piece of capital equipment. The following convex functional forms are chosen:

$$adj^L(L_t^j) = w_t\left(L_t^j u_t^L + \frac{\gamma_L}{2}\Delta L_t^{j2}\right)$$

$$adj^P(P_t^j) = \frac{\gamma_P}{2}\left(\frac{P_t^j}{P_{t-1}^j} - 1\right)^2 Y_t$$

$$adj^{UCAP}(ucap_t^j) = p_t^I K_t\left(\gamma_{ucap,1}(ucap_t^j - 1) + \frac{\gamma_{ucap,2}}{2}(ucap_t^j - 1)^2\right). \tag{3}$$

The firm determines labor input, capital services, and prices optimally in each period given the technological and administrative constraints as well as demand conditions.

### *3.1.2 Residential Construction*

Monopolistically competitive firms $h$ in the residential construction sector use new land ($J_t^{Land}$) sold by (Ricardian) households and final goods ($J_t^{Constr}$) to produce new houses using a CES technology

$$J_t^H = \left(s_L^{\frac{1}{\sigma_L}} J_t^{Land\frac{(\sigma_L-1)}{\sigma_L}} + (1-s_L)^{\frac{1}{\sigma_L}} J_t^{Constr\frac{(\sigma_L-1)}{\sigma_L}}\right)^{\frac{\sigma_L}{\sigma_L-1}} \tag{4}$$

subject to a quadratic adjustment cost constraint

$$adj^{PH}(P_t^H) = \frac{\gamma_P}{2}\left(\frac{P_t^H}{P_{t-1}^H} - 1\right)^2 Y_t. \tag{5}$$

New and existing houses are perfect substitutes. Thus households can make capital gains or suffer capital losses, depending on house price fluctuations.

#### *3.1.3 Investment Goods Producers*

There is a perfectly competitive investment goods production sector which combines domestic and foreign final goods, using the same CES aggregators as households and governments do to produce investment goods for the domestic economy. Denote the CES aggregate of domestic and foreign inputs used by the investment goods sector by $J_t^{inp}$; then real output of the investment goods sector is produced by the following linear production function:

$$J_t = J_t^{inp} U_t^{PI}, \tag{6}$$

where $U_t^{PI}$ is a technology shock to the investment goods production technology which itself follows a random walk,[6]

$$u_t^{PI} = u_{t-1}^{PI} + \varepsilon_t^{UPI}. \tag{7}$$

### *3.2 Households*

The household sector consists of a continuum of households $h \in [0, 1]$. A fraction $s^r$ of all households are Ricardian and indexed by $r$, and $s^c$ households are credit constrained and indexed by $c$. The period utility function is identical for each household type and specified as a nested CES aggregate of consumption $(C_t^h)$ and housing services $(H_t^h)$ and separable in leisure $(1 - L_t^h)$. We also allow for habit persistence in consumption. Thus temporal utility for consumption is given by

$$\begin{aligned} & U(C_t^h, H_t^h, 1 - L_t^h) \\ & \quad = \log \left\{ \left[ s_C^{\frac{1}{\sigma^H}} \left( C_t^h - hC_{t-1}^h \right)^{\frac{\sigma^H - 1}{\sigma^H}} + s_H^{\frac{1}{\sigma^H}} H_t^{h \frac{\sigma^H - 1}{\sigma^H}} \right]^{\frac{\sigma^H}{\sigma^H - 1}} \right\} \\ & \qquad + \exp(u_t^L) \vartheta \left( 1 - L_t^h \right)^{1-\kappa}. \end{aligned} \tag{8}$$

Both types of households supply differentiated labor services to unions which maximize a joint utility function for each type of

[6] This shock is introduced to capture a divergent trend in relative investment prices.

labor $i$. It is assumed that types of labor are distributed equally over the two household types. Nominal rigidity in wage setting is introduced by assuming that the household faces adjustment costs for changing wages. These adjustment costs are borne by the household.

#### 3.2.1 Ricardian Households

Ricardian households have full access to financial markets. They hold domestic government bonds ($B_t^{G,r}$) and bonds issued by other domestic and foreign households ($B_t^r, B_t^{F,r}$), real capitals ($K_t^r$) used in the final goods production sector, as well as the stock of land ($Land_t$) which is still available for building new houses. In addition, they hold a stock of deposits ($D$) with a financial intermediary who provides loans to credit-constrained households. The household receives income from labor, financial assets, rental income from lending capital to firms, selling land to the residential construction sector, plus profit income from firms owned by the household (final goods $\mathrm{Pr}_t^j$, residential construction $\mathrm{Pr}_t^H$, and financial intermediaries $\mathrm{Pr}_t^B$). We assume that all domestic firms are owned by Ricardian households. Income from labor is taxed at rate $t^w$, consumption at rate $t^c$. In addition, households pay lump-sum taxes $T^{LS}$. We assume that income from financial wealth is subject to different types of risk. Domestic bonds and interest income from deposits yield risk-free real return equal to $r_t$. Domestic and foreign bonds are subject to (stochastic) risk premia linked to net foreign indebtedness. An equity premium on real assets arises because of uncertainty about the future value of real assets. Furthermore, the discount factor $\beta^r$ is subject to random shocks.

The Lagrangian of this maximization problem is given by

$$MaxV_0^r = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^{r^t} U(C_t^r, 1 - L_t^r, H_t^r) - \mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^r \beta^{r^t}$$

$$\times \begin{pmatrix} (1+t_t^c)p_t^C C_t^r + p_t^I I_t^r + p_t^H (1+t_t^c) I_t^{H,r} + (B_t^{G,r} + B_t^r + D_t) \\ \quad + rer_t B_t^{F,r} - (1+r_{t-1})(B_{t-1}^{G,r} + B_{t-1}^r + D_{t-1}) \\ \quad - (1+r_{t-1}^F) rer_t B_{t-1}^{F,r} - ((1-t^K) i_{t-1}^K + t^K \delta^K) p_{t-1}^I K_{t-1}^r \\ \quad - (1-t_t^W) w_t L_t^r + adj^W(W_t) - p_t^L J_t^{Land} - \sum_{j=1}^{\mathrm{Pr}_t^j} - \mathrm{Pr}_t^H \\ \quad - \mathrm{Pr}_t^B + T_t^{LS,r} \end{pmatrix}$$

$$
\begin{aligned}
&- \mathrm{E}_0 \sum_{t=0}^{\infty} q_t^{r,K} \beta^{r^t} (K_t^r - J_t^r - (1-\delta^K) K_{t-1}^r) \\
&- \mathrm{E}_0 \sum_{t=0}^{\infty} q_t^{r,H} \beta^{r^t} \left( H_t^r - J_t^{H,r} - (1-\delta^H) H_{t-1}^{H,r} \right) \\
&- \mathrm{E}_0 \sum_{t=0}^{\infty} q_t^{r,L} \beta^{r^t} \left( Land_t + J_t^{Land} - (1+g_t^L) Land_{t-1} \right). \qquad (9)
\end{aligned}
$$

The investment decisions with regard to physical capital and housing are subject to convex adjustment costs; therefore, we make a distinction between real investment expenditure $(I_t^r, I_t^{H,r})$ and physical investment $(J_t^r, J_t^{H,r})$. Investment expenditure of households including adjustment costs is given by

$$
I_t^r = J_t^r \left( 1 + \frac{\gamma_K}{2} \left( \frac{J_t^r}{K_t^r} \right) \right) + \frac{\gamma_I}{2} (\Delta J_t^r)^2 \qquad (10a)
$$

$$
I_t^{H,r} = J_t^{H,r} \left( 1 + \frac{\gamma_H}{2} \left( \frac{J_t^{H,r}}{H_t^r} \right) \right) + \frac{\gamma_{I^H}}{2} (\Delta J_t^{H,r})^2. \qquad (10b)
$$

The budget constraint is written in real terms, with all prices expressed relative to the GDP deflator $(P)$. Investment is a composite of domestic and foreign goods.

We follow Bernanke and Gertler (1999) and assume that residential and non-residential investment decisions are subject to fundamental and non-fundamental shocks. From the first-order conditions of the household investment problem, we obtain the shadow price of non-residential and residential capital:

$$
q_t^{r,K} = \beta E_t \left[ q_{t+1}^{r,K} (1-\sigma^K) + \left( (1-t^K) i_t^K + t^K \sigma^K \right) p_t^I \right] \qquad (11a)
$$

$$
q_t^{r,H} = U_{H,t}^r + \beta E_t \left( q_{t+1}^{r,H} (1-\sigma^H) \right), \qquad (11b)
$$

which is equal to the present discounted value of fundamental shocks, namely the after-tax rental rate of capital and the marginal utility of housing services, respectively. As in Bernanke and Gertler (1999), we assume that in addition there are non-fundamental shocks $x_t^i$ with $i \in (K, H)$, which follow a "near-rational bubble" process $x_{t+1}^i = \frac{a^i}{\beta} x_t^i + e_t^i$ with $a^i < \beta$.

We then define the modified shadow price $Q_t^{r,i} = q_t^{r,i} + x_t^i$, which follows the process

$$(1 - z_t^K)Q_t^{r,K} = \beta E_t\Big(Q_{t+1}^{r,K}(1 - \delta^K) + \big((1 - t^K)i_t^K + t^K\delta^K\big)\, p_t^I\Big) \tag{12a}$$

$$(1 - z_t^H)Q_t^{r,H} = U_{H,t}^r + \beta E_t\Big(Q_{t+1}^{r,H}(1 - \delta^H)\Big), \tag{12b}$$

where $z_t^i = (1 - a^i)\frac{x_t^i}{\beta}$.

Like Bernanke and Gertler, we use the term "bubble" loosely to denote temporary deviations of asset prices from fundamentals due to waves of optimism and excessive risk taking in periods of rising asset prices and waves of pessimism or panics in periods of increased uncertainty.

In the context of the current crisis, alternative explanations could be given for a sudden fall in asset prices. For example, an increase in $z_t^i$ could capture what Gorton (2010) calls a "panic," to describe the uncertainty about the value of certain asset classes which have forced banks to deliver and dump assets, leading to falling asset values. A rising $z_t^i$ could also capture what Hall (2010) refers to as "principal agent frictions," which he models by introducing an exogenous wedge shock between safe assets (government bonds) and risky assets (equity and houses) in order to empirically match rising spreads between safe and risky assets.

The interest rate that households face when making consumption and investment decisions depends on the aggregate level of foreign indebtedness (defined as $(-B_t^{F,r})/(p_tY_t)$):

$$i_t^h = i_t + rprem\left(\frac{(-B_t^F)}{P_tY_t}\right). \tag{13}$$

This specification corresponds to the debt-elastic interest rate premium in the comparison of methods studied by Schmitt-Grohe and Uribe (2003) in closing small open-economy models. The major reason for this specification is that it induces stationarity. However, we also regard the interest elasticity with regard to foreign debt as an important behavioral parameter describing the risk tolerance of foreign creditors. The parameter *rprem*, together with the rate of time preference of Ricardian households, determines the steady-state debt level of the economy.

### 3.2.2 Credit-Constrained Households

Credit-constrained households differ from Ricardian households in two respects. First, they have a higher rate of time preference ($\beta^c < \beta^r$) and, second, they face a collateral constraint on their borrowing. They borrow $B_t^c$ exclusively from domestic Ricardian households. The Lagrangian of this maximization problem is given by

$$\begin{aligned} MaxV_0^c = {} & \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^{c^t} U(C_t^c, 1 - L_t^c, H_t^c) \\ & - \mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^c \beta^{c^t} \Big( (1 + t_t^c) p_t^C C_t^c + p_t^H (1 + t_t^H) I_t^{H,c} - B_t^c \\ & + (1 + r_{t-1}) B_t^c) - (1 - t_t^W) w_t L_t^c + adj^W (W_t) + T_t^{LS,c} \Big) \\ & - \mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^c \zeta_t^c \beta^{c^t} \Big( H_t^c - J_t^{H,c} - (1 - \delta^H) H_{t-1}^c \Big) \\ & - \mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^c \psi_t^c \beta^{c^t} \big( (1 + r_t) B_t^c - \chi_t^c p_t^H H_{t-1}^c \big) . \end{aligned} \tag{14}$$

Notice that the collateral constraint increases the shadow price of borrowing as determined by the Lagrange multiplier $\psi_t^c$ of the collateral constraint.

There is a non-fundamental shock to housing investment which is constrained to be equal across household types.

### 3.2.3 Wage Setting

A trade union is maximizing a joint utility function for each type of labor $i$ where it is assumed that types of labor are distributed equally over constrained and unconstrained households with their respective population weights. The trade union sets wages by maximizing a weighted average of the utility functions of these households. The wage rule is obtained by equating a weighted average of the marginal utility of leisure to a weighted average of the marginal utility of consumption times the real wage of these two household types, adjusted for a wage markup,

$$\frac{s^c U^c_{1-L,t} + s^r U^r_{1-L,t}}{s^c U^c_{c,t} + s^r U^r_{c,t}} = \frac{(1-t^W_t)}{(1+t^C_t)} \frac{W_t}{P^C_t} \eta^W_t, \tag{15}$$

where $\eta^W_t$ is the wage markup factor, with wage markups fluctuating around $1/\theta$, which is the inverse of the elasticity of substitution between different varieties of labor services. The trade union sets the consumption wage as a markup over the reservation wage. The reservation wage is the ratio of the marginal utility of leisure to the marginal utility of consumption. This is a natural measure of the reservation wage. If this ratio is equal to the consumption wage, the household is indifferent between supplying an additional unit of labor and spending the additional income on consumption and not increasing labor supply. Fluctuation in the wage markup arises because of wage adjustment costs

$$adj^W(W_t) = \frac{\gamma_W}{2} \left( \frac{1}{\Pi_{t-1}^{1-sfw} \bar{\Pi}^{sfw}} \frac{W_t}{W_{t-1}} - 1 \right)^2 Y_t. \tag{16}$$

### *3.3 Trade and the Current Account*

In order to facilitate aggregation, we assume that households, the government, and the corporate sector have identical preferences across goods used for private consumption, public expenditure, and investment. Let $Z^i \in \left\{C^i, I^i, C^{G,i}, I^{G,i}\right\}$ be demand of an individual household, investor, or the government, and then their preferences are given by the following utility function:

$$Z^i = \left[ (1 - s^M - u^M_t)^{\frac{1}{\sigma^M}} Z^{d^i \frac{\sigma^M - 1}{\sigma^M}} + (s^M + u^M_t)^{\frac{1}{\sigma^M}} Z^{f^i \frac{\sigma^M - 1}{\sigma^M}} \right]^{\frac{\sigma^M}{(\sigma^M - 1)}}, \tag{17}$$

where the share parameter $s^M$ can be subject to random shocks $u^M$, and $Z^{d^i}$ and $Z^{f^i}$ are indexes of demand across the continuum of differentiated goods produced, respectively, in the domestic economy and abroad.

Exporters buy final domestic goods $X_t$ and transform them into exportables using a linear technology. Exporters act as monopolistic competitors in export markets and charge a markup over domestic prices. Thus export prices are given by

$$\eta_t^X P_t^X = P_t. \tag{18}$$

Importers buy foreign goods at quantity $M_t$ from foreign exporters and sell them on the domestic market. Importers are monopolistic competitors on the market for imported goods and charge a markup over the purchase price of imports denominated in domestic currency.

$$\eta_t^M P_t^M = E_t P_t^F \tag{19}$$

Markup fluctuations arise because of price adjustment costs. Exports and imports, together with interest receipts/payments, and the exogenous balance of primary incomes and transfers determine the evolution of net foreign assets denominated in domestic currency.

$$B_t^F = (1 + i_t^F) B_{t-1}^F + P_t^X X_t - P_t^M M_t + \varepsilon_t^{B^F} \tag{20}$$

### *3.4 Policy*

Both government expenditure and receipts are responding to business-cycle conditions. On the expenditure side, we identify the systematic response of government consumption, government transfers, and government investment to the annual GDP growth rate. In addition, all three expenditure components are used for stabilizing the debt-to-GDP ratio, where $b^T$ is the government debt target and $def^T$ is the associated deficit target. For government consumption and government investment, we specify the following rules for detrended $c^G$ and $i^G$ (removing trend productivity growth):

$$c_t^G - \overline{c^G} = \tau_{Lag}^{CG}(c_{t-1}^G - \overline{c^G}) + \tau^{CG}\left(\sum_{i=1}^{4} \Delta y_{t-i} - 4\overline{\Delta y}\right)$$

$$- \tau^{CGB}\left(\frac{B_{t-1}}{Y_{t-1}P_{t-1}} - b^T\right)$$
$$- \tau^{CGDEF}\left(\left(\frac{\Delta B_{t-1}}{Y_{t-1}P_{t-1}}\right) - def^T\right) + u_t^{CG} \tag{21}$$

$$i_t^G - \overline{i^G} = \tau_{Lag}^{IG}(i_{t-1}^G - \overline{i^G}) + \tau^{IG}\left(\sum_{i=1}^{4}\Delta y_{t-i} - 4\overline{\Delta y}\right)$$
$$- \tau^{IGB}\left(\frac{B_{t-1}}{Y_{t-1}P_{t-1}} - b^T\right)$$
$$- \tau^{IGDEF}\left(\left(\frac{\Delta B_{t-1}}{Y_{t-1}P_{t-1}}\right) - def^T\right) + u_t^{IG}. \tag{22}$$

Government consumption and government investment can temporarily deviate from their long-run targets $\overline{c^G}$ and $\overline{i^G}$ in response to fluctuations in growth rates. In addition, government expenditure is used for stabilizing the debt-to-GDP ratio, where $b^T$ is the government debt target and $def^T$ is the associated deficit target. The shocks $u^{CG}$ and $u^{IG}$ are white noise.

The transfer system consists of two parts: unemployment benefits *UBEN* and other transfers *TR*. The former provides income for the unemployed $(POP_t^W - POP_t^{NPART} - L_t)$. Other transfers *TR* consists of transfers to pensioners $POP_t^P$ and other transfer payments, and is used for stabilizing the debt-to-GDP ratio. We assume that unemployment benefits and pensions are indexed to wages with replacement rates $b^U$ and $b^R$, respectively.

$$tr_t = b^U w_t(POP_t^W - POP_t^{NPART} - L_t) + b^R w_t POP_t^P$$
$$- \tau^{TRB}\left(\frac{B_{t-1}}{Y_{t-1}P_{t-1}} - b^T\right)$$
$$- \tau^{TRDEF}\left(\left(\frac{\Delta B_{t-1}}{Y_{t-1}P_{t-1}}\right) - def^T\right) + u_t^{TR}, \tag{23}$$

where $u^{TR}$ is an autocorrelated shock. Government revenues $R_t^G$ consist of taxes on consumption as well as capital and labor income.

$$R_t^G = (ssc_t + t_t^w)\,W_tL_t + t_t^cP_t^cC_t + t_t^cP_t^HI_t^H$$
$$+ t_t^K[(Y_t - W_tL_t) - \delta K_tP_t^I] \tag{24}$$

We assume consumption and capital income tax follow a linear scheme but a progressive labor income tax schedule

$$t_t^w = \tau_0^w Y_t^{\tau_1^w}, \tag{25a}$$

where $\tau_0^w$ measures the average tax rate and $\tau_1^w$ measures the degree of progressivity. A simple first-order Taylor expansion around a steady-state growth rate yields

$$t_t^w = \tau_0^w + \tau_0^w \tau_1^w \left( \sum_{i=0}^{3} \Delta y_{t-i} - 4\overline{\Delta y} \right)_t . \tag{25b}$$

Government debt ($B_t$) evolves according to

$$B_t = (1 + i_t^B) B_{t-1} + P_t^C C_t^G + P_t^C I_t^G + TR_t - R_t^G - T_t^{LS}, \tag{26}$$

where $i_t^B$ is the implicit interest rate the government pays on its debt, which depends on the average maturity structure of sovereign debt $(1/(1-\rho^B))$ and the policy rate augmented by a markup made up of a sovereign risk premium, which is assumed to depend on the government-debt-to-GDP ratio and an autoregressive term.

$$i_t^B = \rho^B i_{t-1}^B + (1-\rho^B)\left[ i_t + mup^B + rprem^B (B_t/Y_t - \overline{B/Y}) + \varepsilon_t^{rpb} \right] \tag{26$'$}$$

Monetary policy is modeled exogenous, with interest rates $i_t^{EA}$ set by the European Central Bank (ECB).

$$i_t = i_t^{EA} + u_t^{RPREM} \tag{27}$$

In the years prior to EMU, the differential between the policy rate in Spain and the (synthetic) euro-area average was gradually eliminated.

Finally, we define a monetary policy as the deviation of $i_t^{EA}$ from a synthetic interest rate determined by a Taylor rule for Spain that responds to consumer price inflation and the annual growth rate of output, with weights based on estimates for the euro area (Ratto, Roeger, and in 't Veld 2009):

$$z_t^M = i_t^{EA} - \left[ \begin{array}{c} \tau_{lag}^M i_{t-1}^{EA} + (1-\tau_{lag}^M)[r^{EQ} + \pi_t^T + \tau_\pi^M(\pi_t^C - \pi_t^T) \\ + \tau_y^M (gy_t + gy_{t-1} + gy_{t-2} + gy_{t-3} - 4\overline{gy})/4] \end{array} \right]. \tag{28}$$

### *3.5 Equilibrium*

Equilibrium in our model economy is an allocation, a price system, and monetary and fiscal policies such that both non-constrained and constrained households maximize utility; final-goods-producing firms, firms in the construction sector, and investment goods producers maximize profits; and the following market clearing conditions hold for final domestic goods:

$$Y_t = C_t^d + J_t^{inp,d} + J_t^{Constr} + C_t^{G,d} + I_t^{G,d} + X_t, \tag{29}$$

and final imported goods

$$M_t = C_t^f + J_t^{inp,f} + C_t^{G,f} + I_t^{G,f}, \tag{30}$$

where total domestic and imported consumption $C_t^i$ is the sum of savers' and borrowers' consumption, with their per capita consumption multiplied by the respective population shares $s^r$ and $s^c$:

$$C_t^i = s^r C_t^{r,i} + s^c C_t^{c,i}, \text{ with } i = d, f. \tag{31a}$$

Similarly, total housing investment is defined as

$$J_t^H = s^r J_t^{H,r} + s^c J_t^{H,c} \tag{31b}$$

and equilibrium in the labor market is given by

$$L_t = s^r L_t^r + s^c L_t^c \text{ with } L_t^r = L_t^c. \tag{31c}$$

Credit-constrained households only engage in debt contracts with Ricardian households, i.e.,

$$B_t^c = \frac{s^r}{s^c} B_t^r. \tag{32}$$

## 4. Model Estimation

The model is estimated on quarterly data over the period 1995:Q1 to 2012:Q4, using Bayesian inference methods to estimate model

**Table 1. Calibrated Structural Parameters**

| Structural Parameters | Calibrated Value |
|---|---|
| $\chi^c$ | 0.5 |
| $\alpha$ | 0.60 |
| $\delta$ | 0.025 |
| $\delta^{house}$ | 0.01 |
| Target Government Debt to GDP | 0.6 |
| Target Government Deficit to GDP | −0.025 |
| $\rho^B$ | 0.95 |
| $ssc$ | 0.14 |
| $\tau_0^W$ | 0.13 |
| $\tau_1^W$ | 0.8 |
| $t^K$ | 0.29 |
| $t^C$ | 0.15 |
| $1/\beta^c - 1$ | 0.04 |
| $1/\beta^{r,EUR} - 1$ | 0.005 |
| $(1 - s^M)$ | 0.75 |
| $b^R$ | 0.22 |
| $\tau_{lag}^M$ | 0.9 |
| $\tau_\pi^M$ | 1.5 |
| $\tau_y^M$ | 0.4 |
| $mup^B$ | 0.004 |

parameters and shocks.[7] Concerning the steady-state calibration, parameters shown in table 1 have been calibrated to match ratios of main economic aggregates (corporate investment, construction investment, and government consumption and investment) to GDP over the period 1995–99.[8] The two general exceptions to this are the calibration of the labor market and the steady-state debt ratios. For the former, the 1995–99 averages can no longer be considered

[7]We use the Dynare toolbox for MATLAB (Adjemian et al. 2011) to conduct the first-order approximation of the model, to the calibrated steady state and to perform the estimation. We run four Metropolis-Hastings chains of 100,000 draws to estimate the posterior distribution. A detailed description of data sources and estimation is described in appendices 1 and 2.

[8]This period was chosen to exclude the more turbulent 2000s, in which several variables (for example, construction investment share in GDP) could have diverged from their historical level.

representative of the Spanish labor market, as labor market reforms have led to a regime shift in the Spanish economy. Instead we base the calibration of labor market parameters on the full sample 1995:Q1–2012:Q4. The steady-state employment rate as share of total population is set to 0.41, the wage share to 57 percent. Concerning the government debt ratio, we impose the debt target of 60 percent of GDP, which is close to the sample average. This target implies, given the nominal growth rate in the steady state, a deficit target of 2.5 percent of GDP. The average maturity structure of sovereign debt is set at five years. Tax rates are calibrated on sample averages. Government transfers to households are set to 12.9 percent of GDP, benefit indexation ($b^U$) is estimated, and pension indexation ($b^R$) is set to match this steady-state calibration. For construction of the monetary policy shock, Taylor-rule coefficients are imposed based on estimates for the euro area (Ratto, Roeger, and in 't Veld 2009). The constant in the markup of sovereign bond interest rates ($mup^B$) is set at 0.4 percent quarterly. Based on the whole sample, the quarterly GDP trend growth rate was set to 0.55 percent, while the inflation trend growth rate is set to 0.5 percent. Credit-constrained households are calibrated with a high rate of time preference, 4 percent quarterly, while the discount rate for non-constrained households is estimated (see below). The euro-area discount rate is set at 0.5 percent quarterly; openness is calibrated at 0.25.

The estimation results of the main structural parameters are summarized in table 2.[9] The population share of Ricardian households $s^r$ is estimated at 0.49, implying the share of credit-constrained households $s^c$ of 0.51. Concerning consumption, the intertemporal elasticity of substitution is set to 1, habit persistence $h$ is estimated to be 0.75, and the substitution elasticity for housing services $\sigma_H$ is estimated at 0.62. The discount factor for Spanish households $\beta^r$ is estimated close to 0.992, reflecting a higher propensity to consume than for the rest of the euro area. The estimate for *rprem* implies a highly inelastic interest rate with regard to external indebtedness,

[9] "HPD Inf." and "HPD Sup." denote the bounds of the 90 percent highest probability density interval. The prior distributions used and posterior estimates of all parameters can be found in a supplementary appendix on the *IJCB* website (http://www.ijcb.org).

**Table 2. Estimation Results for Main Structural Parameters**

| | Prior Distribution | Prior Mean | Prior S.D. | Posterior Mean | Posterior S.D. | HPD Inf. | HPD Sup. |
|---|---|---|---|---|---|---|---|
| $h$ | Beta | 0.700 | 0.1000 | 0.751 | 0.0519 | 0.6749 | 0.8400 |
| $\kappa$ | Gamma | 1.000 | 0.4000 | 0.892 | 0.3231 | 0.3641 | 1.3872 |
| $\sigma^H$ | Gamma | 0.500 | 0.1000 | 0.623 | 0.1252 | 0.4196 | 0.8192 |
| $\sigma^X$ | Gamma | 1.250 | 0.5000 | 1.864 | 0.3286 | 1.3198 | 2.3870 |
| $\sigma^M$ | Gamma | 1.250 | 0.5000 | 1.153 | 0.2458 | 0.7359 | 1.5503 |
| $\sigma^L$ | Beta | 0.500 | 0.2000 | 0.319 | 0.1272 | 0.1006 | 0.5089 |
| $s^s$ | Beta | 0.500 | 0.1500 | 0.486 | 0.0971 | 0.3340 | 0.6490 |
| $rprem$ | Beta | 0.0025 | 0.0010 | 0.00098 | 0.00029 | 0.00052 | 0.00145 |
| $1/\beta^r - 1$ | Beta | 0.007 | 0.0010 | 0.008 | 0.0007 | 0.0067 | 0.0091 |
| $\tau_{lag}^{CG}$ | Beta | 0.500 | 0.2000 | 0.933 | 0.0135 | 0.9097 | 0.9549 |
| $\tau_1^{CG}$ | Beta | −0.100 | 0.0400 | −0.027 | 0.0124 | −0.0461 | −0.0071 |
| $\tau^B$ | Beta | 0.020 | 0.0100 | 0.021 | 0.0034 | 0.0157 | 0.0266 |
| $\tau^{DEF}$ | Beta | 0.020 | 0.0100 | 0.012 | 0.0055 | 0.0029 | 0.0197 |
| $\tau_{lag}^{IG}$ | Beta | 0.500 | 0.2000 | 0.899 | 0.0666 | 0.8056 | 0.9974 |
| $\tau_1^{IG}$ | Beta | −0.100 | 0.0400 | −0.037 | 0.0165 | −0.0613 | −0.0094 |
| $\tau^{B,IG}$ | Beta | 0.020 | 0.0100 | 0.010 | 0.0032 | 0.0044 | 0.0147 |
| $\tau^{DEF,IG}$ | Beta | 0.020 | 0.0100 | 0.024 | 0.0087 | 0.0097 | 0.0375 |
| $rprem^B$ | Beta | 0.003 | 0.0012 | 0.0031 | 0.0012 | 0.0012 | 0.0051 |
| $b^U$ | Beta | 0.300 | 0.1000 | 0.466 | 0.0683 | 0.3618 | 0.5715 |

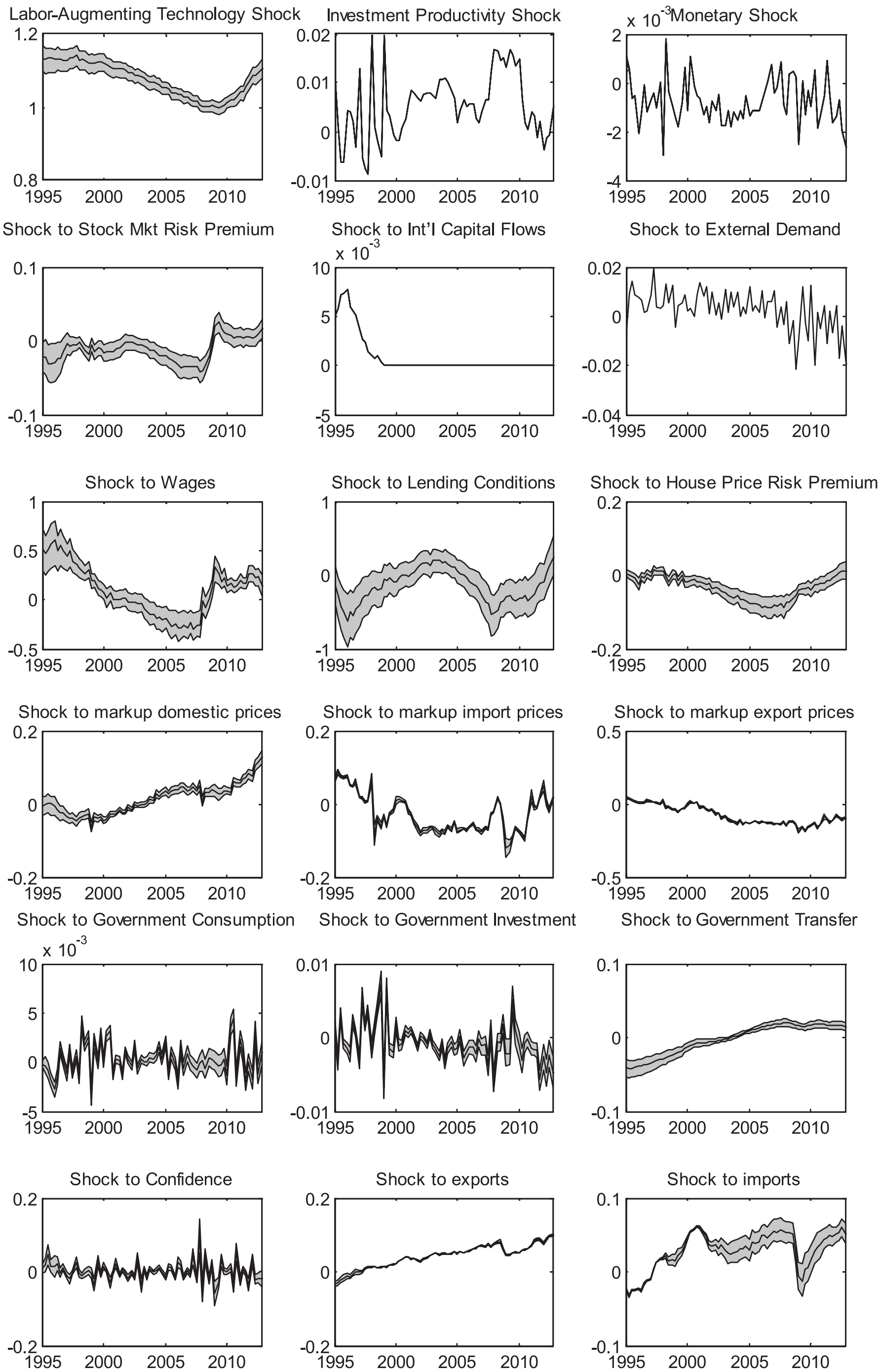
an increase in the risk premium of 4 basis points for every 10-percentage-point increase in net foreign liabilities. This low estimate reflects the persistent buildup in net foreign liabilities over the sample period, reaching almost 100 percent of GDP by the end of the sample period. Fiscal policy reactions are generally countercyclical, while government consumption also contains a debt- and deficit-stabilizing response. The estimated elasticity of the sovereign risk premium with regard to the government-debt-to-GDP ratio implies an increase in the risk premium of 12 basis points for a 10-percentage-point increase in the debt ratio.

### *4.1 Historical Evolution of the Main Shocks*

We now turn to an evaluation of the main shocks identified in the estimation procedure.[10] Figure 2 shows the estimated historical evolution of these fundamental and non-fundamental shocks of the model over the period 1995:Q1–2012:Q4. Some of the shocks can be directly observed; other shocks can be identified as residuals to specific structural equations of the DSGE model. We capture *labor-augmenting technology shocks* to final goods by the terms $U_t^Y$ in the production function and we specify it as a random-walk process. We identify *investment-specific technical change* $U_t^{PI}$ by differences in growth rates between a weighted average of the GDP deflator and the import price deflator on the one hand and the investment deflator on the other. Labor-augmenting technological progress shows a strongly declining trend up to 2008 and then increases again in the recession. The evolution of investment-specific technological progress is less uniform over time and shows less variation, falling in 2000, further declining in 2005, and again experiencing a sharp decline in 2010. Shocks to *monetary policy* $z_t^M$ are identified as stationary deviations of the ECB policy rate from the interest rate implied by a Taylor rule for Spain. The monetary policy shock shows a loose monetary stance for Spain over the whole sample, with the exception of a brief period in 2000 when there were some large increases in the ECB policy rate in quick succession, and again in 2007–8 when the ECB policy rate was raised while conditions in Spain deteriorated.

[10]In total, the model is estimated with twenty-nine shocks, but we focus here on the most important shocks over the estimation period.

**Figure 2. Profile of Selected Shocks 1995–2012**



Following the further reductions in the policy rate, the monetary policy shock turns negative again in the last observations.

By adding exogenous shocks to the discount factors of the various asset market arbitrage equations, we allow for non-fundamental shocks (bubbles) in the model. In particular, we identify *stock market bubbles* as a shock to the discount factor for corporate investment (equation (12a)), and a *house price bubble* as shocks to residential investment (equation (12b)). We find a declining trend in the stock market risk premium that could indicate a bubble building up between 2002 and 2008. This is followed by a sharp increase in the risk premium in 2009–10. The house price risk premium shows a stronger declining trend in the years up to 2008, with a gradual reversal after that, suggesting a bubble that built up between 1999 and 2008 and then slowly burst.

We identify the *shock to international capital flows* $u_t^{RPREM}$ as the differential between nominal interest rate in Spain and the (synthetic) euro-area average rate pre-1999. The shock to international capital flows shows the elimination of the interest rate risk premium when Spain joined EMU in 1999 and which led to the inflow of cheap capital. The *shock to external demand* combines the shock to foreign demand and the shock to foreign prices and is predominantly positive over much of the period up to 2007 but largely negative in the years since then.

The *labor market shock* is identified as the residual to the wage-setting equation, and this shock to the wage markup shows a trend decline up to 2007–8, corresponding to a declining NAIRU over that period, and an increase in the years after 2008. Shifts in *lending conditions* are shocks to the collateral constraint of debtor households $\chi_t$. The shock shows a loosening of lending conditions between 2003 and 2007 and a tightening since 2008.

The shock to the *markup* on domestic prices is increasing over the sample, partly reflecting a sectoral shift towards the non-tradable sector (services) which is generally characterized by higher markups. The shock to the *markup on import prices* shows a decline in 1999, while that on export prices shows a general declining trend over much of the sample. The shocks to the government spending categories represent residuals to estimated responses to the economic cycle. Hence, they cannot be interpreted as discretionary policy shocks, but should be seen as non-systematic innovations, i.e., deviations from "normal" cyclical responses. Government spending is estimated as countercyclical over the sample and with an active response to debt and deficit developments. The shock to government consumption $u^{CG}$ indicates periods of fiscal stimulus and contraction relative to this estimated rule, with some evidence of a positive deviation in 2009–10. Government investment is also estimated to have been countercyclical over the sample, with also some evidence of a positive deviation in $u^{IG}$ in 2009 but a negative deviation in the last two years (consolidation). The shock to government transfers $u^{TR}$ shows a trend increase reflecting increasing generosity in the transfer system, which is reversed in 2011. The *shock to confidence* is the consumption preferences shock to the Euler equation, which suggests some decline in confidence in the crisis. The shocks to exports $u^X$ and imports $u^M$ represent shocks to trade shares and show trend increases over the sample, with noticeable declines in the crisis. In the following section we show the impact of these shocks on the main economic aggregates.

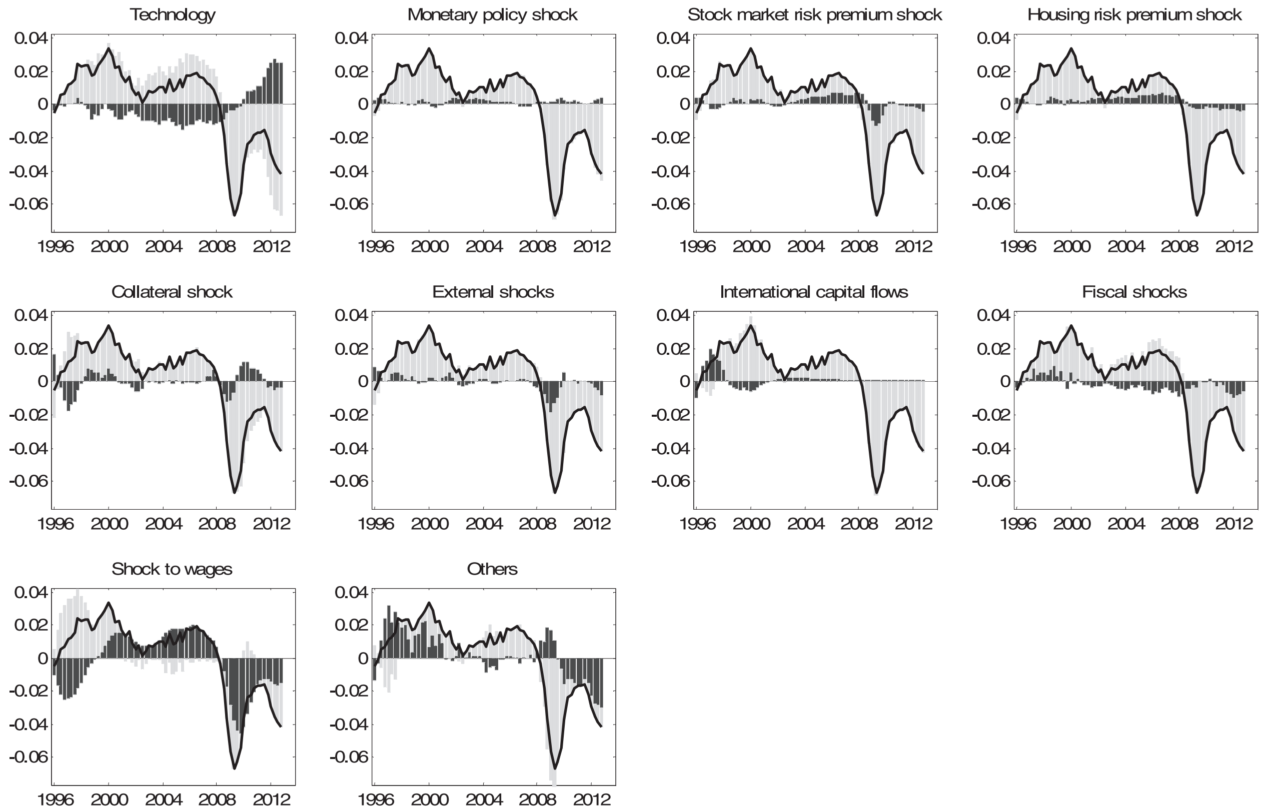
## 5. Historical Shock Decompositions

The estimated shocks can be used to provide a historical decomposition of the data, by decomposing the quarter-on-quarter or year-on-year growth rates or domestic demand shares (in deviations from their steady-state levels) into the different shocks (cf. Christiano, Motto, and Rostagno 2008). The following figures in this section do this for the profiles for GDP growth, respective domestic demand shares, and external position. To keep the analysis tractable, we only focus on the main shocks highlighted in the previous section, and group the contribution of all other shocks into a residual category labeled "others."[11]

Figure 3 shows the additive decomposition of year-on-year real GDP growth (in deviation from steady-state growth) into the different shocks. Real GDP growth was above trend in the early years

[11]In the figures, the category "others" combines all other shocks included in the model (e.g., shocks to markups) and includes the effects of the initial conditions. Detailed shock decompositions of other variables including employment, unit labor costs, and real exchange and interest rates are available in the supplementary appendix.

## Figure 3. Shock Decomposition: GDP Growth



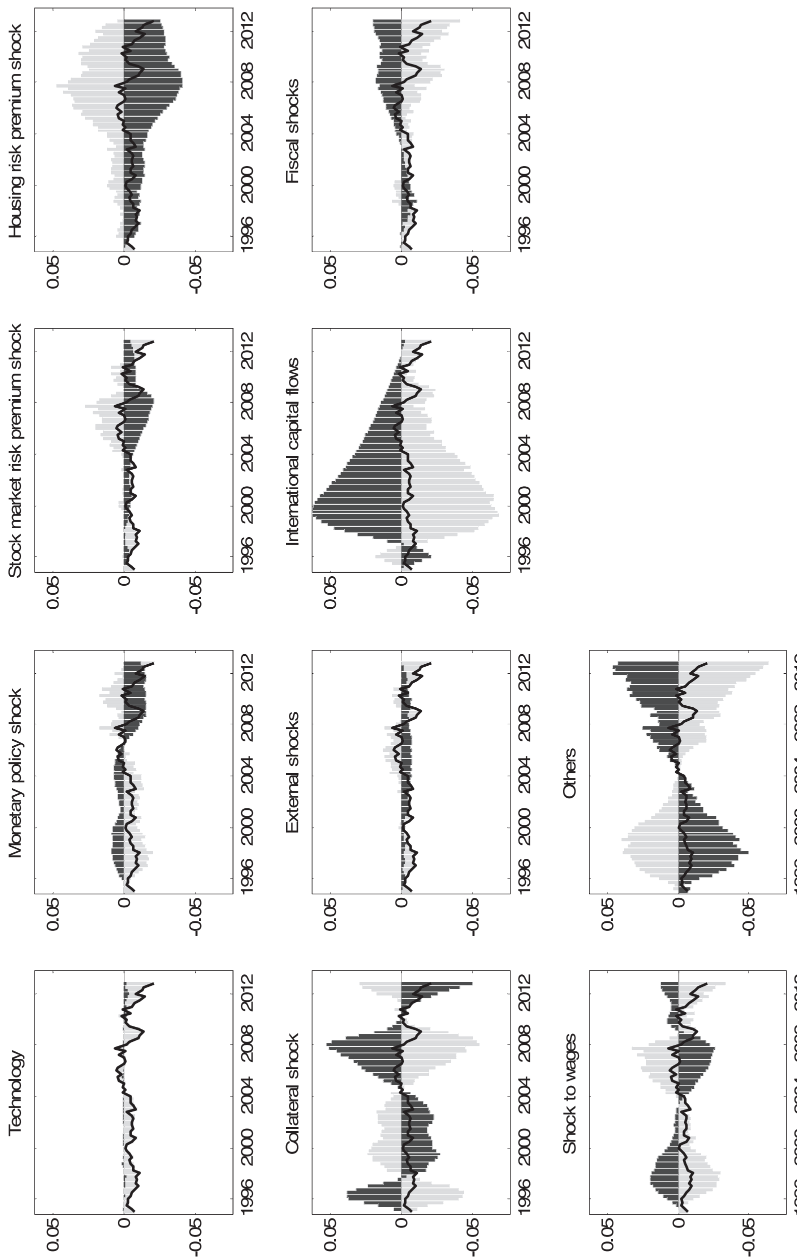

**Notes:** The following notes apply to figures 4–8 as well. The black lines show historical data (from which steady-state values have been subtracted). In each sub-plot, the vertical dark bars show the contribution of a different group of shocks to historical data, while stacked light bars show the contribution of all remaining shocks and initial conditions. Bars above the horizontal axis represent positive shock contributions, while bars below the horizontal axis represent negative contributions. The sum of shock contributions equals the historical data.

of the sample, the buildup and first years of EMU membership, and fell by a maximum of around 6 percent below trend in the trough of the financial crisis. In terms of shock contributions, the technology shock (the combination of the labor-augmenting productivity shock $U_t^Y$ and the investment-specific productivity shock $U_t^{PI}$) contributed negatively to GDP growth throughout the decade but had a positive contribution in the last years of the sample. The (elimination of the) risk premium shock (international capital flows) $u_t^{RPREM}$ boosted growth in the years prior to accession of EMU. For much of the decade, the labor market shock contributed positively to growth, but this turned around in the crisis starting in 2008. Stock market and housing risk premium shocks as well as looser lending conditions (collateral shock) $\chi_t$ contributed positively to growth rates, and these reversed in 2008 when they started to drag down growth.

The main driving factors of the collapse in real GDP growth in the crisis are the tightening in lending conditions (collateral shock), stock market crash (negative contribution of stock market risk premium), the bursting house price bubble (housing risk premium shock), the decline in world trade (negative contribution of external demand shock), and the reversal in the labor market shock (insufficient wage flexibility). Real GDP growth was supported in the crisis by a positive contribution from the productivity shocks (decline of the construction sector, a relatively low-tech sector, raised average productivity) and fiscal stimulus measures (2009–10). Fiscal consolidation in 2011–12 contributed negatively to growth.

Figure 4 shows the shock decomposition of the deviations in the consumption-to-output ratio relative to its steady-state level. Most striking is the large and persistent positive contribution of the financial capital flow shock. The disappearance of the interest rate risk premium upon accession to EMU led to an inflow of cheap capital and boosted consumption. Substitution between residential investment and consumption implies a negative contribution of the housing boom (housing risk premium). In addition, there is some negative effect from the stock market risk premium (substitution to investment). Looser lending conditions (collateral shock) boosted consumption between 2005 and 2008, but reversed into a negative contribution post-2008 (deleveraging). Other dampening effects on the consumption share came from the labor market shock (wage moderation). This turned positive in the crisis years and helped to

# Figure 4. Shock Decomposition: Consumption-to-GDP Ratio



support consumption in the last years of the sample. Fiscal policy (transfers) boosted consumption spending in the years after 2004 and helped to support consumption in the crisis. The positive effect from low policy rates came to an end by 2007 and turned negative in 2008, as the policy rate did not respond sufficiently to the deterioration in conditions in Spain.

The shock decomposition of the deviations in the corporate investment share in GDP from its steady-state level is shown in figure 5. Like for consumption, there is a persistent positive contribution of the capital flow shock (lower interest rates). Non-fundamental factors play an important role in the shock decomposition of investment, with a large contribution from the residual term in the investment decision equation (stock market risk premium). Productivity shocks boosted the investment share, as did the loose monetary policy stance implied by the ECB policy rate for Spain. Lending conditions to households (collateral shock) relaxed between 2004 and 2008 and show as an increasing negative contribution to the investment share, indicating substitution effects towards consumption. But the sharp collapse in investment spending in the crisis is mainly linked to the shock to the stock market risk premium.

The boom-bust cycle in the residential investment share in GDP is also largely associated with what is in the model a non-fundamental shock. As figure 6 shows, the increase in residential investment up to 2007 and the subsequent collapse is primarily driven by the housing risk premium shocks. The interest rate risk premium shock (financial capital flows) also had a positive contribution to housing investment up to 2005, while looser lending conditions also added to the housing boom. Overall, the main driving factor behind the boom-bust cycle in residential investment appears to have been a bubble that, when it burst, led to a sharp reduction in construction investment.

We now turn to a shock decomposition of the external position. Figure 7 shows the trade balance as share of GDP. The trade balance has been in persistent deficit since 1998, widening to more than 6 percent of GDP in 2007. The crisis forced an adjustment, and the trade balance moved into surplus in 2012. The main driver for the trade deficit in the model is the financial capital flows shock. The elimination of the interest rate risk premium in EMU and interest rates determined by a common monetary policy in EMU boosted

**Figure 5. Shock Decomposition: Corporate-Investment-to-GDP Ratio**

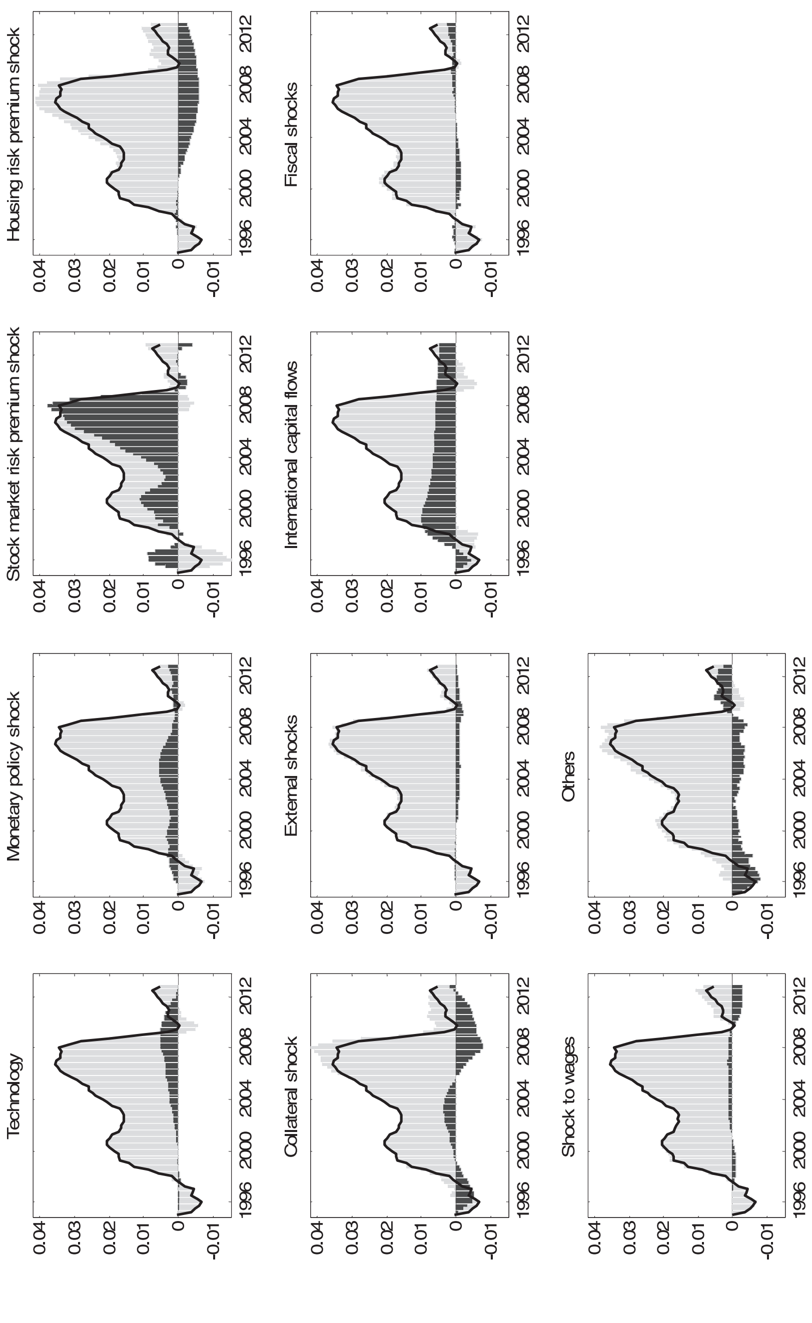


**Figure 6. Shock Decomposition: Residential-Investment-to-GDP Ratio**

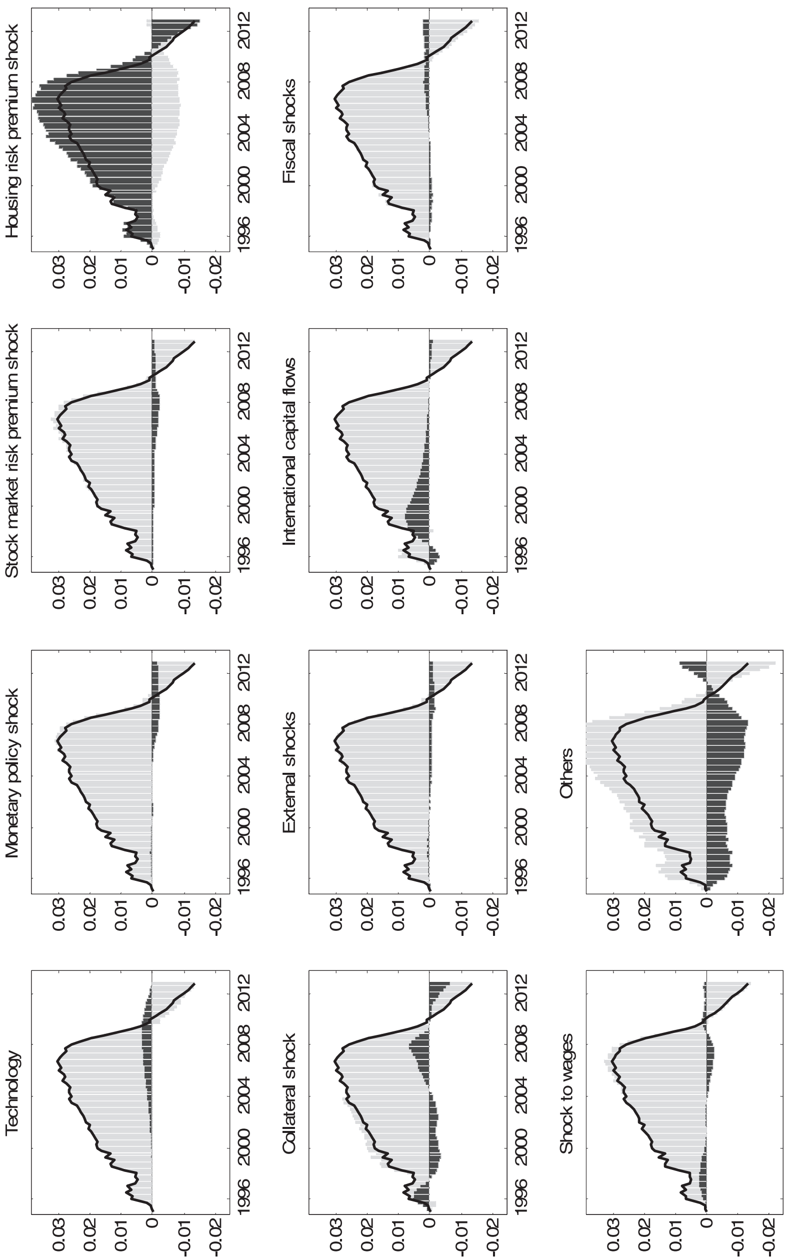
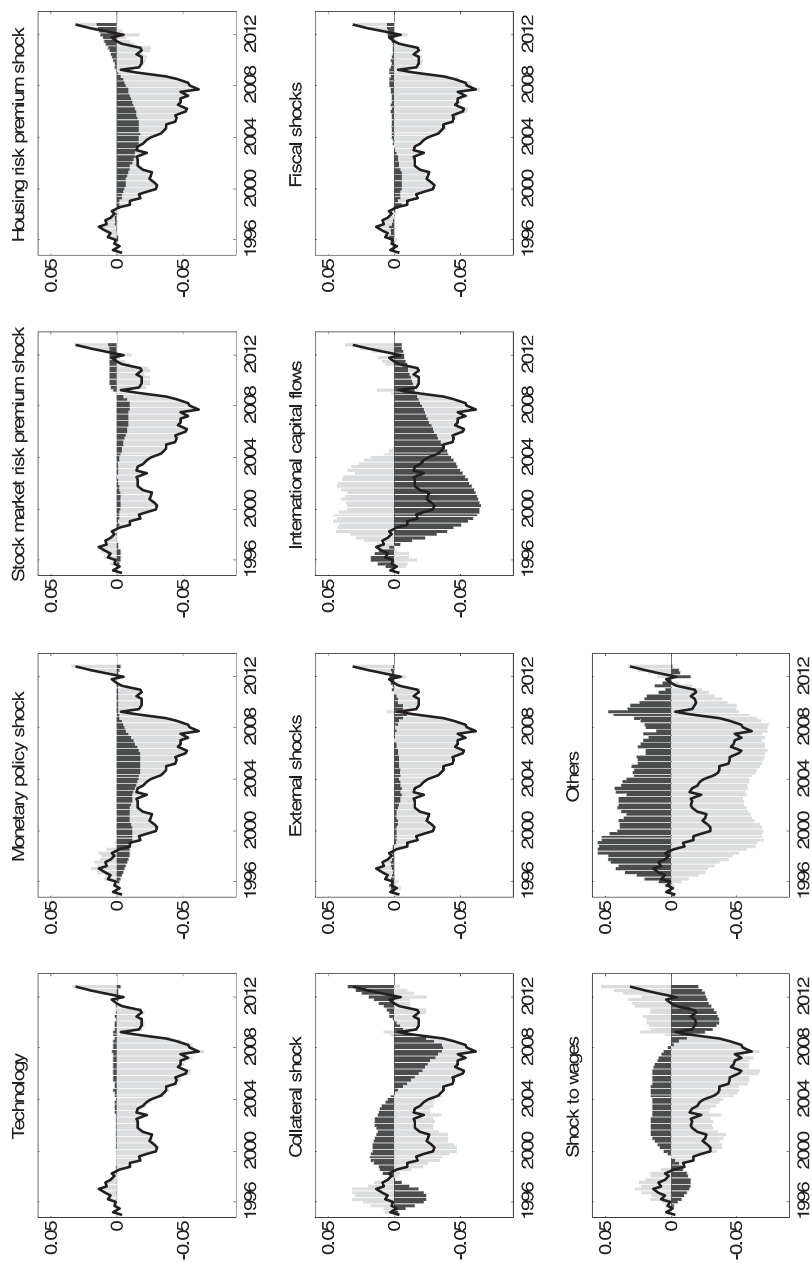


**Figure 7. Shock Decomposition: Trade-Balance-to-GDP Ratio**



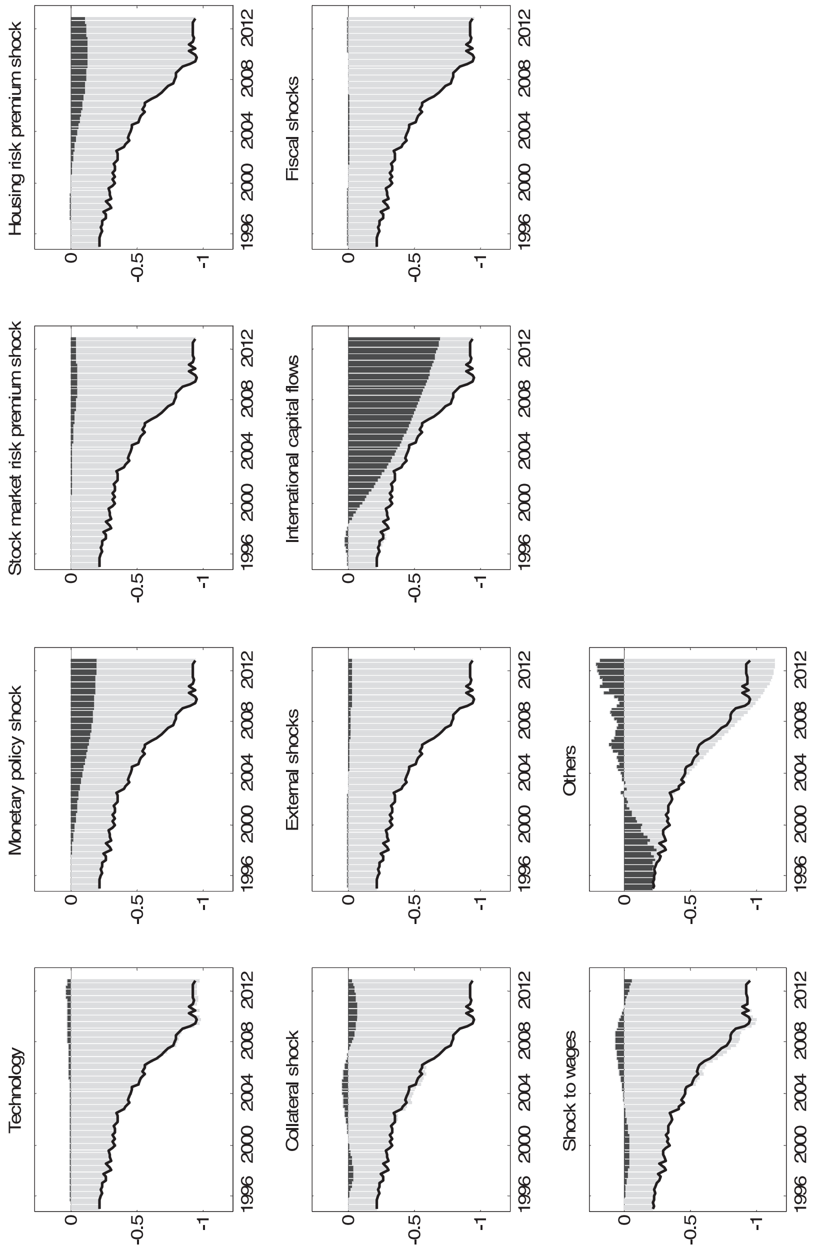
domestic demand and worsened the trade balance (this is the mirror image of the shock decompositions of consumption and investment). The stock market risk premium, the housing risk premium, and, since 2004, looser lending conditions (collateral) contributed further to a widening of the trade balance in the boom years. On the positive side, there was a positive contribution from the labor market shock up to 2007 (wage developments improving competitiveness and supporting exports), but this was reversed in the crisis. The stock market risk premium shock (collapse in corporate investment) and tightening of lending conditions contributed to the improvement in the trade balance in 2010–11.

Figure 8 shows the extent to which each of these factors contributed to the accumulation of net foreign liabilities. All in all, up to three-quarters of the buildup in foreign debt can be attributed to the capital flow shock in the model. Looser monetary policy added further to the buildup, and additional smaller contributing factors were the stock market and housing shocks, and the loosening of lending conditions.

## 6. Concluding Remarks

In this paper we have shown how an open-economy DSGE model with financial frictions and exogenous time-varying risk premia can be used to analyze the driving factors behind internal and external imbalances that have built up over past years. Our estimates for Spain indicate that the main source behind the buildup in debt has been low real interest rates, linked to the inflow of cheap capital due to the disappearance of the risk premium and monetary policy set at the euro-area level. The subsequent adjustment in the trade balance is mainly driven by the collapse in the bubbles in the stock and housing markets and tightening of lending conditions. The correction relies more on expenditure reduction than on expenditure switching, with a decline in domestic absorption. However, the accompanying deflation and decline in unit labor costs also brings about a further depreciation of the real effective exchange rate. We find no strong evidence of excessive wage growth as a driver of external imbalances. However, the dual labor market structure in Spain may create a degree of wage rigidity that hinders any adjustment in wage growth required to improve competitiveness.

**Figure 8. Shock Decomposition: NFA Position**



This analysis highlights the need for an integrated analysis of external imbalances and a proper framework for addressing such imbalances. As the main driver identified in the model is related to low real interest rates, the correction of the imbalances also has to come from an adjustment to the borrowing costs for economic agents. This could lead to a protracted period of depressed demand and a painful correction to past excess demand growth. This underlines the importance of avoiding the buildup of such imbalances in future. The EU's macroeconomic imbalances procedure (MIP) is intended to deal with this by stricter surveillance and introducing early-warning mechanisms that can alert policymakers to the buildup of unsustainable imbalances so they can take timely action. Possible policy responses include timely fiscal adjustment. Although this may be an appropriate strategy for other deficit countries, it should be noted that public-sector borrowing does not appear to have been a factor behind Spain's imbalances, and its fiscal position was, at least up to 2007, on a sustainable path. Policies that improve competitiveness may be called for—in particular, reforms reducing wage costs in the tradable sector—but productivity-enhancing matters will also raise demand, partly offsetting the net effect on external balances.[12] To the extent that non-fundamental shocks have played a role in the buildup phase, the policy recommendation would be to avoid such bubbles building up in the first place. But whether the inflow of cheap capital in a monetary union can or should be avoided is a more challenging question. Prudential policies in both recipient countries of capital flows (Spain) and source countries (surplus countries like Germany) might have helped to prevent the buildup of imbalances. Restrictions on the access to credit for households and firms, or policies to promote savings could have been introduced to avoid excessive demand growth in the early years in EMU, but it is not a priori clear whether such policies would be desirable from a welfare perspective.

[12]The direction of the impact of structural reforms on the current account is ambiguous from a theoretical point of view (see, e.g., Fournier and Koske 2010, Vogel 2011). Empirical evidence is also mixed. Jaumotte and Sodsriwiboon (2010) report a large positive effect of labor productivity on current accounts, while the empirical results in Kerdrain, Koske, and Wanner (2010) imply that such reforms have a negative impact on the current account position.

## Appendix 1. Data

In total, twenty-nine variables have been used in the estimation, and their sample range is 1995:Q1–2011:Q4. GDP and national account data (consumption, government consumption, government investment, gross fixed capital formation, gross fixed capital formation construction (housing), social benefits other than social transfers in kind, as well as the corresponding price deflators) are based on Eurostat data. Residential property prices (new and existing dwellings) are from the ECB. The nominal effective exchange rate, the world price index, and the world output are based on own calculations.[13] They are trade-weighted averages across Spain's main trade partners: Argentina, Australia, Brazil, Canada, China, the euro area, Hong Kong, India, Israel, Japan, Malaysia, Mexico, Norway, Russia, Singapore, South Korea, Switzerland, Taiwan, Turkey, the United Kingdom, and the United States, altogether forty-one countries. General government consolidated gross debt, net government lending, and the implicit interest rate faced by general government are from AMECO. Three-month money-market rates for Spain and the United States are taken from Eurostat. The source for data on international investment position is the Bank of Spain.

The model is estimated in growth rates and GDP shares. Specifically, the following twenty-nine series are treated as observed:

- GDP growth,
- GDP shares (twelve): consumption, government consumption, government investment, transfers, imports, exports, world demand, construction investment, total investment, government deficit and debt, net foreign asset.
- Prices (nine): GDP, consumption, import, export, construction, house, government purchases, total investment, world.
- Spain and euro-area nominal interest rate; government interest rate (three).
- Exchange rate, wages, employment, and non-active population (four).

[13]Available on http://ec.europa.eu/economy_finance/db_indicators/competitiveness/data_section_en.htm.

## Appendix 2. Priors and Estimated Parameters

### Table 3. Results for Posterior Parameters

| | Prior Distribution | Prior Mean | Prior S.D. | Posterior Mean | Posterior S.D. | HPD Inf. | HPD Sup. |
|---|---|---|---|---|---|---|---|
| $dcc$ | Beta | 0.500 | 0.1500 | 0.692 | 0.0863 | 0.5489 | 0.8328 |
| $\gamma_{ucap,2}$ | Gamma | 0.020 | 0.0080 | 0.042 | 0.0109 | 0.0235 | 0.0593 |
| $\tau_1^{CG}$ | Beta | −0.100 | 0.0400 | −0.027 | 0.0124 | −0.0461 | −0.0071 |
| $\gamma_H$ | Gamma | 30.000 | 20.0000 | 51.433 | 22.4214 | 16.3837 | 82.9471 |
| $\gamma_{J,H}$ | Gamma | 30.000 | 20.0000 | 75.882 | 26.1220 | 35.1673 | 113.9595 |
| $\gamma_K$ | Gamma | 30.000 | 20.0000 | 22.858 | 9.6797 | 7.6487 | 37.2564 |
| $\gamma_I$ | Gamma | 15.000 | 10.0000 | 27.631 | 10.8292 | 9.7072 | 43.8167 |
| $\gamma_L$ | Gamma | 30.000 | 20.0000 | 15.170 | 4.9011 | 7.4165 | 22.7198 |
| $\gamma_P$ | Beta | 4.000 | 2.0000 | 6.423 | 1.4369 | 3.9558 | 8.6485 |
| $\gamma_{Pconstr}$ | Gamma | 30.000 | 20.0000 | 30.066 | 12.2682 | 10.4622 | 49.1661 |
| $\gamma_{Phouse}$ | Gamma | 30.000 | 20.0000 | 7.049 | 6.1026 | 0.5685 | 15.9709 |
| $\gamma_{PM}$ | Gamma | 4.000 | 2.0000 | 1.128 | 0.4860 | 0.3754 | 1.8466 |
| $\gamma_{PX}$ | Gamma | 4.000 | 2.0000 | 1.239 | 0.7338 | 0.2797 | 2.3550 |
| $\gamma_W$ | Gamma | 12.000 | 4.0000 | 26.907 | 5.8333 | 17.3277 | 36.2256 |
| $\tau_{lag}^{CG}$ | Beta | 0.500 | 0.2000 | 0.933 | 0.0135 | 0.9097 | 0.9549 |
| $h$ | Beta | 0.700 | 0.1000 | 0.751 | 0.0519 | 0.6749 | 0.8400 |
| $\tau_1^{IG}$ | Beta | −0.100 | 0.0400 | −0.037 | 0.0165 | −0.0613 | −0.0094 |
| $\tau_{lag}^{IG}$ | Beta | 0.500 | 0.2000 | 0.899 | 0.0666 | 0.8056 | 0.9974 |
| $\kappa$ | Gamma | 1.000 | 0.4000 | 0.892 | 0.3231 | 0.3641 | 1.3872 |
| $\rho^L$ | Beta | 0.850 | 0.0750 | 0.924 | 0.0321 | 0.8749 | 0.9775 |
| $\rho^\eta$ | Beta | 0.500 | 0.2000 | 0.934 | 0.0364 | 0.8827 | 0.9916 |
| $\rho^{\eta,Constr}$ | Beta | 0.500 | 0.2000 | 0.824 | 0.0691 | 0.7162 | 0.9445 |
| $\rho^{\eta,M}$ | Beta | 0.850 | 0.0750 | 0.850 | 0.0524 | 0.7648 | 0.9363 |
| $\rho^{\eta,X}$ | Beta | 0.850 | 0.0750 | 0.966 | 0.0179 | 0.9406 | 0.9943 |
| $\rho^X$ | Beta | 0.500 | 0.2000 | 0.989 | 0.0049 | 0.9816 | 0.9969 |
| $\rho^M$ | Beta | 0.500 | 0.2000 | 0.928 | 0.0209 | 0.8957 | 0.9603 |
| $\rho^N$ | Beta | 0.500 | 0.2000 | 0.904 | 0.0534 | 0.8364 | 0.9997 |
| $\rho^{PCPM}$ | Beta | 0.500 | 0.2000 | 0.375 | 0.1369 | 0.1526 | 0.6043 |
| $\rho^{PWPX}$ | Beta | 0.500 | 0.2000 | 0.298 | 0.0776 | 0.1681 | 0.4213 |
| $\rho^{er}$ | Beta | 0.500 | 0.2000 | 0.254 | 0.0110 | 0.2355 | 0.2717 |
| $\rho^{rpk}$ | Beta | 0.850 | 0.0750 | 0.910 | 0.0344 | 0.8571 | 0.9670 |
| $\rho^{rph,c}$ | Beta | 0.850 | 0.0750 | 0.940 | 0.0146 | 0.9162 | 0.9640 |
| $\rho^{rpland}$ | Beta | 0.850 | 0.0750 | 0.950 | 0.0196 | 0.9187 | 0.9808 |
| $\rho^{tax}$ | Beta | 0.850 | 0.0750 | 0.885 | 0.0468 | 0.8098 | 0.9557 |
| $\tau_{lag}^L$ | Beta | 0.500 | 0.2000 | 0.862 | 0.0327 | 0.8091 | 0.9150 |
| $sfp$ | Beta | 0.700 | 0.1000 | 0.827 | 0.0803 | 0.6990 | 0.9559 |
| $sfpconstr$ | Beta | 0.700 | 0.1000 | 0.896 | 0.0538 | 0.8123 | 0.9808 |
| $sfphouse$ | Beta | 0.700 | 0.1000 | 0.772 | 0.0934 | 0.6215 | 0.9260 |
| $sfpm$ | Beta | 0.700 | 0.1000 | 0.819 | 0.0842 | 0.6862 | 0.9561 |
| $sfpx$ | Beta | 0.700 | 0.1000 | 0.818 | 0.0926 | 0.6749 | 0.9666 |
| $sfw$ | Beta | 0.700 | 0.1000 | 0.731 | 0.0966 | 0.5698 | 0.8872 |

(*continued*)

## Table 3. (Continued)

| | Prior Distribution | Prior Mean | Prior S.D. | Posterior Mean | Posterior S.D. | HPD Inf. | HPD Sup. |
|---|---|---|---|---|---|---|---|
| $\sigma^H$ | Gamma | 0.500 | 0.1000 | 0.623 | 0.1252 | 0.4196 | 0.8192 |
| $\sigma^X$ | Gamma | 1.250 | 0.5000 | 1.864 | 0.3286 | 1.3198 | 2.3870 |
| $\sigma^M$ | Gamma | 1.250 | 0.5000 | 1.153 | 0.2458 | 0.7359 | 1.5503 |
| $\sigma^L$ | Beta | 0.500 | 0.2000 | 0.319 | 0.1272 | 0.1006 | 0.5089 |
| $s_L$ | Beta | 0.300 | 0.1000 | 0.274 | 0.0872 | 0.1351 | 0.4116 |
| $s^s$ | Beta | 0.500 | 0.1500 | 0.486 | 0.0971 | 0.3340 | 0.6490 |
| $\tau^B$ | Beta | 0.020 | 0.0100 | 0.021 | 0.0034 | 0.0157 | 0.0266 |
| $\tau^{DEF}$ | Beta | 0.020 | 0.0100 | 0.012 | 0.0055 | 0.0029 | 0.0197 |
| $\tau^{B,IG}$ | Beta | 0.020 | 0.0100 | 0.010 | 0.0032 | 0.0044 | 0.0147 |
| $\tau^{DEF,IG}$ | Beta | 0.020 | 0.0100 | 0.024 | 0.0087 | 0.0097 | 0.0375 |
| $\tau^{DEF,TR}$ | Beta | 0.020 | 0.0100 | 0.021 | 0.0101 | 0.0047 | 0.0359 |
| $rpe$ | Beta | 0.003 | 0.0010 | 0.001 | 0.0003 | 0.0005 | 0.0015 |
| $\theta^s$ | Beta | 0.007 | 0.0010 | 0.008 | 0.0007 | 0.0067 | 0.0091 |
| $rpdebt$ | Beta | 0.003 | 0.0012 | 0.003 | 0.0012 | 0.0012 | 0.0051 |
| $b^U$ | Beta | 0.300 | 0.1000 | 0.466 | 0.0683 | 0.3618 | 0.5715 |
| $\rho^{TR}$ | Beta | 0.850 | 0.0750 | 0.946 | 0.0216 | 0.9116 | 0.9799 |

## Table 4. Results from Posterior Parameters (standard deviation of structural shocks)

| | Prior Distribution | Prior Mean | Prior S.D. | Posterior Mean | Posterior S.D. | HPD Inf. | HPD Sup. |
|---|---|---|---|---|---|---|---|
| $\varepsilon^{UC}$ | Gamma | 0.020 | 0.0080 | 0.036 | 0.0082 | 0.0225 | 0.0486 |
| $\varepsilon^L$ | Gamma | 0.040 | 0.0160 | 0.065 | 0.0140 | 0.0417 | 0.0865 |
| $\varepsilon^\eta$ | Gamma | 0.020 | 0.0080 | 0.015 | 0.0032 | 0.0103 | 0.0207 |
| $\varepsilon^{\eta Constr}$ | Gamma | 0.100 | 0.0400 | 0.122 | 0.0396 | 0.0547 | 0.1833 |
| $\varepsilon^{\eta,M}$ | Gamma | 0.020 | 0.0080 | 0.031 | 0.0053 | 0.0223 | 0.0393 |
| $\varepsilon^{\eta,X}$ | Gamma | 0.020 | 0.0080 | 0.020 | 0.0045 | 0.0136 | 0.0273 |
| $\varepsilon^X$ | Gamma | 0.005 | 0.0020 | 0.006 | 0.0006 | 0.0051 | 0.0070 |
| $\varepsilon^{CG}$ | Gamma | 0.005 | 0.0020 | 0.002 | 0.0002 | 0.0015 | 0.0023 |
| $\varepsilon^{IG}$ | Gamma | 0.005 | 0.0020 | 0.003 | 0.0004 | 0.0027 | 0.0040 |
| $\varepsilon^M$ | Gamma | 0.005 | 0.0020 | 0.008 | 0.0008 | 0.0069 | 0.0095 |
| $\varepsilon^N$ | Gamma | 0.050 | 0.0200 | 0.067 | 0.0172 | 0.0367 | 0.0932 |
| $\varepsilon^{M,EA}$ | Gamma | 0.003 | 0.0010 | 0.001 | 0.0001 | 0.0011 | 0.0014 |
| $\varepsilon^{PC}$ | Gamma | 0.003 | 0.0010 | 0.004 | 0.0003 | 0.0036 | 0.0047 |
| $\varepsilon^{rpe}$ | Gamma | 0.005 | 0.0020 | 0.000 | 0.0000 | 0.0003 | 0.0003 |
| $\varepsilon^{rpk}$ | Gamma | 0.005 | 0.0020 | 0.008 | 0.0019 | 0.0052 | 0.0111 |
| $\varepsilon^{rph,c}$ | Gamma | 0.010 | 0.0040 | 0.009 | 0.0026 | 0.0048 | 0.0128 |
| $\varepsilon^{rpland}$ | Gamma | 0.010 | 0.0040 | 0.016 | 0.0048 | 0.0084 | 0.0237 |
| $\varepsilon^T$ | Gamma | 0.010 | 0.0040 | 0.020 | 0.0029 | 0.0153 | 0.0247 |
| $\varepsilon^{TR}$ | Gamma | 0.005 | 0.0020 | 0.003 | 0.0008 | 0.0021 | 0.0047 |
| $\varepsilon^W$ | Gamma | 0.020 | 0.0080 | 0.030 | 0.0078 | 0.0179 | 0.0426 |
| $\varepsilon^z$ | Gamma | 0.010 | 0.0040 | 0.007 | 0.0008 | 0.0061 | 0.0088 |

## References


Adjemian, S., H. Bastani, M. Juillard, F. Mihoubi, G. Perendia, M. Ratto, and S. Villemot. 2011. "Dynare: Reference Manual, Version 4." Dynare Working Paper No. 1, CEPREMAP. Available at http://www.dynare.org.

Andres, J., S. Hurtado, E. Ortega, and C. Thomas. 2010. "Spain in the Euro: A General Equilibrium Analysis." *SERIEs, Journal of the Spanish Economic Association* 1 (1): 67–95.

Bernanke, B., and M. Gertler. 1999. "Monetary Policy and Asset Price Volatility." *Economic Review* (Federal Reserve Bank of Kansas City) (4th Quarter): 17–51.

Burriel, P., J. Fernández-Villaverde, and J. F. Rubio-Ramírez. 2010. "MEDEA: A DSGE Model for the Spanish Economy." *SERIEs, Journal of the Spanish Economic Association* 1 (1): 175–243.

Catao, L., and G. M. Milesi-Ferretti. 2013. "External Liabilities and Crises." IMF Working Paper No. 13/113.

Christiano, L., R. Motto, and M. Rostagno. 2008. "Shocks, Structures or Monetary Policies? The Euro Area and US after 2001." *Journal of Economic Dynamics and Control* 32 (8): 2476–2506.

European Commission. 2006. "The EU Economy, 2006 Review: Adjustment Dynamics in the Euro Area—Experiences and Challenges. *European Economy* 2006/6.

———. 2008. "EMU@10: Successes and Challenges after 10 Years of Economic and Monetary Union." *European Economy* 2008/2.

Fournier, J., and I. Koske. 2010. "A Simple Model of the Relationship between Productivity, Saving and the Current Account." OECD Economics Department Working Paper No. 816.

Gorton, G. B. 2010. *Slapped by the Invisible Hand. The Panic of 2007.* Oxford University Press.

Hall, R. E. 2010. "The High Sensitivity of Economic Activity to Financial Frictions." Mimeo, Stanford University.

Iacoviello, M. 2005. "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle." *American Economic Review* 95 (3): 739–64.

Iacoviello, M., and S. Neri. 2010. "Housing Market Spillovers: Evidence from an Estimated DSGE Model." *American Economic Journal: Macroeconomics* 2 (2): 125–64.

In 't Veld, J., R. Raciborski, M. Ratto, and W. Roeger. 2011. "The Recent Boom-Bust Cycle: The Relative Contribution of Capital Flows, Credit Supply and Asset Bubbles." *European Economic Review* 55 (3): 386–406.

Jaumotte, F., and P. Sodsriwiboon. 2010. "Current Account Imbalances in the Southern Euro Area." IMF Working Paper No. 10/139.

Kerdrain, C., I. Koske, and I. Wanner. 2010. "The Impact of Structural Policies on Saving, Investment and Current Accounts." OECD Economics Department Working Paper No. 815.

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

Lane, P. R., and G. M. Milesi-Ferretti. 2011. "External Adjustment and the Global Crisis." IMF Working Paper No. 11/197.

Martinez-Mongay, C., L. A. Maza Lasierra, and J. Yaniz Igal. 2007. "Asset Booms and Tax Receipts: The Case of Spain, 1995–2006." European Economy Economic Paper No. 293.

Monacelli T. 2007. "New Keynesian Models, Durable Goods and Collateral Constraints." CEPR Discussion Paper No. 5916.

Ratto, M., W. Roeger, and J. in 't Veld. 2009. "QUEST III: An Estimated Open-Economy DSGE Model of the Euro Area with Fiscal and Monetary Policy." *Economic Modelling* 26 (1): 222–33.

Schmitt-Grohe, S., and M. Uribe. 2003. "Closing Small Open Economy Models." *Journal of International Economics* 61 (1): 163–85.

Vogel, L. 2011. "Structural Reforms and External Rebalancing in the Euro Area: A Model-Based Analysis." European Economy Economic Paper No. 443.