We study the joint dynamics of foreign capital flows and real activity during the recent boom-bust cycle of the Spanish economy, using a two-country New Keynesian DSGE model. We estimate the model using data for Spain and for an aggregate of the rest of the world (ROW). The model includes a construction sector and a government. We show that falling risk premia on Spanish housing, as well as a the fall in the interest rate spread between Spain and the ROW fuelled the sharp rise in Spanish housing investment before the financial crisis, and that these drivers increased the fragility of the balance sheets of Spanish households and firms. We find no strong evidence that excessive wage growth mattered for external imbalance during the boom. In the aftermath of the global financial crisis, falling house prices, a resurgence of the Spanish external interest spread, and a tightening of collateral constraints for Spanish households and firms, led to a sharp reduction in capital flows to Spain, and to a persistent fall in Spanish real activity. The correction of the Spanish trade deficit, since the crisis, relies mostly on a decline in domestic absorption triggered by tightened of financial constraints.

JEL code: C11, E21, E32, E62

Keywords: international capital flows, boom-bust cycle, sudden stop, rebalancing, housing market, financial frictions, Spain, European Monetary Union.
1. Introduction
After the creation of the Euro in 1999, Greece, Ireland, Portugal, Spain, and other countries in the EU periphery ran sizable current account deficits. This was often accompanied by output and construction booms in these countries, and by inflation rates above the Euro Area average. In the wake of the global financial crisis (2007-09), private capital flows to the periphery countries fell sharply, and a strong contraction in real activity and house prices ensued.

This paper provides a quantitative analysis of the joint dynamics of external capital flows and real activity in Spain, the largest of the Euro Area countries that received sizable capital inflows after the creation of the Euro, and then experienced a sudden stop. We do so using a two-country New Keynesian Dynamic Stochastic General Equilibrium (DSGE) model consisting of Spain and an aggregate of the rest of the world (ROW). We estimate this model using quarterly data, for Spain and the ROW during the period 1995Q1-2013Q2. The Spanish bloc of the model has a rich structure that allows us to capture the key features of the Spanish boom-bust cycle. In particular, we assume a construction sector and a government sector; Spanish households and non-financial firms face collateral constraints. The model assumes demand and supply shocks in goods, labor and asset markets, as well as nominal price and wage rigidities. We use the model as a laboratory for quantifying the key drivers and transmission mechanisms that explain the dynamics of the Spanish trade balance since 1995.

The creation of the Euro eliminated intra Euro Area currency risk and led to a convergence of Spanish interest rates to the lower interest rates in the rest of the Euro Area. Competing explanations for the boom in the Spanish economy are loosening credit conditions and housing and stock market bubbles. We find that all these factors fuelled a sharp rise in Spanish housing investment and house prices, and increased the fragility of the balance sheets of Spanish households and non-financial firms. Our estimates suggest that a large part of the build-up in Spanish net external debt after the introduction of the Euro can be attributed to positive shocks to foreign capital inflows. In the aftermath of the global financial crisis, a fall in house prices, a resurgence of the Spanish external interest rate spread, and a tightening of collateral constraints for households and firms, led to a sharp reduction in capital flows to Spain, and a persistent fall in Spanish output and housing investment. The fall in private

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capital inflows was at first partly counterbalanced by a rise in public capital inflows; however, public capital inflows too dried up when the Spanish sovereign debt crisis erupted, in 2010, following the dramatic deterioration of the Spanish government balance due to the recession.

Our analysis highlights the key role of the housing market for the transmission of external capital supply shocks to Spanish real activity. Real house prices doubled between 2001 and 2007, and then fell by about 40% (2008-12). This triggered a severe financial crisis, which led to a sharp contraction of lending to firms and households, and a rise in loan rates.

The economic events in Spain (and other European periphery countries) during the past 15 years are, in many respects, reminiscent of the boom-bust cycles accompanied by capital inflows and sudden stops experienced by many economies in Latin America and Asia during the 20th century; see Calvo et al. (2004) for an empirical overview. The literature on sudden stops uses highly stylized models; see, e.g., Calvo (1998), Mendoza (2010), Reis (2013) and Fornaro (2013). By contrast, the present paper analyzes a boom-bust cycle linked to international capital in- and outflows, using a fully-fledged estimated DSGE model.

Economic theory suggests that a country’s CA reflects domestic and foreign macroeconomic and financial shocks, and the structural features of the domestic and foreign economies. This underscores the importance of analyzing the CA using a quantitative dynamic general equilibrium model that captures the relevant shocks, and their transmission to the macroeconomy.

Several recent empirical studies have highlighted the role of housing and credit markets for the dynamics of the current account (e.g., Aizenman and Jinjarak (2013), Chinn et al. (2013), European Commission (2012)). The paper here analyzes that role using an estimated DSGE model. The present paper is also related to a literature that analyzes current account dynamics using DSGE models (e.g., Kollmann (1998), Erceg et al. (2006), Gomes, Jacquinot and Pisani (2012)); by contrast to the paper here, that literature has typically used calibrated models (not estimated), and it has abstracted from housing markets and the key financial frictions considered in the present model.

Section 2 describes the dynamics of the Spanish macroeconomy during the past two decades. Section 3 describes our model. Section 4 discusses model estimates. Section 5 discusses
dynamic responses to shocks in the estimated model, and Section 6 discusses historical shock decompositions. Section 7 concludes.

2. Dynamics of the Spanish macroeconomy
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% in the first quarter of 2009; Spain experienced a weaker recovery in 2010-11 than the rest of the Euro Area, and entered into a second-dip recession in 2012. During the boom years, all domestic demand components grew faster than GDP; this was especially the case for investment, and in particular residential investment (see Fig. 1.e). By contrast the Spanish consumption-to-GDP ratio rose much less; that ratio averaged about 60% before the crisis (about 4 pp. higher than the Euro Area average), but fell to 57.5% by 2013 (see Figure 1.b). The 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 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 had by 2012 only fallen back at their 2003 levels.

Prior to the launch of the Euro (1.1.1999), Spanish nominal interest rates had been markedly higher than interest rates in the rest of the Euro Area. The creation of the Euro led to a rapid convergence of Spanish nominal rates to Euro Area rates. That reduction in nominal interest rates led to a sharp reduction in Spanish real interest rates, as Spain experienced higher inflation than the rest of the Euro Area, until the financial crisis, due to a strong expansion of aggregate demand. In fact, Spanish real interest rates were even negative between 2001 and 2006. Real interest rates rose to positive values in the immediate aftermath of the financial crisis, but were back to values near zero in recent years. The boom in domestic demand was accompanied by a strong deterioration in the trade balance. After the second half of the 1990s the Spanish economy moved from small trade surpluses to a very large trade deficit of more than 7% of GDP by 2007, and to even larger current account deficits. The persistent trade deficits led to a strong rise in Spain’s net foreign debt (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 Spain’s net international investment position remains around -90% of GDP. Before the crisis, Spain’s public finances were in better health than the Euro Area average. Spanish government balances improved
markedly between the mid-1990s and the mid-2000s, a government budget surplus was even recorded between 2005 and 2007. Much of this fiscal improvement was not due 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 public deficits peaking at 11% of GDP in 2009, and have remained substantial since then. That deterioration in the fiscal position reversed the trend decline in gross debt, which had fallen to 36% of GDP in 2007; public debt increased rapidly to close to 90% of GDP by the end of 2012. The debt of the (non-financial) business sector has also risen sharply before the crisis. The outstanding stock of loans to non-financial corporations as % of GDP doubled between 2003 and 2009, from 45 to 90% of GDP, and then fell to 60% of GDP.

3. Model description [INCOMPLETE!]

We consider a two-country model consisting of Spain and the rest of the world (ROW). [In on-going work, we extend the setting to a three-country world consisting of Spain, the rest of the Euro Area, and the rest of the world.] Spain produces tradable goods which are imperfect substitutes to goods produced in the ROW. 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 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 technological relationships can be subject to autocorrelated shocks denoted by $U^k_t$, where $k$ stands for the type of shock. The logarithm of $U^k_t$ will generally be autocorrelated with autocorrelation coefficient $\rho^k$ and innovation $\epsilon^k_t$.  

3.1. Firms

3.1.1. Final goods producers

Firms 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.

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1 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 US data (in’t Veld et al., 2011) and on German data (Kollmann, Ratto, Roeger, in’t Veld and Vogel, 2013).

2 Lower cases denote logarithms, i.e. $z_i = \log(Z_i)$. Lower cases are also used for ratios and rates. In particular we define $\rho^j_t = P^j_t / P^v_t$ 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

$$Y_t^j = (UCAP_t^j K_t^j)^{1-a} L_t^{j\alpha} U_t^{j\gamma}, \quad \text{with} \quad L_t^j = \left[ \int_0^1 L_t^{j\alpha} \varrho \, d\varrho \right]^{\varrho/(\varrho-1)}.$$

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 utilization ($UCAP_t^j$). There is an economy wide technology shock $U_t^j$ following a random walk process plus drift.

We also consider financial shocks in the production process: all firms pay factors of production before production occurs. Firms face the following collateral requirement:

$$(2.a) \quad (1 + r_t)B_t^{NF,j} \leq \tau^{NF} (1 + r_{t-1})B_{t-1}^{NF,j} + (1 - \tau^{NF})\chi_t^{NF} p_t^K K_t^j,$$

where $B_t^{NF,j}$ is firm debt at the end of period $t$, while $r_t$ is the period $t$ real interest rate on loans. The loan-to-value ratio, $\chi_t^{NF}$, is subject to exogenous disturbances:

$$(2.b) \quad \chi_t^{NF} = \chi + u_t^{XNF}.$$

The period $t$ dividend of a final good producers is:

$$(2.c) \quad div_t^j = p_t^j Y_t^j + B_t^{NF,j} - (1 + r_{t-1})B_{t-1}^{NF,j} - w_t L_t^j - i_t^k p_t^j K_t^j - (adj^p(P_t^j) + adj^L(L_t^j) + adj^{UCAP}(UCAP_t^j) + adj^{div}(div_t^j)),$$

where $i_t^k$ denotes the rental rate of capital. Firms face technological and regulatory constraints which restrict their price setting, employment and capacity utilization decisions. Price setting rigidities can be the result of the internal organization of the firm or specific customer-firm relationships. Costs of adjusting labour have a 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 utilization of capital can result from higher maintenance costs associated with a more intensive use of a piece of capital equipment. Finally, we follow Jermann and Quadrini (2012) and assume that the firm’s payout is subject to a quadratic cost. The following convex functional forms are chosen
\[ \text{adj}^i (L_i^t) = w_i (L_i^t u_i^t + \frac{\gamma_i}{2} \Delta L_i^2) \]
\[ \text{adj}^p (P_i^t) = \frac{\gamma_p}{2} \left( \frac{P_i^t}{P_i^{t-1}} - 1 \right)^2 Y_i \]
\[ \text{adj}^{\text{ucap}} (ucap_i^t) = p_i^t K_i (\gamma_{ucap}^t (ucap_i^t - 1) + \frac{\gamma_{ucap}^2}{2} (ucap_i^t - 1)^2) \]
\[ \text{adj}^d (div_i^t) = \kappa (\text{div}_i^t - \overline{\text{div}})^2 \]

where \( \overline{\text{div}}^t \) is a dividend target. The firm determines labour input, capital services, the demand for loans, dividends and prices optimally in each period given the technological and administrative constraints as well as demand and financing conditions.

Denoting with \( V_i^t \) the market value of firm \( j \) at date \( t \), we have:
\[ V_i^t = \text{Max} \; \text{div}_i^t + E_t \rho_{t,t+1} V_i^{t+1} \text{ s.t. } (1), (2a) \text{ and } (2c), \]
where \( \rho_{t,t+1} \) is the intertemporal marginal rate of substitution of the Ricardian household (see below).

### 3.1.2. Residential construction

Monopolistically competitive firms \( h \) in the residential construction sector use new land (\( J_i^\text{Land} \)) sold by (Ricardian) households and final goods (\( J_i^\text{Constr} \)) to produce new houses using a CES technology
\[ J_i^H = \frac{1}{s_l^t J_i^\text{Land}^\sigma_l} \frac{1}{s_l^t J_i^\text{Constr}^\sigma_l} \left[ \frac{\sigma_l}{\sigma_l - 1} \right] \]

Subject to a quadratic adjustment cost constraint
\[ \text{adj}^m (P_i^H) = \frac{\gamma_m}{2} \left( \frac{P_i^H}{P_i^{H,t-1}} - 1 \right)^2 Y_i \]

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,

\[ J_{t} = J_{t}^{inp}U_{t}^{Pl} \]

where $U_{t}^{Pl}$ is a technology shock to the investment good production technology which itself follows a random walk.\(^4\)

\[ u_{t}^{Pl} = u_{t-1}^{Pl} + \varepsilon_{t}^{PP} \]

### 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 period utility function is:

\[ U(C_{t}^{h}, H_{t}^{h}, 1 - L_{t}^{h}) = \log \left\{ \frac{1}{\sigma^{u}} \left( C_{t}^{h} - hC_{t-1}^{h} \right)^{\frac{\sigma^{u} - 1}{\sigma^{u}}} + \frac{1}{\sigma^{v}} H_{t}^{h} L_{t}^{h-x} \right\} + \exp(u_{t}^{r}) \delta(1 - L_{t}^{h})^{x} \]

All two types of households supply differentiated labour services to unions which maximize 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 ($B_{t}^{F}r$, $B_{t}^{F}x$), 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 provide loans to non-financial firms ($B_{t}^{NF}$) and they hold a stock of deposits ($D_{t}$) with a financial intermediary who provides loans to credit constrained households and to non-financial firms. The household

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\(^4\)This shock is introduced to capture divergent trend in relative investment prices.
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 real return equal to $r$. 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 Ricardian household’s subjective discount factor is subject to random shocks. The household’s decision problem is to maximize live-time utility $V_t' = U(C_t', 1-L_t', H_t') + E_t \beta_{t+1} V_{t+1}'$ (where $\beta_{t+1}$ is the agent’s subjective discount factor between periods $t$ and $(t+1)$) subject to the following budget constraint and laws of motion of asset stocks:

$$
(1+t') p_t'C_t' + p_t'I_t' + p_t^H (1+t') I_t^{H,r} + (B_t^{G,r} + B_t^r + B_t^{NF} + D_t) + rer_t B_t^{F,r} =
(1+r_{t-1}) (B_{t-1}^{G,r} + B_{t-1}^r + B_{t-1}^{NF} + D_{t-1}) + (1+r_{t-1}) rer_t B_{t-1}^{F,r} - ((1-t^K)t^K + t^K \delta^K) p_t' K_t'
$$

$$
+(1-t^w) w_t I_t' - adj^r(W_t) + p_t^H J_{t, land} + \sum div_t' + Pr_t^H + Pr_t^B - T_t^{LS,r};
$$

$$
K_t' = J_t' (1-\delta^K) K_{t-1}';
$$

$$
H_t' = \frac{1}{1-\delta^H} H_{t-1}';
$$

$$
Land_t = (1+g_t^L) Land_{t-1} - J_{t, land}.
$$

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 non-fundamental shocks. Specifically, the Euler equations for residential and non-residential investment are disturbed by exogenous shocks $z^K_t$ and $z^H_t$, respectively, that can be interpreted as representing expectational biases regarding future investment returns:

$$1 = (1 - z^K_t) E_t \rho_{r,t+1} \{ Q^K_{r,t+1} (1 - \delta^K) + (1 - i^K_t) i^K_t + i^K \delta^K \} / Q^r_{t+1} ,$$

$$1 = (1 - z^H_t) E_t \rho_{r,t+1} \{ U^H_{r,t} + Q^H_{r,t+1} (1 - \delta^H) \} / Q^r_{t+1} .$$

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 $z'_t$ 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 $z'_t$ could also capture what Hall (2010) refers to as "principal agent frictions", which he models by introducing an exogenous wedge shock between safe (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 $(-B^F_t) / (p_t Y_t)$)

\begin{equation}
(13) \quad i^h_t = i_t + prem \left( \frac{(-B^F_t)}{p_t Y_t} \right)
\end{equation}

This specification corresponds to the debt-dependent interest rate premium widely assumed in open economy models (e.g., Senhadji (1994), Kollmann (2002), Schmitt-Grohé and Uribe (2003)). This specification induces a stationary equilibrium. However, we also regard the interest elasticity w.r.t. foreign debt as an important behavioral parameter describing the risk tolerance of foreign creditors. The parameter $rpm$ 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 ($\beta^{r,c}_{t+1} < \beta^{r}_t$) and they face a collateral constraint on
their borrowing. They borrow \( B_i^c \) exclusively from domestic Ricardian households. The life-
time utility of Ricardian households is given by
\[
V_i^c = U(C_i^c, 1 - L_i^c, H_i^c) + E_i^c \beta_{t+1} V_i^{c^e}.
\]
Ricardian households maximize life-time utility subject to the following constraints:
\[
(1 + t_i^r) p_i^c C_i^c + p_i^{Hr} (1 + r_{t-1}^H) I_{t-1}^{H,c} + B_i^c = (1 + r_{t-1}^r) B_i^c^* + (1 - t_i^W) w_i L_i^c - \text{adj}_t^W (W_r) - T_{tS,c};
\]
\[
H_i^c = J_i^{H,c} + (1 - \delta^{H}) H_{t-1}^c; \quad (1 + r_{t}^c) B_i^c \leq (1 + r_{t-1}^c) B_i^{c^*} + (1 - \tau^c) \chi_i^c p_{t}^{H^c} H_{t}^c.
\]
There is a non-fundamental shock to housing investment which is constrained to be equal
cross household types.

### 3.2.3 Wage setting

A trade union sets the (after-tax) real wage rate at a mark-up above the ratio of a weighted
average of the marginal utilities of leisure of the two household types to a weighted average
of their marginal utilities of consumption, multiplied by a time-varying wage mark-up factor,
that reflects wage adjustment costs

\[
adj_t^w (W_r) = \gamma_w \left( \frac{1}{W_r} \frac{1}{1 + \tau_{t-1}^r} (1 - \tau_{t-1}^r) \frac{W_r - 1}{W_r} \right) Y_i
\]

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, multiplied by a time-varying wage mark-up factor:

\[
\frac{s^e U_{1-L,i}^c + s^r U_{1-L,i}^{r^r}}{s^e U_{c,i}^e + s^r U_{c,i}^{r^r}} \eta_t^w = \frac{(1 - t_i^W) W_r}{(1 + t_i^r) P_{t}^e}
\]

where \( \eta_t^w \) is the wage mark-up factor (that factor fluctuates around the inverse of the elasticity
of substitution between different varieties of labour services).

### 3.3 Trade and the current account

In order to facilitate aggregation we assume that households, the government and the firm
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
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 mark-up over domestic prices. Thus export prices are given by

$$\eta^X_t P^X_t = P_t$$

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.

$$\eta^M_t P^M_t = E_t P^F_t$$

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.

$$B^F_t = (1 + i^F_t)B^F_{t-1} + P^X_t X_t - P^M_t M_t + \varepsilon^{bF}_t$$

### 3.4 Policy

Both government expenditure and receipts respond 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 to stabilize 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 government consumption and investment, normalized by trend productivity, $c_t^G$ and $i_t^G$:

$$c_t^G - \bar{c}^G = \tau^CG_c (c_{t-1}^G - \bar{c}^G) + \tau^CG_T (\sum_{j=1}^4 \Delta y_{t-j} - 4\bar{\Delta y})$$

$$-\tau^CGB \left( \frac{B_{t-1}}{Y_{t-1}^P} - b^T \right) - \tau^CGDEF \left( \frac{\Delta B_{t-1}}{Y_{t-1}^P} - def^T \right) + u_{i_t^G}$$
$$i_t^G - \bar{i}^G = \tau_{\text{Log}}^{BG}(i_t^G - \bar{i}^G) + \tau^{BG} \left( \sum_{t=1}^{4} \Delta y_{t-i} - 4\bar{\Delta y} \right)$$

(22) $$\tau^{\text{GB}} \left( \frac{B_{t-1}}{Y_{t-1} P_{t-1}} - b^T \right) - \tau^{\text{GDIF}} \left( \frac{\Delta B_{t-1}}{Y_{t-1} P_{t-1}} - \text{def}^T \right) + u_{t}^{BG}$$

Government consumption and government investment can temporarily deviate from their long run targets $c^G$ and $\bar{i}^G$ 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 $\text{def}^T$ 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 $(POP_{t}^{w} - POP_{t}^{\text{Npart}} - L_t)$, and other transfers $TR$ consists of transfers to pensioners $POP_{t}^{c}$ 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 $b^w$ and $b^r$ respectively.

$$tr_t = b^U w_t (POP_{t}^{w} - POP_{t}^{\text{Npart}} - L_t) + b^R w_t POP_t^P$$

(23) $$-\tau^{\text{RR}} \left( \frac{B_{t-1}}{Y_{t-1} P_{t-1}} - b^T \right) - \tau^{\text{RDIF}} \left( \frac{\Delta B_{t-1}}{Y_{t-1} P_{t-1}} - \text{def}^T \right) + u_{t}^{TR}$$

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

(24) $$R_t^G = (ssc_t + \tau_{w}^t)W_t L_t + t_t^C P_t^C C_t + t_t^H L_t + t_t^K [ (Y_t - W_t - L_t) - \delta K, P_t^I ]$$

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

(25a) $$t_t^w = \tau_{w}^t Y_t^{t-1}$$

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

(25b) $$t_t^w = \tau_{w}^t + \tau_{w}^t \frac{1}{\Delta y_i} \left( \sum_{i=0}^{4} \Delta y_{t-i} - 4\bar{\Delta y} \right)$$

Government debt $(B_t)$ evolves according to

(26) $$B_t = (1 + i_t^B)B_{t-1} + P_t^C C_t + P_t^C T_t^G + TR_t - R_t^G - T_t^{LS}.$$
mark-up made up of a sovereign risk premium, which is assumed to depend on the government debt-to-GDP ratio and an autoregressive term.

\[(26') \quad i_t^B = \rho^B i_{t-1}^B + (1 - \rho^B) \left[ i^B_t + mup^B + rprem^B (B_t / Y_t - \bar{B} / \bar{Y}) + \varepsilon_t^{rb} \right] \]

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

\[(27) \quad i_t = i_t^{EA} + u_t^{RPREM} \]

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

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 et al., 2009)

\[(28) \quad z_t^M = i_t^{EA} - \left[ r_{lag}^{EA} + (1 - r_{lag}^M) \left[ V^{E} + \pi_t^T + \tau_t^M (\pi_t - \pi^T) ight.ight.
\left.\left. + \tau_t^M (g_{yt} + g_{yt-1} + g_{yt-2} + g_{yt-3} - 4 \bar{gy}) / 4 \right] \right] \]

### 3.5 Market clearing for final goods and domestic credit

Market clearing conditions hold for final domestic goods and for and final imported goods requires:

\[(29) \quad Y_t = C_t^d + J_t^{imp,d} + J_t^{Constr} + C_t^{G,d} + I_t^{G,d} + X_t, \]

\[(30) \quad M_t = C_t^f + J_t^{imp,f} + C_t^{G,f} + I_t^{G,f}, \]

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 \(s^f\) and \(s^c\):

\[(31a) \quad C_t^i = s^f C_t^{i,d} + s^c C_t^{i,d}, \text{with } i = d, f \]

Similarly, total housing investment is defined as

\[(31b) \quad J_t^H = s^f J_t^{H,d} + s^c J_t^{H,c} \]

and equilibrium in the labour market requires

\[(31c) \quad L_t = s^f L_t^e + s^c L_t^c \text{ with } L_t^e = L_t^c. \]

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

\[(32) \quad B_t^e = s^f B_t^e. \]
4. Model estimation [INCOMPLETE!]

We calibrate selected parameters that pin down key steady state properties of the model, and estimate the remaining parameters using Bayesian methods. The estimation uses quarterly data for the period 1995Q1 to 2013Q2.\(^5\) Concerning the steady state calibration, parameters shown in Table 1 have been calibrated to match ratios of main economic aggregates (productive investment, construction investment and government consumption and investment) to GDP over the period 1995-1999.\(^6\) 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 1995Q1-2013Q2. The steady state employment rate as share of total population is set to 0.41, the wage share to 57%. 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 of sovereign debt is set at 5 years. Tax rates are calibrated on sample averages. Government transfers to households are set to 15% 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 et al., 2009). The constant in the mark-up of sovereign bond interest rates \(mup^B\) is set at 0.4% quarterly. Based on the whole sample, the quarterly GDP trend growth rate was set to 0.55%, while the inflation trend growth rate is set to 0.5%. Credit-constrained households are calibrated with a high rate of time preference, 4% per quarter, 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 estimated at 0.29.

The estimation results of the main structural parameters are summarised in Table 2.\(^7\) The population share of Ricardian households \(s^r\) is estimated at 0.59, implying the share of credit-

\(^5\) 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. Results presented here are based on posterior mode estimation. Full Metropolis runs are in progress. A detailed description of data sources and estimation is described in an appendix.

\(^6\) 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.

\(^7\) 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 supplementary appendix.
constrained households $s^c$ of 0.41. Concerning consumption, the intertemporal elasticity of substitution is set to one, habit persistence $h$ is estimated to be 0.75, and the substitution elasticity for housing services $\sigma_H$ is estimated at 0.7. The steady state discount factor for Spanish households $\beta'$ is estimated close to 0.992, reflecting a higher propensity to consume than for the rest of the euro area. The estimate for $r_{prem}$ implies an inelastic interest rate w.r.t external indebtedness (the external borrowing rate rises by 3 basis points for every 10 percentage points increase in net foreign liabilities normalized by domestic GDP). This low estimate or $r_{prem}$ reflects the persistent build-up in net foreign liabilities since the launch of the Euro was only accompanied by modest changes in the interest rates spread between Spain and the rest of the Euro Area. 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 ppt. increase in the debt ratio.

All model properties discussed in what follows are evaluated at posterior estimated of the model parameters. One period in the model represents one quarter in calendar time.

5. Impulse response functions

In this section, we discuss the dynamic effects of shocks which have played a prominent role for the boom and bust cycle of the Spanish economy. In particular we look at financial shocks and trade shocks.

*Shock to housing risk premium (house price bubble), Figure 2.a.*

A rise in the house price driven by a fall in the housing risk premium (positive housing bubble) increases residential investment. While the shock leads households to shift expenditure from consumption to residential investment, the shock boosts aggregate demand, which raises domestic inflation; initially, this reduces the domestic real interest rate (given the weak response of the nominal interest rate, due to monetary union), which also stimulates non-housing investment. The rise in domestic absorption raises domestic GDP and employment. The trade balance deteriorates persistently--this is also due to the loss of external competitiveness that results from higher domestic inflation. The rise in inflation also leads to a real appreciation (fall in the real exchange rate, in Figure 2.a).
Shock to household loan to value ratio, Figure 2.b.
A loosening of household financing conditions allows credit constrained households to increase both consumption and residential investment, but crowds out non-residential investment. Absorption increases, which leads to a trade balance deterioration.

External risk premium shock, Figure 2.c.
A permanent reduction of the external risk premium leads to a persistent increase of all domestic demand components. The expansionary effect is reinforced in the short run by the fall in the real interest rate caused by inflationary pressure. Because of a loss of price competitiveness and rising domestic demand the trade balance turns strongly negative. It is however, important to notice that, even though there is a permanent reduction of the risk premium, the effect on domestic demand is not permanent. This is best illustrated in the case of residential investment. The fall in the risk premium lowers mortgage rates, however because of a (land) constraint for the supply of houses this leads to an increase in house prices, which eventually dominates the capital cost effect and reverts the residential investment boom. Nevertheless the demand expansion remains important over the medium term and leaves the trade balance persistently negative.

Shock to firm loan-to-value ratio (final goods sector), Figure 2.d.
A tightening of firm financing conditions leads to a temporary reduction of productive investment, which is only marginally offset by a rise in private consumption and residential investment. This translates into an improvement in the trade balance (which is however small compared to the drop in productive investment).

Shock to risk premium on productive capital, Figure 2.e.
Effects are very similar to changes in firm financing conditions.

Shock to government consumption, Figure 2.f.
An increase in government consumption crowds out private demand components, most notably productive investment. However the net demand effect remains positive, which leads to an initial decline of the trade balance.
**Shock to export demand, Figure 2.g.**

Figure 2.g shows dynamic responses to a shift of preferences in favor of Spanish goods. That export demand shock leads to a persistent increase in domestic GDP. The resulting rise in domestic inflation leads to a decline in the Spanish real interest rate, and thus the rise in exports does not crowd out domestic demand. The shock only leads to a short run trade balance improvement, because of opposing income and competitiveness effects.

**Spanish export price mark-up shock, Figure 2.h.**

A negative shock to export prices has a negative short run effect on the trade balance (J curve effect) which is followed by a more persistent improvement with the trade balance.

### 6. Historical shock decompositions

The estimated shocks can be used to provide a historical decomposition of the data (e.g., Christiano et al, 2008). Figures 3.a. – 3.f. do this for Spanish domestic demand components (normalized by GDP) and the Spanish trade balance. To keep the analysis tractable we only focus on the main shocks highlighted, and group the contribution of all other shocks into a residual category referred to as "others".  

**Residential investment (Figure 3.a)**

Residential investment was the main driver of the Spanish boom and bust cycle. The shock decomposition shows that two main shocks explain the residential investment boom, namely negative shocks to the housing risk premium (positive housing bubble), and a fall in the Spanish external interest rate spread. The latter only generated a temporary increase in housing investment. This is because the increase in house prices (due to land constraint) stabilize residential investment. A prolonged boom in residential investment can only be generated by a housing bubble.

Interestingly, the shock estimates suggest a tightening of the loan-to-value ratio for household mortgages in the first half of the 2000s; however, the tightening was far from strong enough to compensate for the expansion of the collateral value generated by the bubble. We only

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8 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. Detailed shock decompositions of other variables incl. employment, unit labour costs, real exchange and interest rates are available in the supplementary appendix.
identify a loosening of the collateral constraint in the last years preceding the fall in residential investment.

Starting in 2008, the housing bubble bursts, and housing investment (as a share of GDP) declined strongly. The bursting of the bubble was accompanied by a tightening of loan-to-value ratios.

**Consumption (Figure 3.b)**
Contrary to residential investment, Spanish private consumption has remained relatively stable as a share of GDP. This should not be interpreted as if the factors driving the residential investment boom were unimportant for consumption. Rather, the stability of the consumption ratio (while residential investment rose sharply) is due to rising household debt. Interestingly, the historical decomposition shows that the housing bubble contributed negatively to private consumption—everything else equal, the housing bubble would have led to a fall in consumption (due to the strong rise in residential investment triggered by the shock). However, this effect was offset by the fact that the fall in the Spanish interest rate spread allowed Spanish households to borrow more from the rest of the world. Towards the end of the boom, a loosening of loan-to-value ratios stabilized the consumption/GDP ratio. However, after 2008 a collateral tightening sets in which eventually reduces both the consumption and the residential investment share.

**Non-housing investment (Figure 3.c)**
Productive (non-housing) investment increased as well from 1996 onwards. A major driver for this was the decline in the Spanish interest rate spread which lowered the borrowing capital costs for Spanish firms. As for household (mortgage) loans, the estimates suggest no loosening of the collateral constraint facing firms during most of the boom, even a slight tightening. It is only towards the end of the boom that the collateral constraint for firms is slightly loosened. In 2012 the collateral constraint tightened again. The investment boom was also fuelled by low risk premium for non-housing capital and by rising employment made possible by falling wage mark ups. According our results, the abrupt decline of investment during the financial crisis is associated with a rise in the investment risk premium, a collapse in external demand and insufficient downward wage adjustment (which amounted to a rise in the wage mark-up). Reduced lending only played a minor role. Unlike residential investment,
during the bust the productive investment/GDP ratio did not fall below the level reached in 1999.

*Trade balance (Figure 3.d)*

The factors driving consumption, residential investment and productive investment also shape the evolution of the trade balance (see Figure 3.d). The most important driver of the trade balance until 2008 was the declining interest rate spread (which increased all domestic private demand components). Quantitatively the housing bubble is less important for the trade balance because it only significantly raises residential investment, which is a relatively small demand component and even reduces private consumption (via the households’ budget constraint) and non-residential investment (via increasing interest rates). The collateral tightening for households and firms initially (early 2000s) had a positive influence on net exports because of its negative influence on all domestic private demand components. Another factor which improved the trade balance before 2008 was wage restraint.

While in the boom period from 1997 until 2008 net exports fell gradually, net exports rose rapidly in the first year of the financial crisis, followed first by a stabilization at a higher level, and then by a further noticeable increase from 2011 onwards. The initial rise was largely due to trade shocks, in particular declining import demand shocks. Household collateral tightening and a further reduction of the risk premium as well as fiscal consolidation were the main drivers which have turned around the Spanish trade balance after 2009. Our analysis suggests that the correction of the Spanish external imbalance was mostly due to deleveraging in the private sector and here largely the household sector as well as to public deleveraging.

There is a wide debate about the role of structural reforms for the rebalancing of the Spanish economy. In this respect, we can distinguish five possible measures of structural adjustment, namely an improvement of technology (from sectoral restructuring), labour market reforms, falling price mark ups, falling export price mark ups and increasing world market shares. Our analysis suggests that structural reforms will take time until they have significant effects. At least up to the end of our sample period, structural goods and labour market indicators are still dominated by negative after effects of the crisis. The most promising structural improvement seems to be a persistent rise in Spanish TFP growth. For example the European Commission estimates an acceleration of trend TFP growth since 2008 of around 0.2% p. a. However, standard labour market indicators such as NAWRU estimates show rising trends until the end
of our sample period. (Commission estimates an increase of the NAWRU from 15% (2009) to 21% in 2012). Recently, the Spanish central bank has reported price mark-up estimates which show an increase from 1.2 (in 2008) to 1.3 (in 2011) (see de Cos 2013). These findings are roughly consistent with our structural shocks. There is a slight positive effect of improved productivity growth on the trade balance, however labour market shocks exert a negative effect on the trade balance. We also identify rising mark-ups in the goods market. This has offsetting effects on the trade balance via income and competitiveness effects and the net impact on the trade balance is slightly positive. Also trade shocks themselves (e.g. falling mark ups for exports, or increase in exports) have only played a minor role over the recent period. This should, however, not be misinterpreted, since we only measure the impact of shocks to exports and export prices, i.e. increases in market share which cannot be explained by a fall in the terms of trade or a fall in export prices (fall in export price mark ups) which cannot be explained by a fall in unit labour cost.

7. Concluding remarks

This paper has shown how an open economy DSGE model with financial frictions and financial shocks can be used to analyses the driving factors behind internal and external imbalances in the Spanish economy. Our estimates suggest that the key factors behind those imbalances were low real interest rates, linked to the inflow of foreign capital, and a housing bubble. The persistence of the housing boom, which is the most noticeable macroeconomic event in Spain, can only be explained by a persistent fall in housing risk premia. Lending to households and firms has accommodated the growth in loan demand fuelled by the asset price boom. The adjustment in the trade balance after the financial crisis is mainly driven by the collapse in the housing bubbles, and a tightening of lending conditions. The correction of the trade balance relies mostly on a decline in domestic absorption and a drop in imports. The accompanying deflation and decline in unit labour costs bring about a further depreciation of the real effective exchange rate. We find no strong evidence of excessive wage growth as a driver of the Spanish external imbalance during the boom.

During the Great Recession, the fall in house prices and tightening credit conditions have led to a gradual improvement of the trade balance--tighter credit conditions for households and fiscal consolidations are closely aligned with the rise in next exports. Another factor contributing positively to the recent improvement in the trade balance is accelerated TFP
growth in Spain. Falling mark ups for exports, or increased export demand have only played a
minor role since the crisis.
References:
European Commission (2008), EMU@10: Successes and Challenges after 10 years of Economic and Monetary Union. European Economy 2008/2.
Table 1 Calibrated structural parameters

<table>
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<tr>
<th>Structural parameters</th>
<th>Calibrated value</th>
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Table 2  Estimation results for main structural parameters

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<th>Posterior mode</th>
<th>Posterior s.d.</th>
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Figure 1 Spain: 1995Q1-2013Q2

Figure 1.a Annual GDP growth

Figure 1.b Consumption/GDP share

Figure 1.c Gross fixed capital formation and construction investment shares in GDP

Figure 1.d House prices rel. to GDP deflator

Figure 1.e Nominal interest rates Spain and euro area

Figure 1.f Real interest rate

Figure 1.g Trade, current account and government balance (% GDP)

Figure 1.h Government debt and international investment position (% GDP)
Figure 2. Impulse responses
Figure 2.a. Negative shock to housing risk premium

Figure 2.b. Positive shock to household loan-to-value ratio
Figure 2.c. Negative shock to external risk premium (domestic interest rate spread)

Figure 2.d. Shock to firm loan-to-value ratio
Figure 2.e. Positive shock to risk premium on productive capital

Figure 2.f. Positive shock to government consumption
Figure 2.g. Positive shock to Spanish export demand (preference shock for Spanish goods)

Figure 2.h. Positive shock to export mark-up:
Figure 3.a: Shock decomposition residential investment to GDP ratio

Figure 3.b: Shock decomposition consumption to GDP ratio
Figure 3.c: Shock decomposition productive investment to GDP ratio

Figure 3.d: Shock decomposition trade balance-GDP ratio
Figure 3.e Shock decomposition NFA position (4 shocks)

Figure 3.f Shock decomposition GDP growth
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. 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 27 series are treated as observed (29 including the stocks government debt and IIP):

- GDP growth,
- GDP shares (12): consumption, government consumption, government investment, transfers, imports, exports, world demand, construction investment, total investment, government deficit and debt, net foreign asset.
- 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).

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## APPENDIX B  Priors and estimated parameters

Table B.1 Results for posterior parameters

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<td>2</td>
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<td>0.1</td>
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</tr>
<tr>
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<td>( \rho^L )</td>
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<tr>
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<td>0.012472</td>
</tr>
<tr>
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<tr>
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</tr>
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<td>Prior s.d.</td>
<td>Posterior mean</td>
<td>Posterior s.d.</td>
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<td>0.0100</td>
<td>0.0172</td>
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<td>0.3654</td>
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Table B.2 Results from posterior parameters (standard deviation of structural shocks)