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Abstract

This paper uses an estimated DSGE model to analyse the factors behind the build-up 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. While the reduction in external imbalances has started in the recent period, projections of the estimated model indicate that faster correction to these imbalances will require an adjustment in domestic demand and a significant improvement in the trade balance in the coming years. The correction would be eased in a more favourable and less risk-averse environment.

JEL classification: C54; E21; E62;F32
Keywords: current account; imbalances; deficits; DSGE model

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1. Introduction

Large internal and external imbalances have built up in the Spanish economy since its accession to the euro area. This manifested itself in an excessive allocation of resources to the construction sector associated with a boom in house prices, and large current account deficits and escalating external debt. With 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 credit boom. Spain was not the only country experiencing this build-up of imbalances and growing current account deficits were recognised as one of the main challenges for adjustment in EMU (European Commission, 2006, 2008). [1] A correction started in 2007, accelerated by the financial crisis, and the Spanish economy has since gone through a sharp adjustment, with unemployment soaring to above 20%. The share of construction investment in GDP has fallen back to pre-boom levels and there has been some improvement in the trade balance. But Spain's external indebtedness remains at highly elevated levels.

The crisis also had dire consequences for the fiscal position. In the boom years transitory composition effects due to the increase in asset prices had boosted tax revenues (Martinez-Mongay et al, 2007), and the government balance had rached a surplus. This deteriorated dramatically when revenues related to housing and wealth declined and spending increased. Government debt had been reduced to below 40% of GDP before the crisis, but has since risen and exceeded the 60% threshold in 2010. While debt is still below the euro area average, it is projected to rise fast given that government's net borrowing exceeded 8% of GDP in 2011. Spain has become subject to financial market pressure in the euro area sovereign debt crisis and as large imbalances remain, far-reaching fiscal consolidation measures and structural reform agenda are recommended to tackle these (European Commission, 2012).

An even more challenging problem for Spain is its large external indebtedness. Net foreign liabilities have accumulated to unprecedentedly high levels of 90% of GDP. This far exceeds euro area averages and its elevated level raises doubts about its long run sustainability. For the scoreboard for the surveillance of macroeconomic imbalances in the European Union, the 'threshold' for the net international investment position is set at 35% of GDP, and for Spain this indicator would have been flashing since 2002. Given the stock nature of this indicator and the projected current account deficits in the near future, it is unlikely this alert will stop flashing anytime soon. Catao and Milesi-Ferretti (2011) find that once economies' net foreign liabilities rise above 40% of GDP the risk of crisis, defined as either an outright external default or the disbursement of a large multilateral financial support package, accelerates with further net liability exposure. For Spain their model predicts a 10% probability of a crisis in 2010 (IMF, 2011, p.64).

This paper presents an analysis of the determinants of Spain's macroeconomic fluctuations in EMU. For that purpose we estimate a structural model of Spain as a small open economy in a monetary union and use this to identify the main shocks which have played a role in creating the imbalances. Our model has some features which make it especially suitable to analyse 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[2]. This should both help us in quantifying the extent in which financial innovations have contributed to the boom but also shed 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

[1] E.g, the EMU@10 report emphasised the need to monitor the growth of current account deficits, persistent inflation divergences or trends of unbalanced growth "given that the occurrence of spillover effects and the growing interdependence of euro-area economies mean these developments represent a concern not just for the country in question but for the euro area as a whole. " (European Commission, 2008, p. 8)

[2] See e.g. also Iacoviello (2005), Monacelli (2007), Iacoviello and Neri (2008).

contributions of these shocks. This can help to identify the main driving factors behind the build-up 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 labour, housing and credit markets.

Our shock decompositions suggest that one of the main factors behind the build-up 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 an earlier exercise with the QUEST model, we emphasised the role of the decline in the risk premium in explaining current account deficits in adjustment in a monetary union (European Commission (2006)). 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-nineties. More generally, Jaumotte and Sodsriwiboon (2010) suggest Southern Euro area countries might have benefitted 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 nontradable sectors, such as construction, and current account deficits now exceed their long-run fundamental “norms”.

We proceed by using the model to project forward the correction that is required for a return to steady states. As net foreign liabilities have increased dramatically over recent years, any reduction in external indebtedness will require significant trade balance surpluses. In the model projection scenarios, this occurs through a contraction in domestic demand and leads to a period of below trend inflation or outright deflation. The degree of demand contraction and the speed at which it occurs depend crucially on the debt-contingent interest rate premium (Schmitt-Grohe and Uribe, 2003). Over the estimation period this risk premium is relatively small. But risk assessments have changed fundamentally since the financial crisis, and in order to assess the sensitivity of our results to this risk premium, we compare our projections with an alternative scenario where we assume a lower risk tolerance in the projection period. The second scenario illustrates what could occur in a more risk-averse environment when financial markets take fright of Spain's external indebtedness: it would lead to a much sharper contraction and more prolonged period of deflation. Lane and Milesi-Ferretti (2011) show that current account adjustment in deficit countries has more relied on expenditure reduction than on expenditure switching. Our results suggest adjustment occurs first and foremost in domestic absorption with in particular a sharp decline in consumption, but the accompanying deflation and decline in unit labour costs also brings about a strong depreciation of the real effective exchange rate.

The remainder of the paper is structured as follows. The following section describes some of the main stylised 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 section 5 shows the historical evolution of the main shocks over the estimation period. Section 6 discusses then the shock decomposition of the main variables of interest to determine the underlying factors behind the build-up of imbalances. Section 7 describes the model-based scenario that leads to the required rebalancing in the long run and compares this with an alternative scenario of a higher risk premium. Section 8 concludes.

2. Some stylised facts of the Spanish Economy

GDP growth in Spain increased sharply in the second half of the 1990s, and exceeded average growth in the euro area by 1-2 pps. (Figure 2.1). The quarterly annualized real GDP growth rate reached its peak of around 6% at the turn of the century. For most of the decade up to 2007, the Spanish economy continued to grow faster than the euro area, with growth rates between 3-4%. But the financial and economic crisis hit Spain severely, with quarter-to-quarter annualized growth rates falling to almost -6% in the first quarter of 2009 and a slower recovery in 2010 compared to the rest of the euro area. Inflation in Spain was also much above euro area average and hovered around 4% for much of the boom years. It fell sharply in the crisis to zero by the end of 2009, before rising again in 2010-11 (Fig. 2.5).

Looking in some detail at the domestic demand aggregates (Figure 2.2-2.4) tells a more nuanced story. While over the period considered all domestic demand components showed a trend increase in their share in GDP, this trend increase was much more pronounced in investment, and in particular in residential construction. The Spanish consumption-to-GDP ratio remained relatively stable, at a relatively high level of around 60%, around 3 to 5 pp. higher than the euro area average. It fell in 2008-9, but rose again in 2010. 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 price in this period (Figure 2.6) 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 only a modest correction since their peak in 2007.

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 (Fig. 2.7). 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 (Fig 2.8). 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 almost 8% by 2007 (Figure 2.4) and even larger current account deficits. The persistent trade deficits accumulated into an ever increasing net foreign indebtedness, rising from around 20% of GDP in the late 1990s to more than 90% 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% of GDP.

Spain's public finances were up to the crisis in a better state 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 et al., 2007). The crisis led to a sharp reversal of this trend, with the deficit peaking at 11% of GDP in 2009, and only gradually recovering afterwards. This deterioration in the fiscal position reversed the trend decline in gross debt, which had fallen to 36% of GDP in 2007, but which increased again to 70% of GDP by the end of 2011.

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

Figure 2.1.Annual. GDP growth

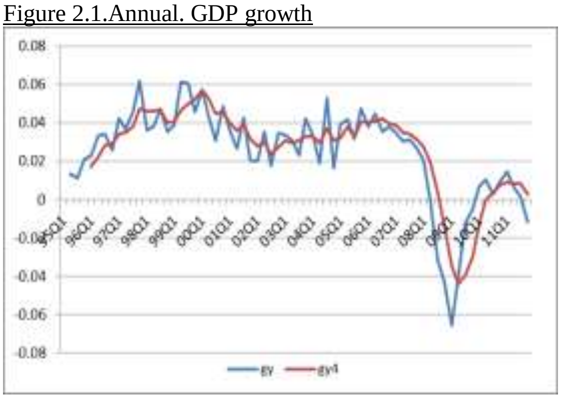


Figure 2.2 Consumption/GDP share

Figure 2.3 Gross fixed capital formation-GDP share

Figure 2.4 Construction investment/GDP share

Figure 2.5 Inflation GDP deflator (q-on-q(t-4))

Figure 2.6 House prices relative to GDP deflator

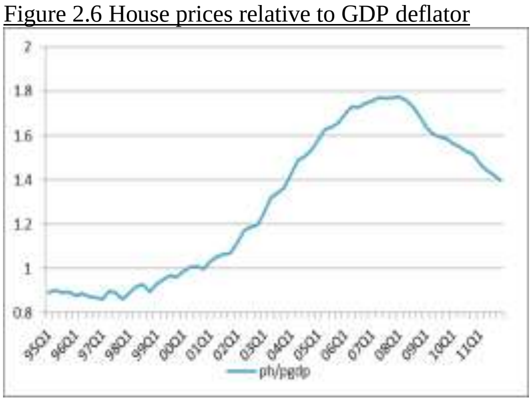


Figure 2.7 Nominal interest rates Spain and euro area

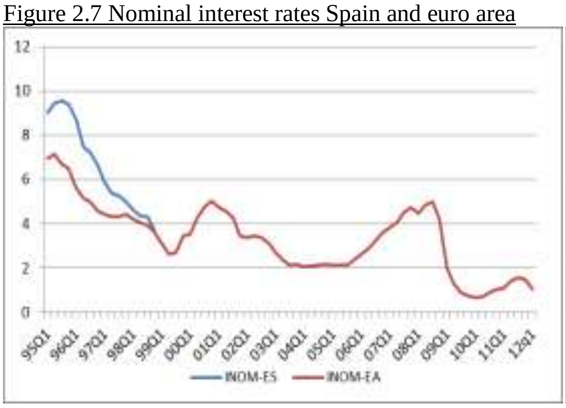


Figure 2.8 Real interest rate

Figure 2.9 Government deficit

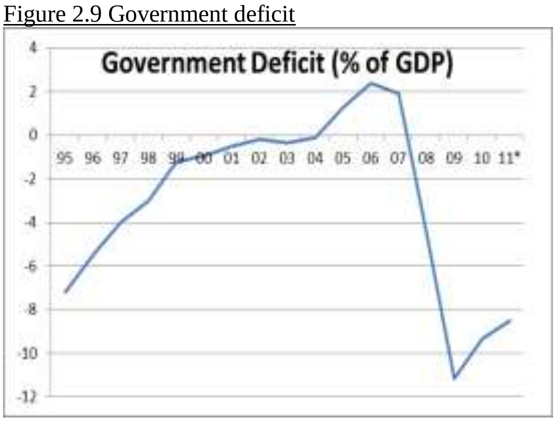


Figure 2.10 Government debt

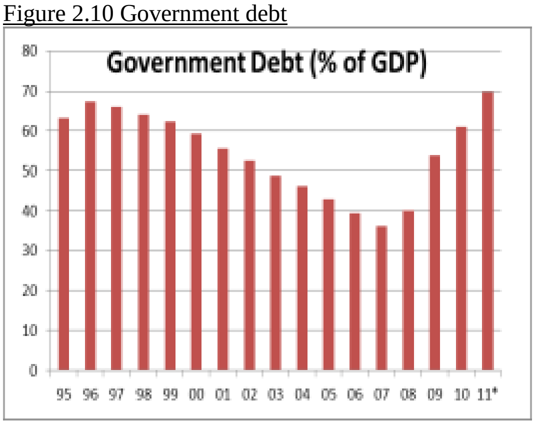


Figure 2.11 Trade balance and current account

Figure 2.12 International Investment Position

3. Model

We consider an open economy, which produces goods which are imperfect substitutes to goods produced in the RoW. [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 stabilisation policies. Behavioural and 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 [5] will generally be autocorrelated with autocorrelation coefficient ρ^k and innovation ε_t^k.

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.

[4] The model is an extension of the QUEST model estimated on euro area data (Ratto, Roeger and in 't Veld, 2009) and a similar version has been estimated on US data (in 't Veld et al., 2011).

[5] Lower cases denote logarithms, i.e. $z_t = log(Z_t)$. Lower cases 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 w. r. t. the GDP deflator

Because of imperfect substitutability, firms are monopolistically competitive in the goods market and face a demand function for goods. Domestic final good 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

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

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

$$(2) \qquad \Pr_t^j = p_t^j Y_t^j - w_t L_t^j - i_t^K p_t^{K,j} K_t^j - (adj^P(P_t^j) + adj^L(L_t^j) + adj^{UCAP}(UCAP_t^j)).$$

where i^K denotes the rental rate of capital. Firms also face technological and regulatory constraints which restrict their price setting, employment and capacity utilisation decisions. Price setting rigidities can be the result of the internal organisation of the firm or specific customer-firm relationships associated with certain market structures. Costs of adjusting labour have a strong job specific component (e.g. training costs) but higher employment adjustment costs may also arise in heavily regulated labour markets with search frictions. Costs associated with the utilisation 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

$$(3) \qquad \begin{aligned} adj^L(L_t^j) &= w_t\left(L_t^j u_t^L + \frac{\gamma_L}{2}\Delta L_t^{j\,2}\right) \\ adj^P(P_t^j) &= \frac{\gamma_P}{2}\frac{(P_t^j - P_{t-1}^j)^2}{P_{t-1}^j} \\ adj^{UCAP}(ucap_t^j) &= p_t^I K_t\left(\gamma_{ucap,1}(ucap_t^j - 1) + \frac{\gamma_{ucap,2}}{2}(ucap_t^j - 1)^2\right) \end{aligned}$$

The firm determines labour 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

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

Subject to a quadratic adjustment cost constraint

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

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 with J_t^{inp}, then real output of the investment goods sector is produced by the following linear production function,

(6) $$J_t = J_t^{inp} U_t^{PI}$$

where U_t^{PI} is a technology shock to the investment good production technology which itself follows a random walk

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

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 constant elasticity of substitution (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

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

All two types of households supply differentiated labour services to unions which maximise a joint utility function for each type of labour *i*. It is assumed that types of labour 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 labour, 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 $\Pr_t^j$, residential construction $\Pr_t^H$ and financial intermediaries $\Pr_t^B$). We assume that all domestic firms are owned by Ricardian households. Income from labour 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 nominal return equal to i_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 β^r is subject to random shocks.

The Lagrangian of this maximisation problem is given by

(9)

$$Max \quad V_0^r = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^{r\,t} U(C_t^r, 1-L_t^r, H_t^r)$$

$$-\mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^r \beta^{r\,t} \left(\begin{array}{l} (1+t_t^c) p_t^C C_t^r + p_t^I I_t^r + p_t^H (1+t_t^c) I_t^{H,r} + (B_t^{G,r} + B_t^r + D_t) + rer_t B_t^{F,r} - \\ (1+r_{t-1})(B_{t-1}^{G,r} + B_{t-1}^r + D_{t-1}) - (1+r_{t-1}^F) rer_t B_{t-1}^{F,r} - ((1-t_t^k) i_{t-1}^K + t_t \delta^k) p_{t-1}^I K_{t-1}^r \\ -(1-t_t^W) w_t L_t^r + \frac{\gamma_W}{2} \frac{\Delta W_t^2}{W_{t-1}} - p_t^L J_t^{Land} - \sum_{j=1} \Pr_t^j - \Pr_t^H - \Pr_t^B + T_t^{LS,r} \end{array} \right)$$

$$-\mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^r \xi_t \beta^{r\,t} (K_t^r - J_t^r - (1-\delta^K) K_{t-1}^r)$$

$$-\mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^r \zeta_t^r \beta^{r\,t} \left(H_t^r - J_t^{H,r} - (1-\delta^H) H_{t-1}^{H,r} \right)$$

$$-\mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^r \xi_t^r \beta^{r\,t} \left(Land_t + J_t^{Land} - (1+g_t^L) Land_{t-1} \right)$$

The investment decisions w. r. t. 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

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

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

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.

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

(11) $$i_t^h = i_t + rprem\left(\frac{(-B_t^F)}{P_t\, Y_t}\right)$$

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 w.r.t. foreign debt as an important behavioural 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 they face a collateral constraint on their borrowing. They borrow B_t^c exclusively from domestic Ricardian households. The Lagrangian of this maximisation problem is given by

(12)

$$\begin{aligned}
&Max \quad V_0^c = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^{c\,t} U(C_t^c, 1 - L_t^c, H_t^c) \\
&- \mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^c \beta^{c\,t} \left((1+t_t^c) p_t^C C_t^c + p_t^H (1+t_t^H) I_t^{H,c} - B_t^c + (1+r_{t-1}) B_t^c) - (1-t_t^W) w_t L_t^c + \frac{\gamma_W}{2} \frac{\Delta W_t^{\,2}}{W_{t-1}} + T_t^{LS,c} \right) \\
&- \mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^c \zeta_t^c \beta^{c\,t} \left(H_t^c - J_t^{H,c} - (1-\delta^H) H_{t-1}^c \right) - \mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^c \psi_t^c \beta^{c\,t} \left((1+r_t\ ) B_t^c - \chi_t^c p_t^H H_{t-1}^c \right)
\end{aligned}$$

Notice, the collateral constraint increases the shadow price of borrowing as determined by the Lagrange multiplier ψ_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 maximising a joint utility function for each type of labour *i* where it is assumed that types of labour are distributed equally over constrained and unconstrained households with their respective population weights. The trade union sets wages by maximising 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 mark up

(13) $$\frac{s^c U_{1-L,t}^c + s^r U_{1-L,t}^r}{s^c U_{c,t}^c + s^r U_{c,t}^r} = \frac{(1-t_t^W)}{(1+t_t^C)} \frac{W_t}{P_t^C} \eta_t^W$$

where η_t^W is the wage mark-up factor, with wage mark ups fluctuating around $1/\theta$ which is the inverse of the elasticity of substitution between different varieties of labour services. The trade union sets the consumption wage as a mark-up 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 labour and spending the additional income on consumption and not increasing labour supply. Fluctuation in the wage mark-up arises because of wage adjustment costs

(14) $$adj^W(W_t) = \frac{\gamma_W}{2} \frac{(W_t - W_{t-1})^2}{W_{t-1}^H}$$

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 $Z^i \in \{C^i, I^i, C^{G,i}, I^{G,i}\}$ be demand of an individual household, investor or the government, and then their preferences are given by the following utility function

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

where the share parameter s^M can be subject to random shocks 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 mark-up over domestic prices. Thus export prices are given by

(16) $$\eta_t^X P_t^X = P_t$$

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 mark over the purchase price of imports denominated in domestic currency.

(17) $$\eta_t^M P_t^M = E_t P_t^F$$

Mark-up 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.

(18) $$B_t^F = (1 + i_t^F) B_{t-1}^F + P_t^X X_t - P_t^M M_t + Transfers_t + \varepsilon_t^{BF}$$

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 stabilising 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)

$$(19)\quad \begin{aligned} c_t^G - \overline{c^G} &= \tau_{Lag}^{CG}(c_{t-1}^G - \overline{c^G}) + \tau^{CG}(\sum_{i=1}^{4}\Delta y_{t-i} - 4\overline{\Delta y}) \\ &- \tau^{CGB}\left(\frac{B_{t-1}}{Y_{t-1}P_{t-1}} - b^T\right) - \tau^{CGDEF}\left(\left(\frac{\Delta B_t}{Y_t P_t}\right) - def^{\,T}\right) + u_t^{CG} \end{aligned}$$

$$(20)\quad \begin{aligned} i_t^G - \overline{i^G} &= \tau_{Lag}^{IG}(i_{t-1}^G - \overline{i^G}) + \tau^{IG}(\sum_{i=1}^{4}\Delta y_{t-i} - 4\overline{\Delta y}) \\ &- \tau^{IGB}\left(\frac{B_{t-1}}{Y_{t-1}P_{t-1}} - b^T\right) - \tau^{IGDEF}\left(\left(\frac{\Delta B_t}{Y_t P_t}\right) - def^{\,T}\right) + u_t^{IG} \end{aligned}$$

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 stabilising the debt to GDP ratio, where b^T is the government debt target and $def^{\,T}$ is the associated deficit target.

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 stabilising 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.

$$(21)\quad \begin{aligned} tr_t &= b^U w_t (POP_t^W - POP_t^{NPART} - L_t) + b^R w_t POP_t^P \\ &- \tau^{TRB}\left(\frac{B_{t-1}}{Y_{t-1}P_{t-1}} - b^T\right) - \tau^{TRDEF}\left(\left(\frac{\Delta B_t}{Y_t P_t}\right) - def^{\,T}\right) + u_t^{TR} \end{aligned}$$

Government revenues R_t^G consist of taxes on consumption as well as capital and labour income.

$$(22)\quad R_t^G = \left(ssc_t + t_t^w\right)W_t\, L_t + t_t^c P_t^c C_t + t_t^c P_t^H I_t^H + t_t^K[(Y_t\text{-}W_t L_t)\text{-}\delta K_t P_t^I]$$

We assume consumption and capital income tax to follow a linear scheme, but a progressive labour income tax schedule

$$(23a)\quad t_t^w = \tau_0^w Y_t^{\tau_1^w} U_t^{TW}$$

where τ_0^w measures the average tax rate, and τ_1^w the degree of progressivity. A simple first-order Taylor expansion around a steady state growth rate yields

$$(23b)\quad t_t^w = \tau_0^w + \tau_0^w \tau_1^w (\sum_{i=0}^{3}\Delta y_{t-i} - 4\overline{\Delta y})_t$$

Government debt (B_t) evolves according to

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

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 mark-up made up of a sovereign risk premium dependent on the government debt-to-GDP ratio and an autoregressive term.

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

Monetary policy is modelled exogenous, with interest rates i_t^{EA} set by the ECB.

(25) $$i_t = i_t^{EA} + u_t^{RPREM}$$

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

A monetary policy shock is defined as the deviation of i_t 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 et al., 2009)

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

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 maximise utility, final goods producing firms, firms in the construction sector and investment goods producers maximise profits and the following market clearing conditions hold for final domestic goods:

(27) $$Y_t = C_t^d + J_t^{inp,d} + J_t^{Constr} + C_t^{G,d} + I_t^{G,d} + X_t,$$

and final imported goods

(28) $$M_t = C_t^f + J_t^{inp,f} + C_t^{G,f} + I_t^{G,f},$$

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:

(29a) $$C_t^i = s^r C_t^{r,i} + s^c C_t^{c,i} \quad \text{,with } i = d, f$$

Similarly, total housing investment is defined as:

(29b) $$J_t^H = s^r J_t^{H,r} + s^c J_t^{H,c}$$

and equilibrium in the labour market is given by

(29c) $L_t = s^r L_t^r + s^c L_t^c$ with $L_t^r = L_t^c$.

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

(30) $B_t^c = \frac{s^r}{s^c} B_t^r$.

3.6 Adding exogenous asset price bubbles

The model so far assumes that arbitrage equations in asset markets (stock and housing market) exclude non-fundamental shocks. Since the fundamentals-only explanation for the boom has been questioned (see Shiller (2007) for example) and since it has also been argued that freezing up of financial markets can best be explained as "panic" reactions of market participants (see, for example Gorton, 2010), i.e. as temporary deviations from standard rational behaviour, we also consider non-fundamental shocks to asset prices and follow Bernanke and Gertler (1999) for implementing bubble processes for house and stock prices. 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.

Consider the arbitrage equation for the stock price, which determines the stock price in period t as being equal to the current dividend plus the expected capital gain, discounted with the factor d_t^E

(31) $q_t = div_t + E_t d_t^E q_{t+1}$[6]

We assume that besides div_t, there is a non-fundamental shock x_t which also influences the current price. And we assume that x_t follows the "near rational" bubble process[7]

(32) $$x_{t+1} = \begin{cases} \left(\frac{a}{prob}\right) x_t / d_t^E + e_t & \text{with probability } prob \\ 0 & \text{with probability } (1-prob) \end{cases}$$

with $a < d_t^E$[8]. The expected value of x_t is

(33) $E_t x_{t+1} = a x_t / d_t^E$

Now we can define the market price q_t^M for the respective asset

(34) $q_t^M = q_t + x_t$,

which follows the process

[6] Similarly we implement a bubble process for house and land prices.

[7] We confine ourselves to near rational bubbles for technical reasons (see next footnote). By deviating from a rational bubble we implicitly allow for the presence of noise trading which is not eliminated by rational speculators.

[8] This restriction allows us to introduce a stationary non fundamental shock into the model.

(35) $$\left[1-(1-a)\frac{x_t}{q_t^M}\right]q_t^M = d_t^E(div_t + E_t q_{t+1}^M)$$

In the presence of bubbles the expected return of the asset differs from the fundamental return by the presence of a positive or negative premium. The asset price including the bubble obeys the asset price equation with a declining risk premium and the risk premium is defined as

(36) $$Z_t^V = -(1-a)\frac{x_t}{q_t^M}$$

and x_t rises before the bubble bursts and vanishes afterwards, , leading to a fall in asset prices. 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^v 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^v could also capture what Hall (2010) calls "principal agent frictions" which he models by introducing an exogenous wedge shock between save (government bonds) and risky assets (equity and houses) in order to empirically match rising spreads between save and risky assets.

Since we are not modelling panics, principal agent frictions and bubbles explicitly but only allow for risk premia shocks in asset arbitrage equations we can only quantify the extent in which risk shocks have affected macro aggregates but we can say little about the underlying mechanisms. There is however one interesting feature which distinguishes a bubble from a panic or a principal agent friction. A full bubble cycle is characterised by a prolonged period of a falling risk premium followed by a rather abrupt increase, while a panic or other temporary financial market friction can be associated with a strong increase in the risk premium without being preceded by a gradual decline in the risk shock. Studying the boom and bust together thus gives the possibility to judge whether the current crisis can be seen as a sudden contraction of output or rather as a correction of previous non fundamental developments.

4. Model estimation

The model is estimated on quarterly data over the period 1995Q1 to 2011Q4, using Bayesian inference methods to estimate model parameters and shocks. 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 4 Metropolis-Hastings chains of 100,000 draws to estimate the posterior distribution. A detailed description of data sources and estimation is described in an appendix.

Concerning the steady state calibration, parameters shown in Table 4.1 have been calibrated to match ratios of main economic aggregates (corporate investment, construction investment and government consumption and investment) to GDP over the period 1995-1999.[9] The two general exceptions to this are the calibration of the labour market and the steady state debt ratios. For the former the 1995-99 averages can no longer be considered representative of the Spanish labour market, as labour market reforms have led to a regime shift in the Spanish economy. Instead we base the calibration of labour market parameters on the full sample 1995Q1-2011Q4. The steady state employment rate as share of total population is set to 0.41, the wage share to 57%.

[9] 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.

Concerning the government debt ratio, we impose the debt target of 60% 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% of GDP. The average maturity structure of sovereign debt is set at 5 years. Tax rates are calibrated on sample averages. Government transfers to households are set to 12.5% of GDP, and benefit and pension indexation are set to match this. For construction of the monetary policy shock, Taylor rule coefficients are imposed based on estimates for the euro area (Ratto et al., 2009). Based on the whole sample, the quarterly GDP trend growth rate was set to 0.56% , while the inflation trend growth rate is set to 0.5%. Credit-constrained households are calibrated with a high rate of time preference, 4% quarterly, while the discount rate for non-constrained households is estimated (see below). The euro area discount rate is set at 0.5% quarterly, openness is calibrated at 0.25.

Table 4.1 Calibrated structural parameters

Structural parameters	*Calibrated value*
χ^c	0.5
α	0.60411
δ	0.025
δ^{house}	0.01
Target government. debt to GDP	0.6
Target government deficit to GDP	-0.0252
ρ^B	0.95
ssc	0.14
τ_0^W	0.13
τ_1^W	0.8
t^K	0.29632
t^C	0.15
$1/\beta^c - 1$	0.04
$1/\beta^{r,EUR} - 1$	0.005
$(1 - s^M)$	0.75
b^U	0.28444
b^R	0.24625
τ_{lag}^M	0.9
τ_π^M	1.5
τ_y^M	0.4

The estimation results of the main structural parameters are summarised in Table 4.2. [10] The population share of Ricardian households s^r is estimated at 0.33, implying the share of credit-constrained households s^c of 0.67. Concerning consumption, the intertemporal elasticity of substitution is set to one, habit persistence h is estimated to be 0.79, and the substitution elasticity for housing services σ_H is estimated at 0.56. The discount factor for Spanish households β^r is estimated close to 0.99, reflecting a higher propensity to consume than for the rest of the euro area. The estimate for *rprem* implies a highly inelastic interest rate w.r.t external indebtedness, an increase in the risk premium of 0.66 basispoints for every 1 percentage points increase in net foreign liabilities. This low estimate reflects the persistent buildup in net foreign liabilities over the sample period, reaching almost 100% of GDP by the end of the sample period. As risk tolerance of international investors may have changed since the crisis, in section 7 we discuss an alternative scenario with a

[10] HPDinf and HPDsup denote the bounds of the 90% Highest Probability Density interval. The prior distributions used and posterior estimates of all parameters can be found in the appendix.

lower risk tolerance of foreign creditors, in which this risk premium term is increased to *rprem=0.003*. Fiscal policy reactions are generally counter cyclical, while government consumption also contains a debt- and deficit stabilising response. The estimated elasticity of the sovereign risk premium w.r.t. the government debt-to-GDP ratio implies an increase in the risk premium of 12 bps. for a 10 pps. increase in the debt ratio.[11]

Table 4.2 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	0.791	0.0541	0.7056	0.8756
κ	Gamma	1.000	0.4000	0.859	0.3371	0.3301	1.3575
σ^H	Gamma	0.500	0.1000	0.559	0.1176	0.3698	0.7391
σ^X	Gamma	1.250	0.5000	1.741	0.2209	1.3800	2.1018
σ^M	Gamma	1.250	0.5000	0.658	0.1108	0.4774	0.8370
σ^L	Beta	0.500	0.2000	0.373	0.1421	0.1417	0.5980
s^s	Beta	0.500	0.1500	0.325	0.1019	0.1526	0.4864
$rprem$	Beta	0.003	0.0010	0.00041	0.00020	0.00018	0.00062
$1/\beta^r - 1$	Beta	0.007	0.0010	0.0091	0.0004	0.0085	0.0097
${\tau_{lag}}^{CG}$	Beta	0.500	0.2000	0.898	0.0212	0.8624	0.9315
${\tau_1}^{CG}$	Beta	-0.100	0.0400	-0.030	0.0140	-0.0507	-0.0072
τ^B	Beta	0.020	0.0100	0.028	0.0048	0.0203	0.0361
τ^{DEF}	Beta	0.020	0.0100	0.018	0.0080	0.0047	0.0300
${\tau_{lag}}^{IG}$	Beta	0.500	0.2000	0.328	0.1524	0.0837	0.5750
${\tau_1}^{IG}$	Beta	-0.100	0.0400	-0.081	0.0296	-0.1301	-0.0327
$rprem^B$	Beta	0.003	0.0012	0.0030	0.0017	0.0011	0.0050

[11] The modelspecification includes adjustment cost, and these are larger for residential investment (γ^H and γ^{IH}) than for corporate investment (γ^K and γ^I), not implausible given the different nature of the two investment activities. The estimated shares of forward-looking behaviour in price indexation are relatively high, 0.7-0.9.

5. Historical evolution of the main shocks

We now turn to an evaluation of the main shocks identified in the estimation procedure.[12] Figure 5.1 shows the estimated historical evolution of these fundamental and non-fundamental shocks of the model over the period 1995Q1 to 2011Q4. 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 *labour augmenting technology shocks* to final goods by the terms U_t^Y in the production function and we specify it as a random walk processes. 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. Labour 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, a further decline in 2005, but a trend increase in recent years. It is interesting to note that technology shocks are positive in the recent recession.

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 2007-08 when the ECB policy rate was raised while conditions in Spain deteriorated. The sharp reduction in the policy rate in response to the financial crisis shows as a large negative outlier in 2009, followed by a tightening in 2011, which was reversed again in the last quarter of 2011.

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, and a *house price bubble* as shocks to residential investment (see section 3.7 for the bubble interpretation of correlated shocks to asset price equations in the model description). 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 sharp reversal after that, suggesting a bubble that built up between 1999-2008 and then 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 residual to net exports and shock to foreign prices and is predominantly positive over much of the period up to 2007, but largely negative when world trade collapsed in 2008-9.

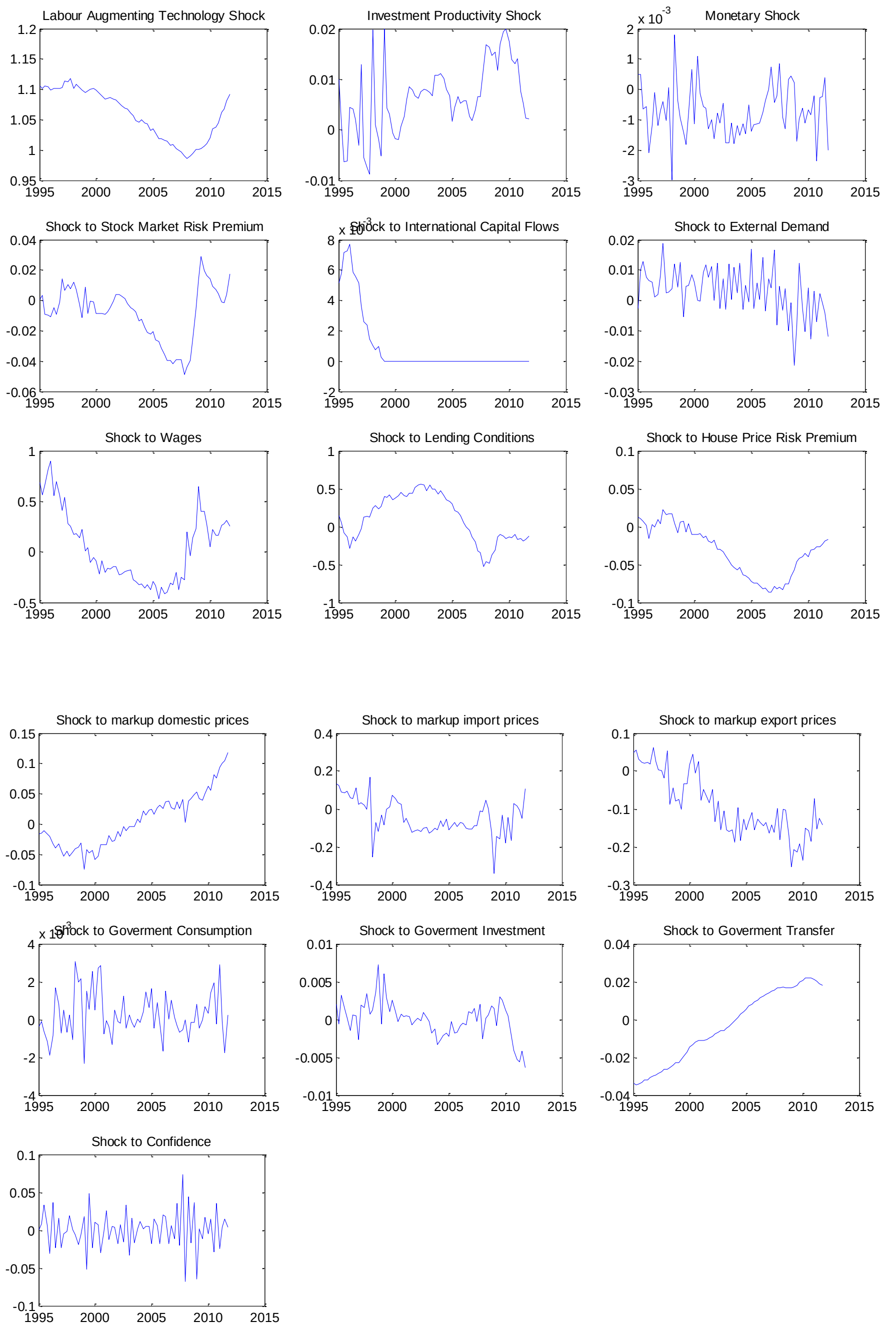
The *labour market shock* is identified as the residual to the wage setting equation and this shock to the wage mark-up shows a trend decline up to 2007-8, corresponding to a declining NAIRU over that period, and an increase in the years after 2008. Shifts in *lending conditions* are shocks to the collateral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

The shock to the mark-up on domestic prices is increasing over the sample, partly reflecting a sectoral shift towards the non-tradable sector (services) which is generally characterised by higher mark-ups. The shock to the mark-up on import prices shows a decline in 1999, while that on export prices 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 counter-cyclical over the sample and with an active response to debt and deficit developments. The shock to

[12] In total, the model is estimated with 29 shocks but we focus here on the most important shocks over the estimation period.

government consumption 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, and the shock profile indicates a trend increase in 2007-09, but this declined in the final years (consolidation). The shock to government transfers 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. In the following section we show the impact of these shocks on the main economic aggregates.

Figure 5.1: Profile of selected shocks 1995-2011:



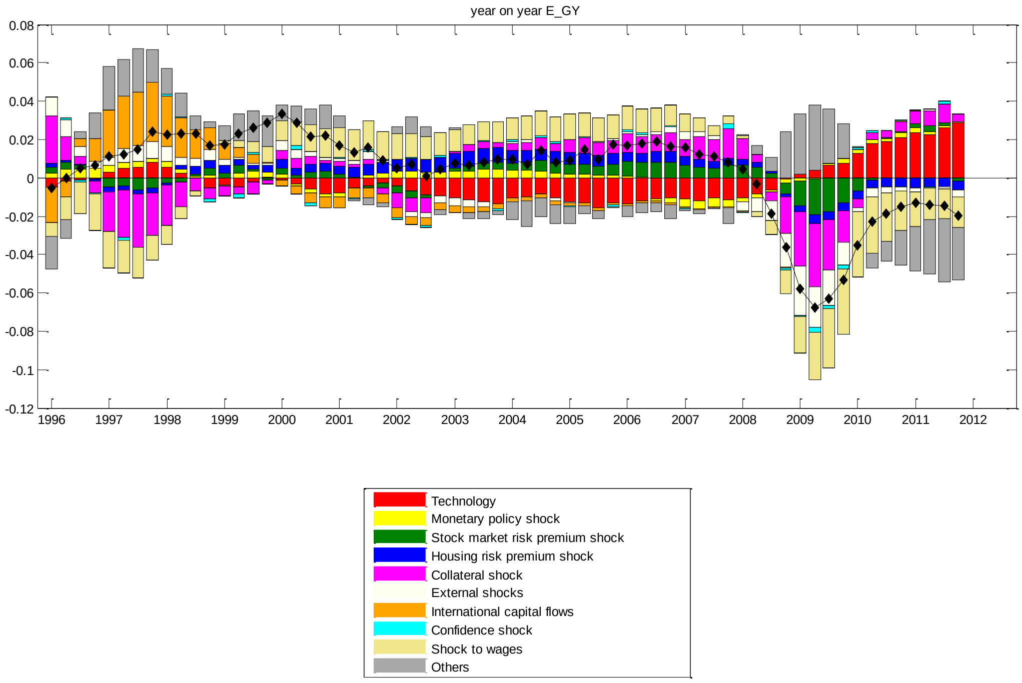
6. Historical shock decompositions

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 et al, 2008). The following charts in this section do this for the profiles for GDP growth, respective domestic demand shares, employment, competitiveness, trade balance and the real interest rate. 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 "others". [13]

6.1 Real GDP growth

Figure 6.1 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 of the sample, the build-up and first years of EMU membership, and fell by a maximum of around 6 percent below trend in the trough of the financial crisis.

Figure 6.1: Shock decomposition GDP Growth



In terms of shock contributions, the technology shock (the combination of the labour augmenting productivity shock and the investment specific productivity shock) contributed negatively to GDP growth throughout the decade, but contributed positively in the last years of the sample. The (elimination of the) risk premium shock (international capital flows) boosted growth in the years prior to accession of EMU. For much of the decade, the labour 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) contributed positively to growth rates, and these reversed in 2008 when they started to drag down growth.

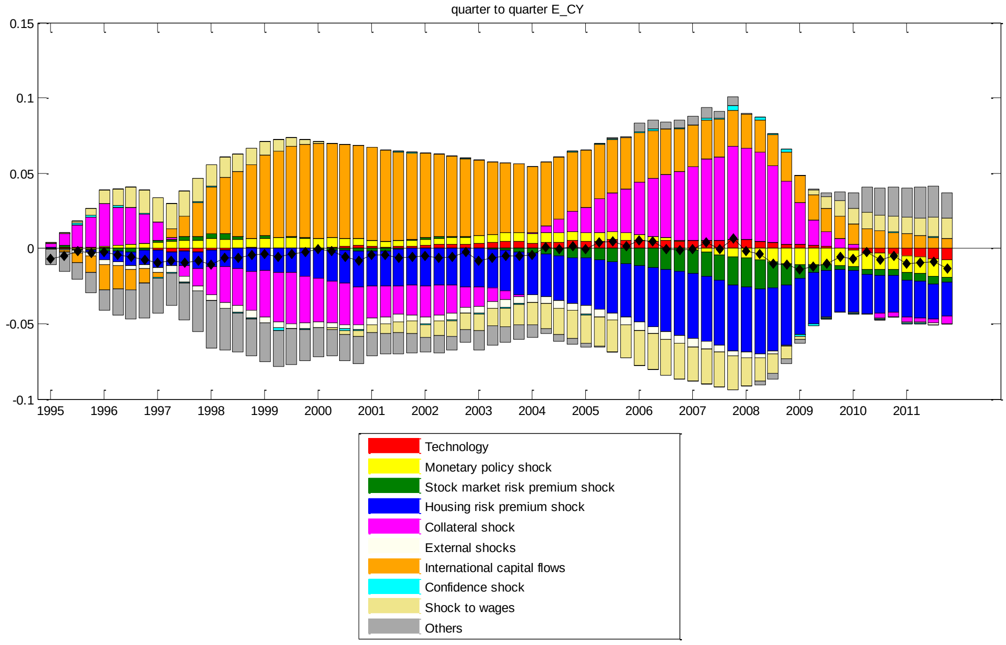
[13] In the figures, the line marked with black diamonds indicates observed data. The category "others" combines all other shocks included in the model (e.g shocks to mark-ups) and includes the effects of the initial conditions.

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 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 labour market shock (insufficient wage flexibility). Real GDP growth was supported in the crisis by a positive contribution from the productivity shocks (decline of construction sector, a relatively low tech sector, raised average productivity), the collateral shock (a relaxation again in the lending conditions) and a looser monetary policy stance (2009-10).

6.2 Consumption share

Figure 6.2 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 2004-08, but reversed into a negative contribution post 2008 (deleveraging). Other dampening effects on the consumption share came from the labour market shock (wage moderation). This turned positive in the crisis years and helped to support consumption in the last years of the sample. 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.

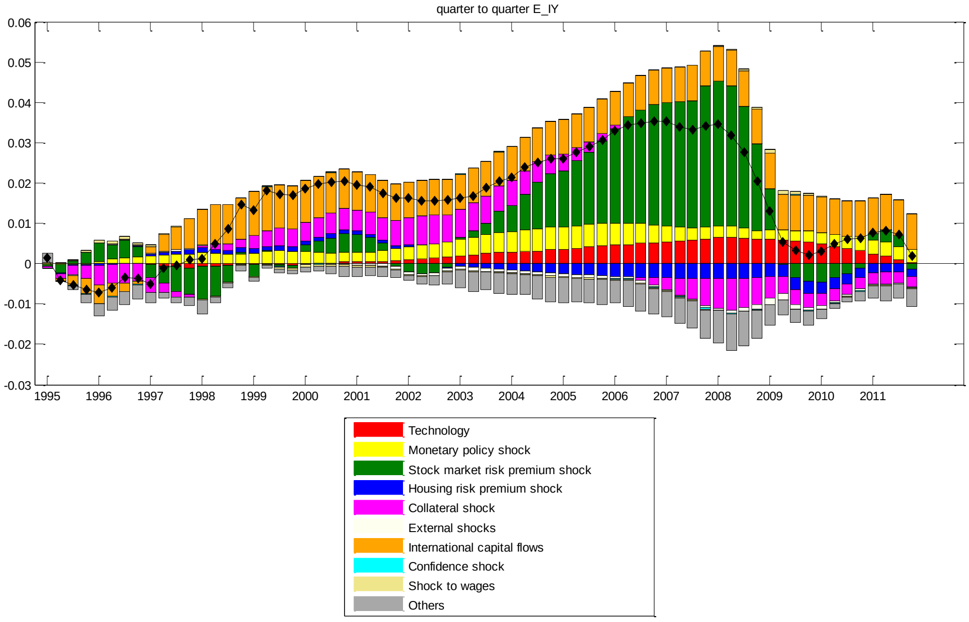
Figure 6.2: Shock decomposition consumption to GDP ratio



6.3 Corporate investment share

The shock decomposition of the deviations in the corporate investment share in GDP from its steady state level is shown in Figure 6.3. 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 2004-08 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.

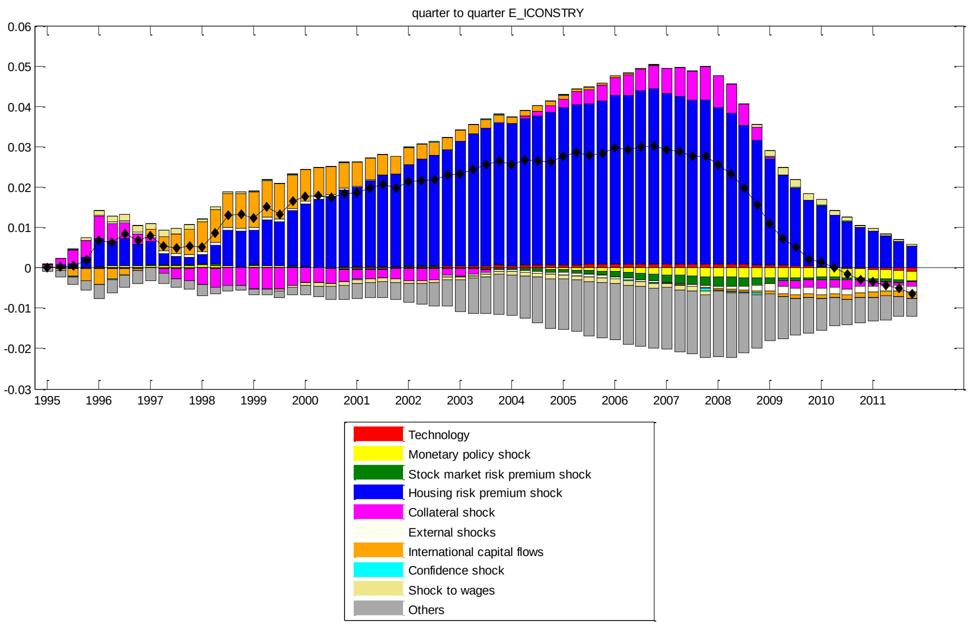
Figure 6.3: Shock decomposition corporate investment to GDP ratio



6.4 Residential investment share

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 Fig. 6.4 shows, the sharp 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) had also 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.

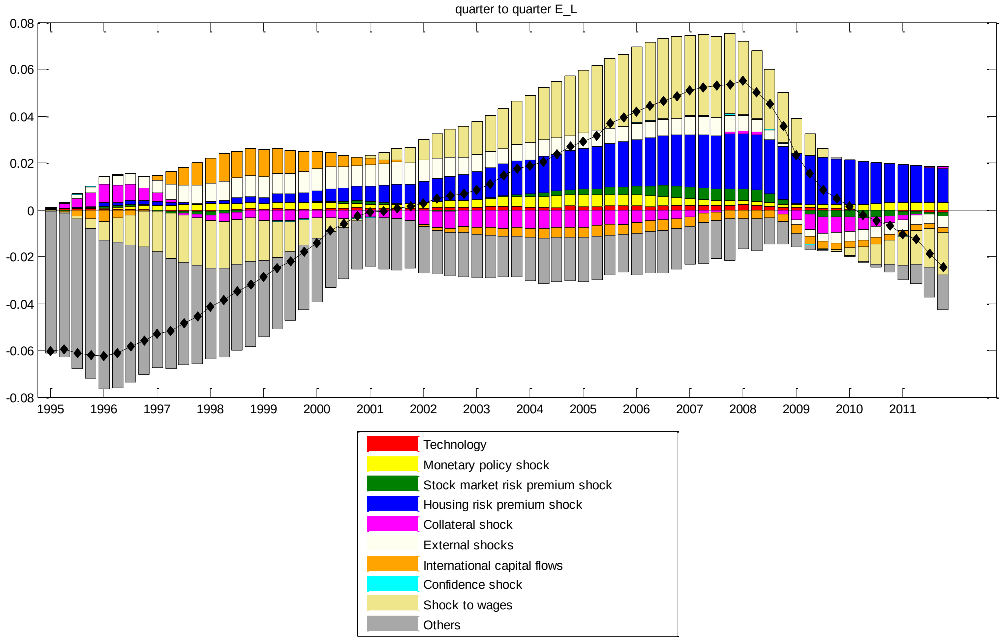
Figure 6.4: Shock decomposition residential investment to GDP ratio



6.5 Employment rate

Figure 6.5 shows the shock decomposition of the deviations of the employment rate, as share of total population, from its steady state. The employment share increased over the sample by almost 20 percentage points by 2007 before falling back again by almost half.[14] The contribution of the wage mark-up shock was negative in the first years of the estimation period but gradually reduced in size and turned into a positive contribution in 2001. It continued to boost employment up to 2007-08, but then declined.[15] The positive effect mainly reflects moderate wage growth and an increase in the participation rate. Other shocks that played a role are a positive contribution from the housing risk premium shock and since 2009 a negative contribution from external demand.

Figure 6.5: Shock decomposition employment



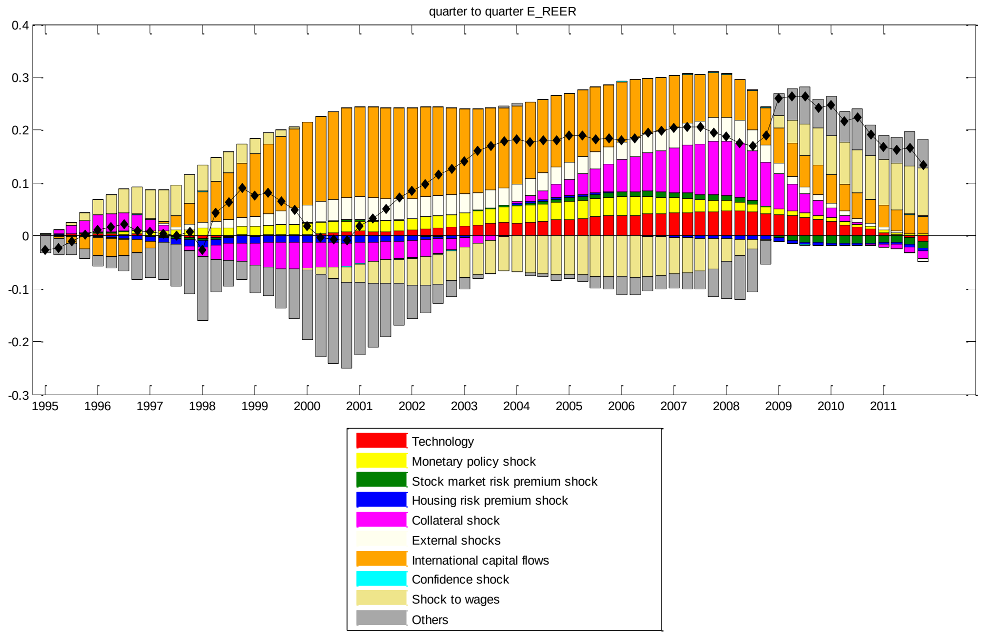
6.6 Real exchange rate

The real exchange rate shows a strong trend appreciation since 2001, to a large extent driven by the positive contribution of the capital flows shock (lower interest rates), which boosted demand and inflation (Figure 6.6). Positive contributions also came from technology and loosening lending conditions. Lower productivity growth raised inflation in Spain and shows up as a positive contribution to the real exchange rate. The main negative factor reducing the trend appreciation was the labour market shock (labour market developments helped to reduce inflationary pressures in the period up to 2008). Insufficient wage flexibility in the crisis led to a further overvaluation of the real effective exchange rate. In recent years some correction has taken place but there is still a sizeable overvaluation by the end of the sample period.

[14] The accumulated shocks and the data line show a large gap at the beginning of the sample (grey area). The reason for the initial gap is the calibration of the steady state employment rate at 60%, or 41% as share of total population, which is above the level in the beginning of the sample. We assume a higher steady state level in the calibration as the 1995-99 averages can no longer be considered representative for the Spanish labour market as labour market reforms have led to a regime shift in the Spanish economy. Instead we base the calibration of labour market parameters on the full sample 1995-2011 (see section 4).

[15] The profile of this shock corresponds to European Commission estimates of the NAIRU for Spain that show a decline from 18 per cent in 1995 falling to 8 per cent in 2007, and rising again since the onset of the crisis.

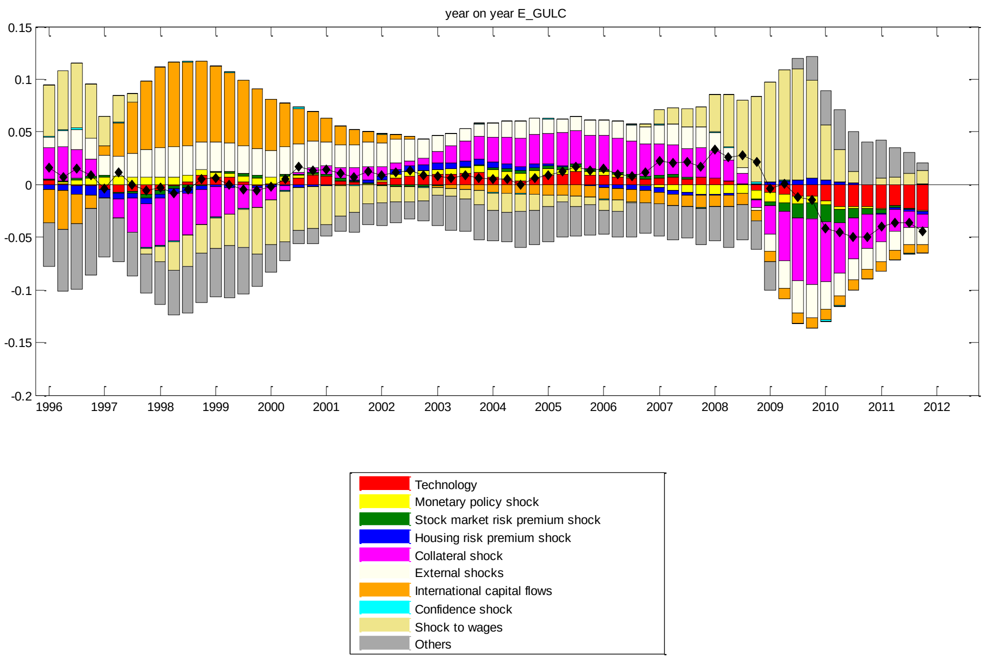
Figure 6.6: Shock decomposition real exchange rate



6.7 Unit labour costs

The shock decomposition of the y-o-y growth rate in unit labour costs shows over most of the sample no strong deviation of growth in unit labour costs from steady state levels, reaching a peak in 2008 and has fallen since (Figure 6.7). The capital flows shock boosted demand and inflation and contributed to growth in unit labour costs up to 2003, and the collateral shock played a similar role in following years. The shock to wages helped to offset these two factors, but turned into a positive contribution in 2007-9. In the last two years growth in unit labour costs has been kept down by negative contributions of the technology shock and the collateral shock (tighter lending conditions), the negative stock market risk premium shock, and the external demand shock (decline in world trade).

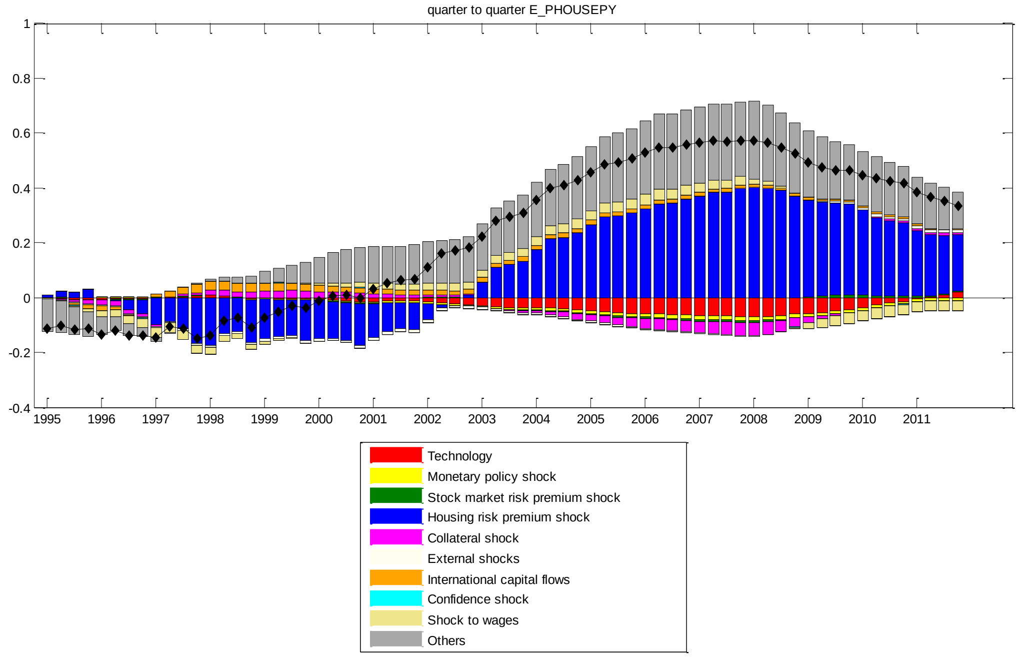
Figure 6.7: Shock decomposition growth ULC



6.8 House prices

The shock decomposition of real house prices (deflated by the GDP deflator) shows the sharp rise in house prices is mainly driven by non-fundamental factors in the model (housing risk premium shock). This house price bubble appears not to have completely burst yet and there is still a significant positive contribution of the risk premium shock on house prices at the end of 2011. In addition there was also a small positive contribution of the capital flows shock. Technological progress put some downward pressure on house prices but this effect has become smaller in recent years.

Figure 6.8 Shock decomposition house prices



6.9 Trade balance

We now turn to a shock decomposition of the external position. Figure 6.9.a shows the trade balance as share of GDP. The trade balance has been in persistent deficit since 1998, widening to more than 6% of GDP in 2007. The crisis forced an adjustment, and the trade balance was close to balance by 2011. 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 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 labour 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 led to the improvement in the trade balance in 2010-11.

Figure 6.9.b shows the extent to which each of these factors contributed to the accumulation of net foreign liabilities. All in all, up to ¾ of the build-up in foreign debt can be attributed to the capital flow shock in the model. Looser monetary policy added further to the build-up, and additional smaller contributing factors were the stock market and housing shocks, and the loosening of lending conditions.

Figure 6.9.a Shock decomposition trade balance-GDP ratio

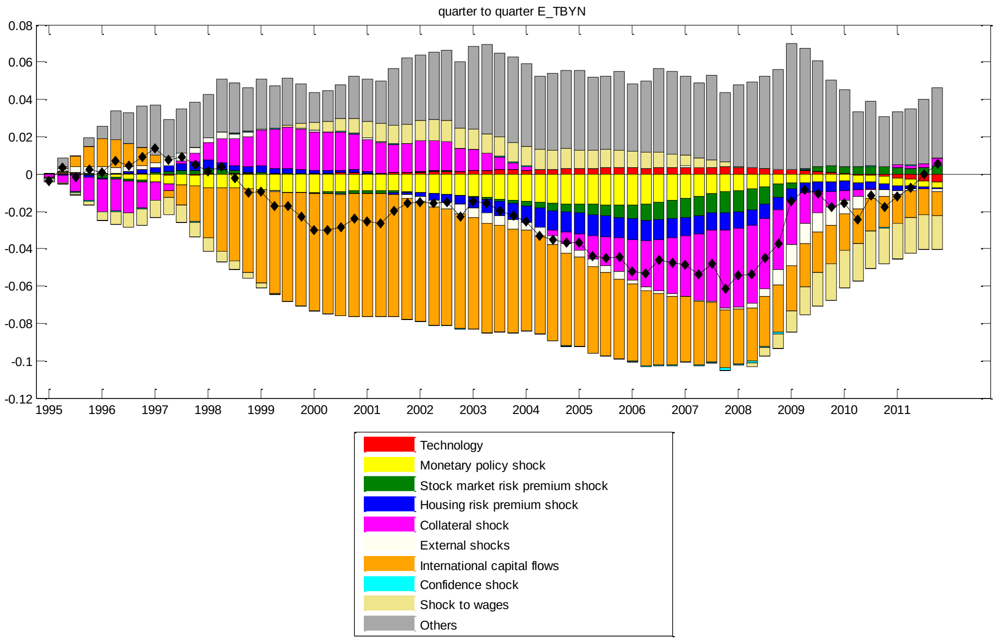
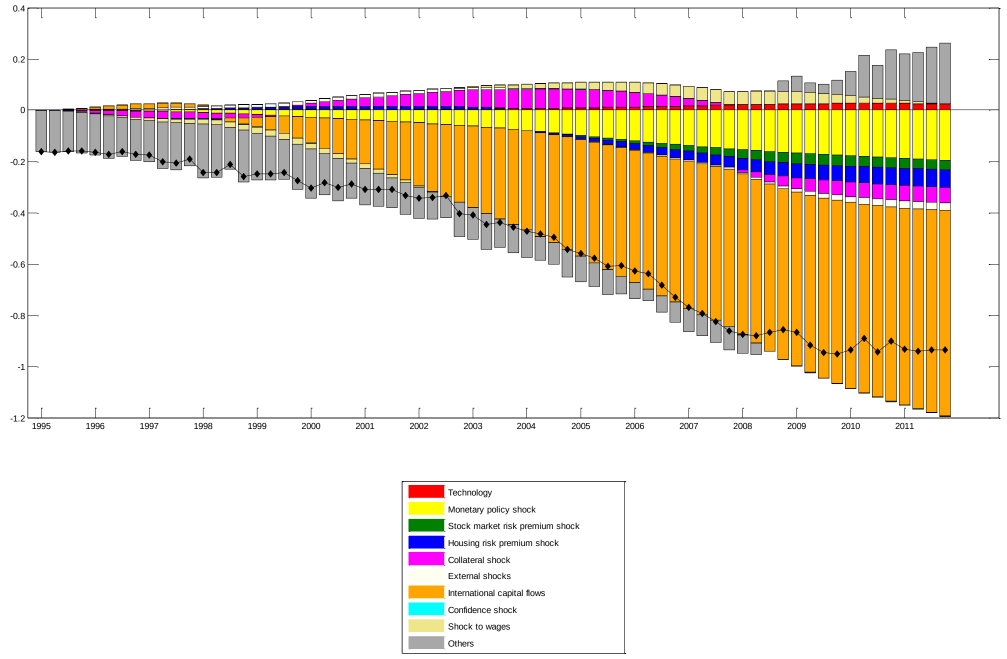


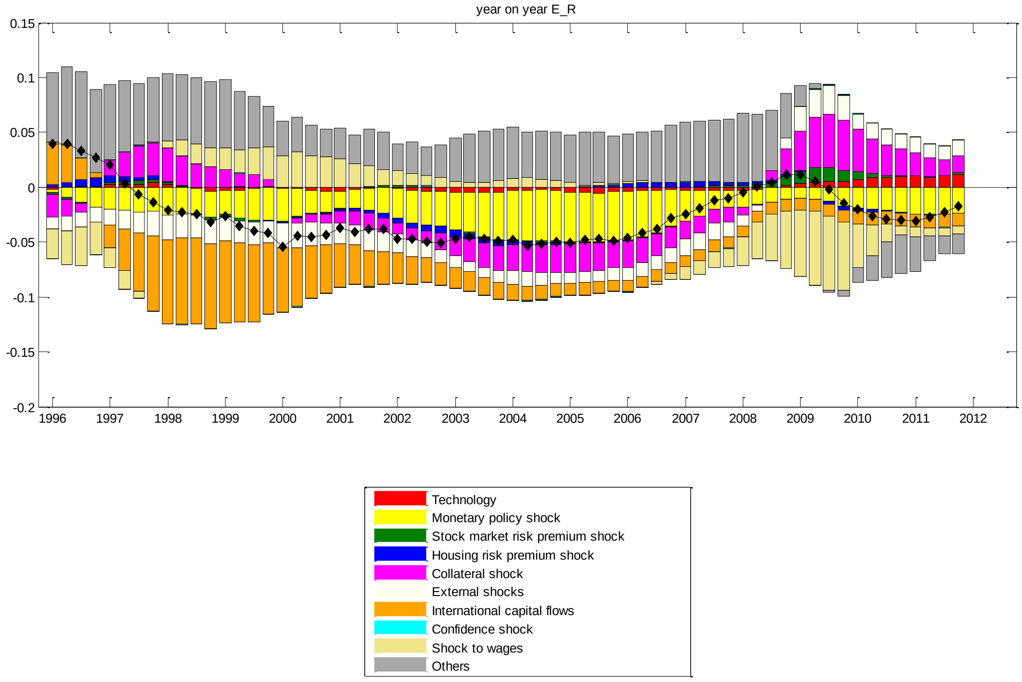
Figure 6.9.b Shock decomposition NFA position



6.10 Real interest rate

The shock decomposition of the real interest rate (Fig. 6.10) shows the dominant effect of the financial shocks (elimination of risk premium in EMU and relative monetary stance). Real interest rates were below their steady state level for most of the period since 1997, and were only briefly above it in 2008, when the ECB kept interest rates high while conditions in Spain deteriorated and Spain experienced a short period of deflation. Then, in late 2008, the ECB policy rate came down and the real interest rate declined again.

Figure 6.10 Shock decomposition real interest rate



7. Model-based rebalancing scenarios

We now move to an analysis of rebalancing scenarios based on the estimates of the model presented in previous sections. The model is used to produce projections for all the endogenous model variables from 2012-Q1 onwards. These scenarios, shown in Figure 7.1, illustrate the model-based adjustment to the fiscal and external imbalances that have built-up over the last decade. The speed at which growth rates and nominal demand shares return to steady state levels is determined by the persistence of the identified shocks.[16] Figure 7.1 also shows the 90% confidence bands based on the estimated magnitude of all the structural shocks in the model.

The net foreign liabilities position has risen from around 20 per cent of GDP in 1995 to 90 per cent of GDP by 2011. The model projections are based on an estimate for the debt-related risk premium *rprem* of 0.00041, which in itself does not lead to a long term adjustment in external debt. The level of foreign debt reached by the end of the sample period exceeds what is widely considered sustainable in the long run. The European Commission applies in its Alert Mechanism Report for the Macroeconomic Imbalances Procedure a threshold level for external debt of 35%, based on the lower quartile of observations over time and across countries, excluding the current crisis years. Catao and Milesi-Ferretti (2011) examine thresholds in accumulated net foreign liabilities beyond which the risk of a country being tipped into an external crisis becomes nontrivial. They find some evidence the tipping point threshold has risen from 40-50 percent of GDP to around 60 per cent in recent (2007-10) crises. Considering that there has been a widespread reassessment of risk in recent years, and a reduction in the risk tolerance of international investors due to the financial crisis, we include in the graphs an alternative scenario, based on a higher risk premium *rprem* of 0.003, implying a risk premium of 4.8 basispoints per 1 percentage point increase in liabilities (dashed lines in the figures).

[16] See appendix for details.

Such a sudden shock to the risk tolerance of international creditors would drive the net foreign liabilities towards a lower target of 35% of GDP in the long run. [17]

Even in the benchmark scenario with a low risk premium term, net foreign liabilities have to be stabilised eventually and this requires an improvement in trade balance to equilibrium in the long run, but with an overshoot in the medium run. This adjustment is sizeable and not without costs. Households and firms face ever higher interest rates due to the debt-dependent interest rate premium, and this depresses consumption and (corporate and residential) investment. Domestic demand remains at the subdued levels reached by the end of the sample period and does not recover to pre-crisis levels. This leads to a protracted period of deflation, with below trend inflation and below trend growth in unit labour costs. This profile implies an adjustment that is not particularly tax rich but mainly depended on export growth. For fiscal policy, the government consumption equation includes a response to deviations of debt-to-GDP ratios from the target of 60%. By the end of 2011, government debt was close to 70% of GDP and with persistent primary deficits there is a further accumulation of government debt which has to be corrected by a reduction in the government consumption share. The projected government deficit only gradually returns to its 2.5% steady state level, and government debt continues to grow to almost 100% of GDP by 2015 and only returns then gradually to its 60% target. In the high risk premium scenario, the government deficit increases to almost 13% of GDP as the recession reduces revenues and raises expenditures. Debt also rises to above 110% by 2014.

Looking at the model projections in more detail, labour augmenting and investment specific technological progress return to trend growth instantaneously, as implied by the assumed random walk model for TFP. The quarterly trend growth rate averages around 0.56% over the estimation period. In the projection quarterly GDP growth initially falls further, and then returns only gradually to this trend. The alternative scenario based on a higher risk premium shows a sharp decline in GDP growth to almost -4% in the first quarter of the projection and growth remaining far below trend throughout the following years. In order to generate the improvement in the trade balance required to reduce net foreign liabilities, the consumption share has to fall by a further 1 percentage points. The alternative scenario with a higher risk premium shows a collapse in the consumption share to 53% of GDP by 2014. The investment share has already fallen in the crisis years, and is projected to undershoot its steady state level further. In the high-risk-premium scenario it is projected to decrease by a further 1 percentage points for a protracted period of time. The residential investment share has plunged from its peak in 2007, fallen below its long run level by the end of the estimation period and is projected to remain below trend for the foreseeable future, while in the high-risk premium projection it drops by a further 1 percentage point. The employment share in total population has also collapsed below its steady state level and is projected to remain depressed in the medium term. Only by 2025 is the employment share back at its long run level. Note that employment does not return to the peak levels reached in 2007 as part of this was related to the bubble in house prices and construction boom. The high risk premium scenario shows a further decline in the employment rate by almost an additional percentage point.

With the projected fall in domestic demand, the model predicts a prolonged period of below trend inflation. There is a 4-5 year period of deflation, in particularly strong in the high risk premium scenario, and this while the nominal policy interest rate gradually moves back to its steady state level. For the recovery in exports it is required that unit labour costs decline over the near future, and growth of unit labour costs remains negative for a prolonged period of time. In the high risk premium case, unit labour costs have to fall steeper, by around 4%. The model estimates suggest an overvaluation of the real effective exchange rate of around 15%. The real exchange rate declines in the low risk premium projections by around 25% by the end of the decade, while in the high risk premium scenario the depreciation has to be significantly steeper, up to 35% by 2017.

Although fiscal balance is restored in these model-based projections through an adjustment in government consumption, this occurs only very gradually. The government consumption share in

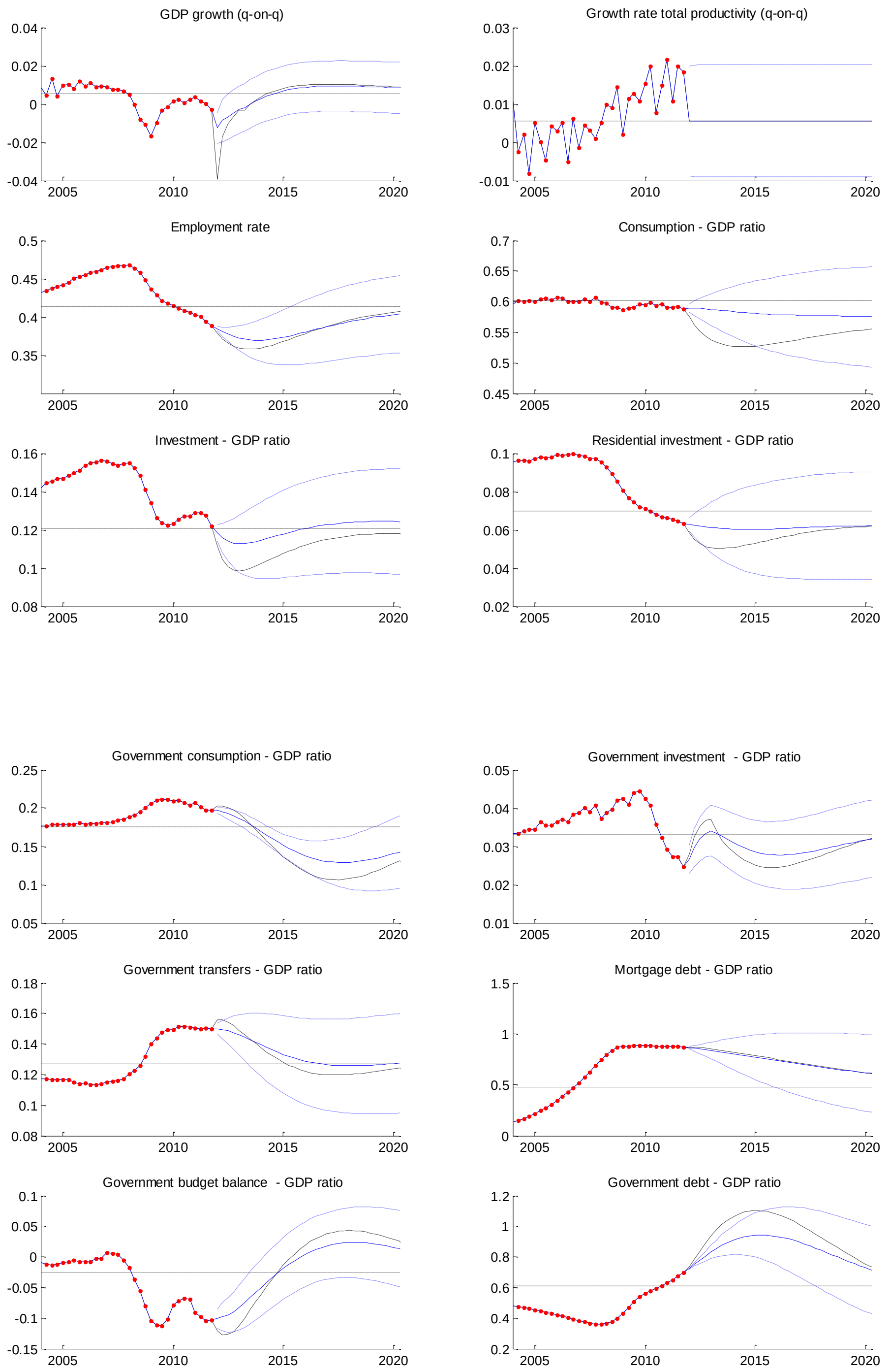
[17] The steady state net foreign asset position is tied down in the model by the difference between the foreign (EA) rate of time preference and the estimated rate of time preference of Spanish households, and the estimated riskpremium term *rprem* (eq. 11).

GDP has risen above its average over the estimation period and in the projections it falls back to its steady state level by the end of 2013, a decline of more than 2 pps., and has to undershoot in the second half of the decade in order to reduce the debt-to-GDP ratio. The government investment share had gradually risen up to 2009 but fallen below its long run steady state level by 2011, and rises in the projections back to this level with some light countercyclical behaviour. Transfers to households remain at much elevated levels as unemployment remains high over the projection. Transfers only very gradually return back to steady state levels. Mortgage debt of constrained households as share of GDP has hardly fallen since the bubble burst and the projections indicate a very gradual deleveraging, with households only slowly reducing their indebtedness. The estimated debt and deficit corrections are extremely protracted. Without any further consolidation measures in these projections, government deficits remain well above target till the end of the decade. These projections reflect the absence of sovereign risk spreads over much of the estimation period, and do not properly capture the sharp increase in sovereign spreads which has occurred in the last few quarters of our estimation period, raising concerns over long run debt sustainability and the introduction of fiscal consolidation measures. [18]

In the high risk premium scenario, with the strong projected decline in domestic demand, the trade balance improves dramatically, to a surplus of 10% of GDP by 2016. Note however that even this sharp improvement in the trade balance achieves only a gradual reduction in net foreign liabilities. By the end of the decade net foreign liabilities are still around 50% of GDP and it takes another decade before the threshold of 35% is reached.

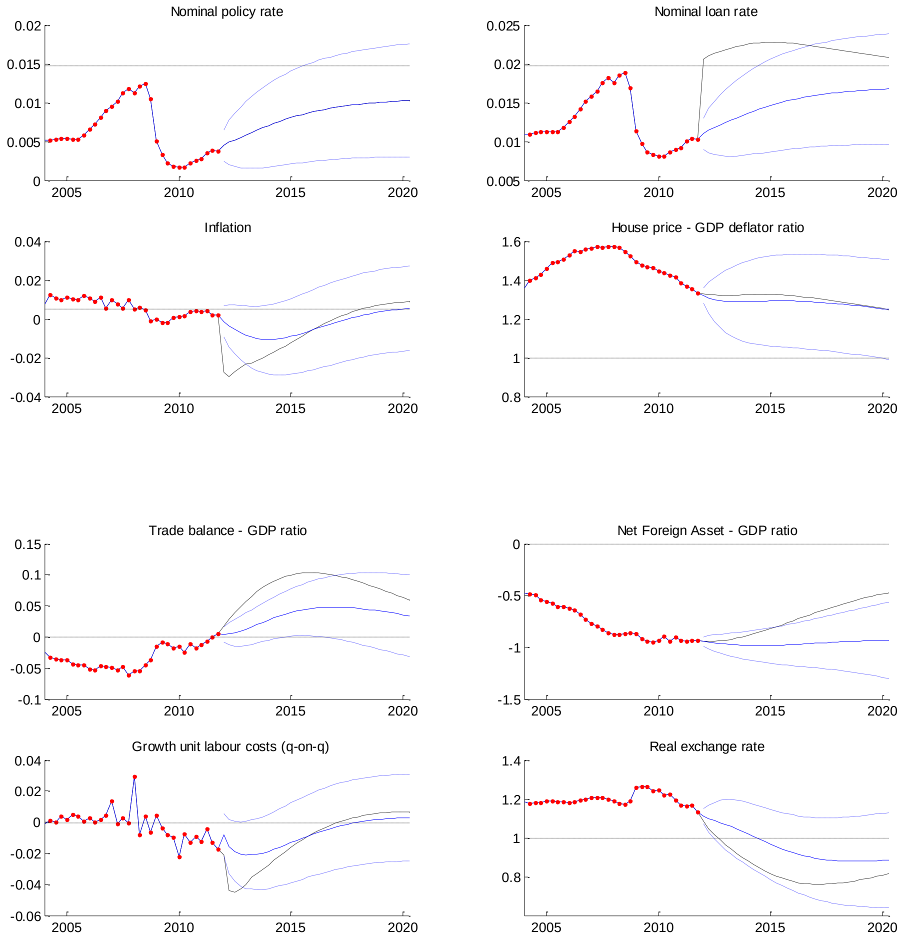
[18] In a companion paper we explore alternative scenarios including recent sovereign risk spreads and examine possible consolidation scenarios that achieve a faster convergence to medium term objectives.

Figure 7.1: Rebalancing scenarios: low vs. high risk premium scenario



Note: blue line = baseline scenario (with 90% confidence interval bands); black dashed line = higher risk premium scenario

Figure 7.1(cont'd)



Note: blue line = baseline scenario (with 90% confidence interval bands); black dashed line = higher risk premium scenario

8. Concluding remarks

In this paper we have shown how an estimated structural model can be used to analyse the driving factors behind internal and external imbalances that have built up over past years. The European Union's new Macroeconomic Imbalances Procedure identifies imbalances relative to specific thresholds. Depending on a more in-depth analysis to distinguish between benign and harmful macroeconomic developments, a Member State can then be placed into an Excessive Imbalance Position and corrective action can be demanded. While the Spanish economy has already gone through a sharp correction of its housing bubble induced boom, the build-up in its net foreign liabilities still far exceeds any measure of what is considered sustainable in the long run. Our estimates indicate the main source behind this build-up 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. We find no strong evidence of excessive wage growth as driver of external imbalances. However, the dual labour market structure in Spain may create a degree of wage rigidity that hinders any adjustment in wage growth required to improve competitiveness.

The model-based scenarios for the post-sample period show the rebalancing that is required to eliminate these imbalances. Although the crisis may have forced some adjustment, further corrections are needed. In particular, a scenario with a lower risk tolerance of international creditors, which would drive net foreign liabilities towards a target of 35% of GDP, as used as threshold in the EU's MIP, requires significant trade surpluses in the years to come. In the model projections this is achieved through sharp contractions in domestic demand and a prolonged period of below trend inflation. This alternative scenario illustrates the danger of a sudden reappraisal of risks in the financial markets for highly exposed countries like Spain. It also shows that adjustment is then more likely to rely on expenditure-reduction than on expenditure-switching, with a decline in domestic absorption, in particular in consumption. However, the accompanying deflation and decline in unit labour costs also bringing about a strong depreciation of the real effective exchange rate.

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 will lead to a protracted period of depressed demand, and a painful correction to past excess demand growth. This underlines the importance of avoiding the build-up of such imbalances in future. The Macroeconomic Imbalances Procedure (MIP) is intended to deal with this by stricter surveillance and introducing early warning mechanisms that can alert policy makers to the build-up of unsustainable imbalances in order to 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.[19] To the extent that non-fundamental shocks have played a role in the build-up 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 build-up 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.

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

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APPENDIX A

Data

In total 26 variables have been used in the estimation and their sample range is 1995Q1-2011Q4. 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 ECB. The nominal effective exchange rate, the world price index and the world output are based on own calculations.[20] They are trade-weighted averages across Spain's main trade partners: Argentina, Australia, Brazil, Canada, China, euro area, Hong Kong, India, Israel, Japan, Malaysia, Mexico, Norway, Russia, Singapore, South Korea, Switzerland, Taiwan, Turkey, UK and US, altogether 41 countries. General government consolidated gross debt, net government lending and the implicit interest rate faced by general government are from AMECO. 3 month money market rates for Spain and US are taken from Eurostat. The source for data on international investment position is Bank of Spain.

The model is estimated in growth rates and GDP shares. Specifically, the following 26 series are treated as observed (28 including the stocks government debt and IIP):
GDP growth,
GDP shares (11): consumption, government consumption, government investment, transfers, world demand, construction investment, total investment, government deficit and debt, net foreign asset, transfer account.
Prices (9): GDP, consumption, import, export, construction, house, government purchases, total investment, world.
Spain and Euro-Area nominal interest rate; government interest rate (3).
Exchange rate, wages, employment, and non-active population (4).

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

APPENDIX B Priors and estimated parameters

Table B.1 Results for posterior parameters

	Prior distribution	Prior mean	Prior s.d.	Posterior mean	Posterior s.d.	HPD inf	HPD sup
$\gamma_{ucap,2}$	Gamma	0.020	0.0080	0.027	0.0087	0.0122	0.0400
τ_1^{CG}	Beta	-0.100	0.0400	-0.030	0.0140	-0.0507	-0.0072
γ_H	Gamma	30.000	20.0000	57.071	20.6770	23.7451	89.9431
$\gamma_{J,H}$	Gamma	30.000	20.0000	70.868	23.8850	33.8445	107.5526
γ_K	Gamma	30.000	20.0000	29.554	10.9444	11.3859	46.1848
γ_I	Gamma	15.000	10.0000	25.681	14.0359	5.0967	45.2530
γ_L	Gamma	30.000	20.0000	23.255	5.6199	13.9935	32.1850
γ_P	Beta	4.000	2.0000	7.826	1.0470	6.2700	9.5084
$\gamma_{Pconstr}$	Gamma	30.000	20.0000	27.509	10.6820	10.0603	44.3217
γ_{Phouse}	Gamma	30.000	20.0000	2.944	1.7293	0.5261	5.5073
γ_{PM}	Gamma	30.000	20.0000	6.125	3.1668	1.2296	10.8023
γ_{PX}	Gamma	30.000	20.0000	9.087	4.2949	0.9092	15.0852
γ_W	Gamma	12.000	4.0000	17.736	3.6466	11.5112	23.3920
τ_{lag}^{CG}	Beta	0.500	0.2000	0.898	0.0212	0.8624	0.9315
h	Beta	0.700	0.1000	0.791	0.0541	0.7056	0.8756
τ_1^{IG}	Beta	-0.100	0.0400	-0.081	0.0296	-0.1301	-0.0327
τ_{lag}^{IG}	Beta	0.500	0.2000	0.328	0.1524	0.0837	0.5750
κ	Gamma	1.000	0.4000	0.859	0.3371	0.3301	1.3575
ρ^B	Beta	0.850	0.0750	0.848	0.0761	0.7346	0.9669
ρ^L	Beta	0.850	0.0750	0.952	0.0259	0.9138	0.9902
ρ^η	Beta	0.500	0.2000	0.928	0.0345	0.8759	0.9849
$\rho^{\eta,Constr}$	Beta	0.500	0.2000	0.798	0.0597	0.6958	0.8928
$\rho^{\eta,M}$	Beta	0.850	0.0750	0.743	0.0819	0.6145	0.8823
$\rho^{\eta,X}$	Beta	0.850	0.0750	0.897	0.0531	0.8084	0.9817
ρ^{CG}	Beta	0.500	0.2000	0.244	0.1329	0.0351	0.4360
ρ^{IG}	Beta	0.500	0.2000	0.572	0.1803	0.2899	0.8787
ρ^N	Beta	0.500	0.2000	0.871	0.0364	0.8120	0.9313
ρ^{PCPM}	Beta	0.500	0.2000	0.453	0.1655	0.1792	0.7217
ρ^{PWPX}	Beta	0.500	0.2000	0.313	0.0937	0.1577	0.4685
ρ^{er}	Beta	0.850	0.0750	0.263	0.0112	0.2447	0.2815
ρ^{rpk}	Beta	0.850	0.0750	0.922	0.0266	0.8797	0.9651
$\rho^{rph,c}$	Beta	0.850	0.0750	0.951	0.0151	0.9267	0.9736
ρ^{rpland}	Beta	0.850	0.0750	0.958	0.0155	0.9347	0.9842
ρ^{tax}	Beta	0.850	0.0750	0.863	0.0561	0.7750	0.9539
ρ^{tb}	Beta	0.500	0.2000	0.858	0.0388	0.7969	0.9236
τ_{lag}^{L}	Beta	0.500	0.2000	0.893	0.0251	0.8526	0.9336
sfp	Beta	0.700	0.1000	0.851	0.0686	0.7431	0.9618
$sfpconstr$	Beta	0.700	0.1000	0.909	0.0482	0.8377	0.9829
$sfphouse$	Beta	0.700	0.1000	0.731	0.0951	0.5744	0.8877
$sfpm$	Beta	0.700	0.1000	0.892	0.0556	0.8093	0.9813
$sfpx$	Beta	0.700	0.1000	0.892	0.0606	0.8056	0.9831
sfw	Beta	0.700	0.1000	0.772	0.0949	0.6136	0.9246
σ^H	Gamma	0.500	0.1000	0.559	0.1176	0.3698	0.7391
σ^X	Gamma	1.250	0.5000	1.741	0.2209	1.3800	2.1018
σ^M	Gamma	1.250	0.5000	0.658	0.1108	0.4774	0.8370
σ^L	Beta	0.500	0.2000	0.373	0.1421	0.1417	0.5980
s_L	Beta	0.300	0.1000	0.196	0.0535	0.1121	0.2769
s^s	Beta	0.500	0.1500	0.325	0.1019	0.1526	0.4864
τ^B	Beta	0.020	0.0100	0.028	0.0048	0.0203	0.0361
τ^{DEF}	Beta	0.020	0.0100	0.018	0.0080	0.0047	0.0300
$\tau^{B,IG}$	Beta	0.020	0.0100	0.020	0.0071	0.0087	0.0311
$\tau^{DEF,IG}$	Beta	0.020	0.0100	0.025	0.0107	0.0080	0.0426
$\tau^{DEF,TR}$	Beta	0.020	0.0100	0.019	0.0094	0.0042	0.0337
$rprem$	Beta	0.003	0.0010	0.00041	0.0001	0.00018	0.00062
$1/\beta^r - 1$	Beta	0.007	0.0010	0.009	0.0004	0.0085	0.0097
$rpremdebt$	Beta	0.003	0.0012	0.0030	0.0012	0.0011	0.0050
b^U	Beta	0.300	0.1000	0.284	0.0740	0.1626	0.4079
ρ^{TR}	Beta	0.850	0.0750	0.953	0.0193	0.9242	0.9841

Table B.2 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
ε^{B}	Gamma	0.010	0.0040	0.010	0.0043	0.0034	0.0166
ε^{UC}	Gamma	0.020	0.0080	0.039	0.0093	0.0237	0.0536
ε^{L}	Gamma	0.040	0.0160	0.075	0.0152	0.0498	0.0983
ε^{η}	Gamma	0.100	0.0400	0.017	0.0029	0.0118	0.0212
$\varepsilon^{\eta Constr}$	Gamma	0.100	0.0400	0.128	0.0418	0.0592	0.1933
$\varepsilon^{\eta, M}$	Gamma	0.100	0.0400	0.088	0.0312	0.0384	0.1350
$\varepsilon^{\eta, X}$	Gamma	0.100	0.0400	0.054	0.0195	0.0214	0.0873
ε^{TB}	Gamma	0.005	0.0020	0.005	0.0005	0.0043	0.0059
ε^{CG}	Gamma	0.005	0.0020	0.002	0.0002	0.0012	0.0020
ε^{IG}	Gamma	0.005	0.0020	0.003	0.0005	0.0017	0.0033
ε^{N}	Gamma	0.050	0.0200	0.126	0.0259	0.0844	0.1670
$\varepsilon^{M, EA}$	Gamma	0.003	0.0010	0.001	0.0001	0.0010	0.0014
ε^{PC}	Gamma	0.003	0.0010	0.003	0.0003	0.0025	0.0033
ε^{rpe}	Gamma	0.005	0.0020	0.000	0.0000	0.0003	0.0004
ε^{rpk}	Gamma	0.005	0.0020	0.009	0.0020	0.0056	0.0119
$\varepsilon^{rph, c}$	Gamma	0.010	0.0040	0.008	0.0025	0.0040	0.0113
ε^{rpland}	Gamma	0.010	0.0040	0.014	0.0042	0.0079	0.0214
ε^{T}	Gamma	0.010	0.0040	0.014	0.0022	0.0105	0.0175
ε^{TR}	Gamma	0.005	0.0020	0.003	0.0007	0.0018	0.0040
ε^{W}	Gamma	0.020	0.0080	0.034	0.0073	0.0224	0.0462
ε^{z}	Gamma	0.010	0.0040	0.008	0.0009	0.0062	0.0091

APPENDIX C Projection scenarios

The projection scenarios are obtained propagating the model transition matrix and decision rules from the last observed state onwards. Projection exercises can be done by setting all shocks to zero and letting the corresponding AR exogenous processes decay to steady-state following their estimated auto-correlation coefficients. This would however force projections to quickly converge to steady state growth and imply an overly optimistic recovery from the current recession. In order to keep projection at a more credible path, therefore, we imposed a smooth path for a selected number of shocks, which present very large innovations in the last observed quarters 2011q3 2011q4. These shocks are: the private investment and housing investment risk-premium shocks (bubbles), the price mark-up shock and the world demand shock. The last observed shock of private investment risk premium is projected with a persistency of 0.75; the last shock for housing risk-premium and mark-up are projected with a persistency of 0.9; the last shock for world demand is projected with a persistency of 0.5. The resulting patterns for the shock and the corresponding exogenous variables in the model are shown in Figures C.1-2.

Figure C.1: projected patterns for selected shocks: dotted lines denote the standard approach (zero shocks in projections), solid lines denote the shocks used in this study.

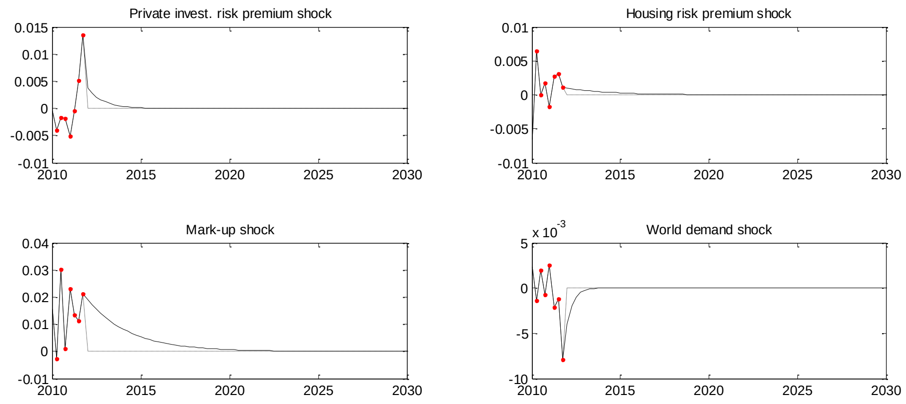
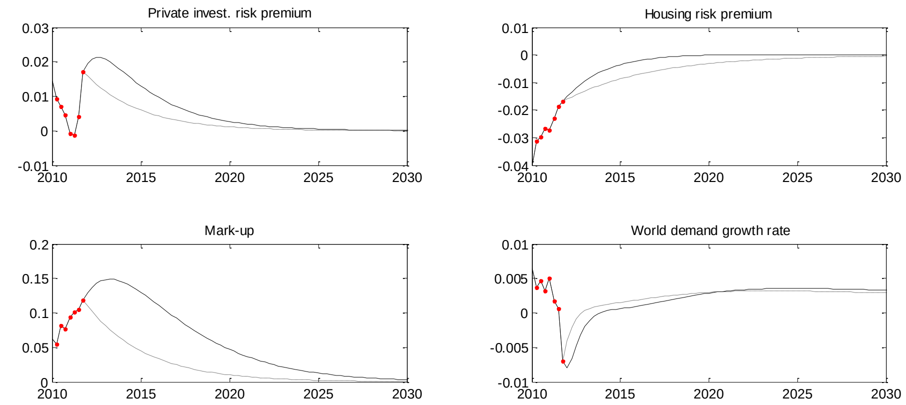


Figure C.2: projected patterns for selected exogenous processes: dotted lines denote the standard approach (zero shocks in projections), solid lines denote the projected path used in this study.



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