

Mayer, Eric; Maas, Daniel; R uth, Sebastian

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# Current Account Dynamics and the Housing Cycle in Spain

Daniel Maas, Eric Mayer, and Sebastian R uth\*

## Abstract

We investigate the negative correlation between housing markets and the current account in Spain. By employing robust sign restrictions, which we derive from a DSGE model for a currency union, we analyze the effects of Spanish pull and Eurozone push factors in a mixed frequency VAR framework. Savings glut, risk premium, and housing bubble shocks are capable of generating the negative co-movement of housing markets and the current account in the data. In contrast, and counterfactual to the housing boom, financial easing shocks in Spain predict a decline in, both, residential investment and house prices. Among the four identified shocks, savings glut shocks have most explanatory power for real house prices, whereas risk premium shocks account for most of the variation in residential investment. Financial easing shocks explain fluctuations to a similar extent as savings glut and risk premium shocks, while housing bubble shocks explain slightly less variance in the data.

**Keywords:** Current account, housing markets, monetary union.

**JEL codes:** E32, F32, F45.

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\*University of W rzburg, Department of Economics, Sanderring 2, 97070 W rzburg, Germany  
**Corresponding author:** Sebastian R uth, sebastian.rueth1@uni-wuerzburg.de, +49 931 31 86398.

# 1 Introduction

What are common drivers of the well-established, negative correlation between housing markets and the current account in Spain? Spain witnessed a pronounced boom and bust cycle in housing<sup>1</sup>, which coincided with a deterioration and subsequent contraction of its current account (see Figure 1). From 1995 to 2008 real square meter property prices tripled on average, and during the culmination of the boom one fourth of the Spanish male labor force was employed in the construction sector that temporarily accounted for 20 percent of GDP growth. At the peak of the boom, the current account to GDP ratio recorded minus 10 percent, followed by a sharp correction after the bust.

This paper tests four popular hypotheses along their ability to generate the joint behavior of housing markets and the current account that is present in Spanish data. In this regard, we account for Spain-specific as well as for external shocks emerging in the rest of the Eurozone. The comparison of such “pull” (domestic) and “push” (foreign) factors, at least, dates back to Calvo et al. (1993) and is still subject to research on the sources of capital flows (Fratzscher, 2012).

The pull hypothesis emphasizes the importance of domestic factors as potential drivers of the housing boom in Spain. By initiating a domestic boom these factors, ultimately, attract capital inflows from the rest of the Eurozone. Prime candidates for this hypothesis are a relaxation of credit standards that foster credit supply by the banking industry (see, e.g., Helbling et al., 2011; Bassett et al., 2014) as well as housing bubble shocks that fuel markets against the backdrop in belief of ever surging house prices (see, e.g., Shiller, 2005, 2007; In’t Veld et al., 2011).

In contrast, the push hypothesis explains housing markets by external factors that proactively allocate capital to Spain. One representative is the risk premium shock (see In’t Veld et al., 2014). The creation of the common Euro denominated market eliminated risk premia among the member countries, which led core Eurozone investors to invest in Spain and further lowered risk free rates. Vice versa, the economic turmoil in 2008 reintroduced risk spreads and reverted capital flows. A further push representative is a European version of the “savings glut” shock originally proposed by Bernanke (2005) for the US. The rationale of this shock is that Spain as member of a monetary union was overheated by too low interest rates compared to a Taylor rate. As a consequence, and in line with consumption dynamics, core Europe had systematically higher saving rates than Spain and lower economic momentum during the run-up phase. Consequently, excess savings from the core broke its way through to Spanish housing markets.

We empirically analyze how the competing shocks impact the current account and housing market variables. We study how the shocks propagate through the economy and, furthermore, we judge their quantitative relevance. We do so by applying a robust sign restrictions approach as in Peersman and Straub (2009) to Spanish and rest of Euro Area data. We derive restrictions from a single currency union

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<sup>1</sup>Fernández-Villaverde et al. (2013), Gonzalez and Ortega (2013), and Akin et al. (2014) provide an overview of the Spanish cycle in housing markets. In general, housing is of particular importance in Spain as the rate of home ownership and the share of private wealth allocated to housing both exceed 80 percent, which is considerably beyond European average.

DSGE model incorporating two countries, i.e., Spain and the rest of the Euro Area. The model builds on Rabanal (2009) and Iacoviello and Neri (2010) and features a variety of nominal and real frictions. Following Kiyotaki and Moore (1997), households consist of two subgroups according to their time preferences, i.e., savers and borrowers (see Monacelli, 2009). As in Iacoviello (2005), borrowers face a collateral constraint such that their borrowing is limited to the present value of their housing multiplied by a loan-to-value (LTV) ratio. In the empirical analysis, we employ an open-economy vector auto-regressive (VAR) model, which allows a discrimination of push and pull forces. Due to the short sample size, we follow Eraker et al. (2014) and draw on a Bayesian mixed frequency approach for estimation and inference. The identification of structural shocks is along the lines of Uhlig (2005). Concretely, we identify a savings glut, a risk premium, a financial easing, and a housing bubble shock. Except for the financial easing shock, all identified disturbances are capable of generating the observed, negative correlation of the current account and housing markets. In contrast to the competing macroeconomic disturbances, the financial easing shock predicts no robust, significant drop in the current account and, most notably, a decline in residential investment and house prices. Moreover, the savings glut shock has most explanatory power for real house prices, while the risk premium shock, in particular, has explanatory power for residential investment. Overall, the housing bubble shock accounts for a slightly smaller share of variation in the data, while the financial easing shock explains the key variables to a similar extent as both push disturbances.

Our contribution to the current literature is along the following dimensions. First, for the US there is a number of theoretical and empirical studies analyzing the joint dynamics of the current account and housing markets (see, e.g., Sá and Wieladek, 2015; Justiniano et al., 2014). However, *prima facie*, it is not evident, which conclusions drawn from US data can be applied to Spain.<sup>2</sup> Most importantly, Spain is member of a currency union and net capital inflows did not come from Asia and oil exporting countries, but largely from the rest of the Euro Area. Thus the study of Spain, in particular, helps to understand the specifics of the nexus between housing markets and the current account inside a monetary union, where shocks propagate differently due to the common conduct of monetary policy. Despite different currency regimes, we reinforce the results of Sá and Wieladek (2015) for the US by also revealing the importance of savings glut shocks for Spain. Second, In't Veld et al. (2014) estimate a rich DSGE model by Bayesian techniques with Spanish data. They find a strong influence of falling risk premia, a loosening of collateral constraints, and asset price shocks on the Spanish output boom and capital inflows. We complement their analysis with a time series approach, which imposes less structure on the data. Furthermore, we focus on the housing boom rather than the Spanish output cycle. We find little support for financial easing shocks in explaining the negative correlation of housing markets and the current account,

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<sup>2</sup>For instance, Spain has a bank-based financial system operating under the tight Basel regulatory framework, where new constructions were only moderately fueled by sub-prime residential mortgage-backed securities. In contrast, the US is known to be a predominantly market-based financial system, where sub-prime markets were loosely regulated, which was center stage at the crisis (see, e.g., Goddard et al., 2007).

which is in line with In't Veld et al. (2014). Third, due to limited data availability, contributions like Hristov et al. (2012) or Ciccarelli et al. (2015) rely on panel data approaches to achieve efficiency gains. Likewise, single country VAR approaches often resort to data samples that extend the relevant time period for the same reason. To tackle this issue, we simultaneously employ monthly and quarterly data for Spain in the Bayesian mixed frequency framework as in Eraker et al. (2014).

The paper is structured as follows. In Section 2, we explain the different hypotheses that we empirically test in detail. Section 3 discusses the model employed to derive the sign restrictions. Section 4 describes the econometric framework and presents the results. Section 5 provides some extensions and robustness, while Section 6 concludes.

## 2 Four hypotheses

To motivate the analysis, we further discuss four different sources that potentially link the housing and current account<sup>3</sup> cycles in Spain.

We begin the exposition with pull factors of capital flows. In Spain's bank-based financial system the majority of mortgages was supplied by the banking industry. Formally, under the Basel regulatory framework, banks faced stricter equity requirements, once LTV ratios exceeded 80 percent of the collateral value. In practice, banks placed 40 percent of all mortgage loans exactly on the limit of 80 percent. Furthermore, appraisal firms systematically overstated property values (Akin et al., 2014), thereby effectively raising LTV ratios in terms of market values and softening lending standards before the crisis (see Figure 2). As the fraction of collateral constrained households is sizeable in Spain (Hristov et al., 2014), the effective loosening of collateral requirements is of first order macroeconomic importance. Beyond, and induced by, inter alia, tough competition in the banking sector, Spanish mortgage rates were 21 percent below European average. The expansion in the effective loan supply of Spanish banks, of course, could also have been driven by changes in the conduct of local banking supervision or the regulatory environment as well as through shifts in industry strategies (e.g., Bassett et al., 2014). As mortgage growth was not backed by domestic wholesale funding, it triggered capital inflows, predominantly, from core Eurozone countries. In summary, we refer to these developments as financial easing shocks.

A second prominent pull hypothesis are housing bubble shocks (see, e.g., In't Veld et al., 2011). Following Shiller (2005, 2007), a housing bubble is best described by a social pandemic, which is fueled by the belief of ever increasing house prices thereby raising the willingness to pay higher prices. According to Laibson and Mollerstrom (2010), Adam et al. (2012), and In't Veld et al. (2014), housing bubble shocks,

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<sup>3</sup>As argued in Shin (2012) and Acharya and Schnabl (2010), gross financial flows are more crucial for overall financing conditions than net capital flows as reflected by the current account. Yet, Obstfeld (2012) emphasizes the importance of the current account for the scrutiny of policy makers (see Fratzscher et al., 2010). Catão and Milesi-Ferretti (2014) point out the current account as a predictor of external crises. Furthermore, Giavazzi and Spaventa (2011) stress the relevance of the current account, in particular, for the case of a monetary union.

moreover, cause current account deficits and thus capital inflows.<sup>4</sup> Empirically, asset prices are a main driver of the US current account, which is in line with the housing bubble hypothesis (Fratzscher et al., 2010). The rationale of the housing bubble shock is that housing demand is stimulated by the belief of rising house prices. As housing serves as collateral, higher house prices also lead to stronger demand for non-durable goods. Accordingly, the domestic demand expansion induces imports causing current account deficits. Besides, housing bubble shocks can explain the coincidence of increasing house prices and strong residential investment, whereas financial easing shocks need not necessarily account for this feature (Justiniano et al., 2014). The dynamics of residential investment are an important facet of the Spanish housing boom, as the ratio of residential investment to GDP almost doubled from 1995 to 2006. As increasing house prices loosen collateral constraints, the overall transmission of housing bubble shocks to the broader economy, however, is similar to financial easing shocks.

Now, we discuss the competing push hypothesis. The push view, for instance, underlies the so-called risk premium shock (In't Veld et al., 2014). Beginning with the Madrid Summit in 1995, Spanish risk free rates started to converge to the level of German bond rates (see Figure 3). According to the risk premium narrative, the introduction of the common European currency, as a whole, created an institutional environment that encouraged portfolio investors and banks to expand portfolio investment and lending to the periphery as, e.g., Spanish assets were paying higher yields. First and foremost, the creation of the Euro eliminated currency risks and might even have made investors believe in possible bail outs, decreasing the perception of political risks. Besides, as pointed out in Hale and Obstfeld (2014), the ECB's refinancing policy did not discriminate between Spanish and, e.g., German sovereign bonds, despite their different credit ratings. The same applies to capital requirements that attached zero risk weights to all Euro Area government debt obligations. The introduction of an efficient payment settlement system (TARGET), in addition, eliminated transaction cost. With the financial crisis hitting in 2008, risk spreads re-emerged, the current account reverted, and housing markets collapsed.

Another push factor conveys a European variant of the "savings glut" (Bernanke, 2005; Mendoza et al., 2009) shock operative for Spain. Clearly, the savings glut hypothesis cannot be literally applied to Spain. The idea of "uphill" flowing money, in particular, from China to the US, due to an underdeveloped Chinese financial system with a limited amount of financial instruments, is US specific. Instead, we argue for the case of Spain as follows. In the course of the housing boom, Spanish GDP and HCPI growth rates were roughly one percentage point higher than in the rest of the Euro Area. Thus monetary conditions, measured against a Taylor rate, were excessively expansionary for Spain and provide another rationale for the current account deficits as low real interest rates, on the one hand, discouraged saving and, on the other hand, fostered investment in housing.<sup>5</sup> Figure 4 depicts net saving rates for Spain and the Euro Area from 1999 to 2013. Since 2003, Spanish net

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<sup>4</sup>Beyond, Cheng et al. (2014) and Ling et al. (2014) stress the importance of housing bubble shocks for a housing boom.

<sup>5</sup>See also Adam et al. (2012) for the interaction of real interest rate dynamics and beliefs in fueling house price booms.

saving rates dropped from 7 to 0 percent, before sharply reverting at the onset of the Great Recession, while the Euro Area counterpart series fluctuated modestly around 8 percent. This setting is reminiscent of a savings glut idea as savings from the core Eurozone were seeking profitable investment opportunities in the periphery. Slack in core economies depressed Spanish exports, while the booming Spanish economy attracted imports and triggered current account deficits.

### 3 DSGE model sign restrictions

In this section, we develop a New Keynesian DSGE model building on Rabanal (2009), Iacoviello and Neri (2010), and Aspachs-Bracons and Rabanal (2011).<sup>6</sup> We use the predictions of the model to derive robust sign restrictions of impulse response functions, which we employ for identification in the empirical analysis.

#### 3.1 Model

The model features two economies in a closed monetary union, i.e., a domestic (Spain of size  $n$ ) and a foreign country (rest of Eurozone of size  $1 - n$ ). In both economies, households are composed of two types, i.e., borrowers and savers, where the latter have the higher discount factor as in Kiyotaki and Moore (1997). Firms consist of monopolistically competitive intermediate goods producers as well as perfectly competitive final goods bundlers, and are partitioned into two sectors. By employing capital and labor services, firms in the first sector produce non-durable consumption and investment goods, which are traded across countries. Firms in the second sector produce housing by employing land in addition to the input factors capital and labor, with savers owning the stocks of capital and land. Households maximize lifetime utility subject to a budget constraint, where utility concavely increases in consumption of non-durables and housing, and convexly decreases in labor. Optimizing borrowers and savers allocate resources among each other, which results in equilibrium debt. As in Iacoviello (2005), debtors borrow against housing. The expected present value of housing multiplied by a LTV ratio, as a consequence, determines borrowers' collateral constraints and thus their leverage (see also Kiyotaki and Moore, 1997). Following Smets and Wouters (2003) and Christiano et al. (2005), the model considers several real and nominal frictions.

We derive sign restrictions from the DSGE model, exclusively, for shocks that are necessary for identification in the empirical analysis and which ensure orthogonality to other macroeconomic disturbances. We restrict the presentation to the optimization problems of home country households and firms as there exists symmetry across the home country and the rest of the single currency area.

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<sup>6</sup>Mayer and Gareis (2013) estimate a model similar to ours with Bayesian techniques to study the housing boom and bust cycle in Ireland.

### 3.1.1 Borrowers' program

We denote the continuum of borrowing households (see Monacelli, 2009) with  $b \in [0, \omega]$ .  $b$  represents a borrower, the share of borrowers in the economy is  $\omega < 1$ , and

$$\mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \zeta_{\beta,t} \tilde{\beta}^t \left( \alpha \log(\tilde{C}_t(b) - h\tilde{C}_{t-1}) + (1 - \alpha) \log(\tilde{D}_t(b)) - \frac{\tilde{L}_t(b)^{1+\eta}}{1 + \eta} \right) \right\} \quad (1)$$

is the intertemporal utility function.  $\tilde{\beta}$  is the discount factor of borrowers (indicated with  $\sim$ ), where borrowers are less patient than savers, i.e.,  $\tilde{\beta} < \beta$ .  $\zeta_{\beta,t}$  is an exogenous shock disturbing the discount factor and logarithmically follows  $\log(\zeta_{\beta,t}) = \rho_\beta \log(\zeta_{\beta,t-1}) + \epsilon_{\beta,t}$ , with  $\epsilon_{\beta,t} \sim \mathcal{N}(0, \sigma_\beta)$  and  $\rho_\beta \geq 0$ .  $\mathbb{E}_t$  represents expectations formation at time  $t$ . Consumption of dwellings,  $\tilde{D}_t(b)$ , i.e., the stock of housing, increases borrowers' utility, whereas an index of labor supply,  $\tilde{L}_t(b)$ , negatively affects utility.  $\eta$  stands for the inverse Frisch elasticity. Consumption of a composite index comprising domestic and foreign non-durables,  $\tilde{C}_t(b)$ , is subject to external habits, with  $h$  determining the degree of habit formation.

The basket of non-durables is  $\tilde{C}_t(b) = (\tau^{\frac{1}{\iota}} \tilde{C}_{H,t}(b)^{\frac{\iota-1}{\iota}} + (1 - \tau)^{\frac{1}{\iota}} \tilde{C}_{F,t}(b)^{\frac{\iota-1}{\iota}})^{\frac{\iota}{\iota-1}}$ , where subscripts indicate whether the non-durable is produced in the home,  $H$ , or foreign country,  $F$ .  $\iota$  is the substitution elasticity between both non-durable goods, and  $\tau$  defines the fraction of goods produced in the home country. Reallocating labor services from the non-durable consumption goods sector,  $\tilde{L}_{C,t}(b)$ , to the housing sector,  $\tilde{L}_{D,t}(b)$ , is subject to frictions as in Iacoviello and Neri (2010) and Aspachs-Bracons and Rabanal (2011).  $\iota_L \geq 0$  measures cost associated with labor reallocation, and  $\varrho$  is the size of the housing sector, where the index of labor services is  $\tilde{L}_t(b) = ((1 - \varrho)^{-\iota_L} \tilde{L}_{C,t}(b)^{1+\iota_L} + \varrho^{-\iota_L} \tilde{L}_{D,t}(b)^{1+\iota_L})^{\frac{1}{1+\iota_L}}$ .

Borrowers are constrained by the following sequence of budget restrictions

$$P_{C,t} \tilde{C}_t(b) + P_{D,t} \tilde{X}_t(b) + R_{t-1} \tilde{S}_{t-1}(b) = \sum_j^{C,D} \frac{W_{j,t}}{\mathcal{M}_{j,t}} \tilde{L}_{j,t}(b) + \tilde{S}_t(b) + \Pi'_t(b). \quad (2)$$

$P_{j,t}$ ,  $W_{j,t}$ , and  $\mathcal{M}_{j,t}$  denote prices, wages, and nominal wage markups in sector  $j = C, D$ , with  $C$  denoting the non-durable and  $D$  indicating the durable consumption goods sector. The markups result from monopolistic competition that drives a wedge between wages paid by producers and those earned by borrowing households.  $\tilde{X}_t(b)$  is borrowers' investment in residential property, and  $\tilde{S}_t(b)$  represents one period debt that borrowers hold against domestic savers for a gross interest rate of  $R_t > 1$ . Ultimately, labor unions pay dividends,  $\Pi'_t(b)$ .

Indebted households borrow against the expected present value of their dwellings, which serve as collateral (see Iacoviello, 2005). The nominal collateral constraint holds in every period and reads

$$R_t \tilde{S}_t(b) \leq \zeta_{LTV,t} (1 - \chi) (1 - \delta) \mathbb{E}_t \left\{ P_{D,t+1} \tilde{D}_t(b) \right\}, \quad (3)$$

where  $\chi$  is the rate of down-payment, i.e.,  $1 - \chi$  the LTV ratio, respectively.  $\zeta_{LTV,t}$  represents an exogenous AR(1) shock to the loan-to-value ratio with unconditional



mean of zero, which eases or tightens lending standards for borrowers. Furthermore, the housing stock depreciates with rate  $\delta$  and has the accumulation equation  $\tilde{D}_t(b) = (1 - \delta)\tilde{D}_{t-1}(b) + \tilde{X}_t(b)$ . To ensure a well-defined steady state of nominal debt (Schmitt-Grohé and Uribe, 2003), borrowers in the home country pay a risk premium on the union-wide risk free bond rate, which inversely relates to deviations of the net foreign asset position from its non-stochastic steady state as in Aspachs-Bracons and Rabanal (2011)

$$\frac{R_t}{R_t^*} = \exp[-\kappa(b'_t - b') + \zeta_{RP,t}]. \quad (4)$$

$b'_t$  is the net foreign asset to nominal GDP ratio and  $b'$  the respective steady state.  $\kappa \geq 0$  measures how sensitive the risk premium,  $R_t/R_t^*$ , reacts to fluctuations in  $b'_t$ , where the union-wide (indicated with \*) risk free bond rate is  $R_t^*$ .  $\zeta_{RP,t}$  is an exogenous disturbance that stochastically manipulates the risk premium, with  $\zeta_{RP,t} = \rho_{RP}\zeta_{RP,t-1} + \epsilon_{RP,t}$  and  $\epsilon_{RP,t} \sim \mathcal{N}(0, \sigma_{RP})$ .

Borrowers optimally choose non-durable consumption as well as debt holdings such as to maximize (1) subject to (2), which gives

$$\tilde{U}_{C,t} = P_{C,t}\tilde{\lambda}_t \quad \text{and} \quad R_t^{-1} = \tilde{\beta}\mathbb{E}_t \left\{ \frac{P_{C,t}}{P_{C,t+1}} \frac{\tilde{U}_{C,t+1}}{\tilde{U}_{C,t}} \right\} + \tilde{\psi}_t. \quad (5)$$

$\tilde{U}_{C,t}$  denotes the marginal increase in utility associated with consumption of one extra unit of the non-durable good.  $\tilde{\lambda}_t$  and  $\tilde{\lambda}_t\tilde{\psi}_t$  are multipliers on the budget and collateral constraint, respectively. The optimal choice of the housing stock yields

$$\zeta_{B,t} \frac{\tilde{U}_{D,t}}{\tilde{U}_{C,t}} = \frac{P_{D,t}}{P_{C,t}} - (1 - \delta) \left( \tilde{\psi}_t \zeta_{LTV,t} (1 - \chi) \mathbb{E}_t \left\{ \frac{P_{D,t+1}}{P_{C,t}} \right\} - \tilde{\beta} \mathbb{E}_t \left\{ \frac{\tilde{U}_{C,t+1}}{\tilde{U}_{C,t}} \frac{P_{D,t+1}}{P_{C,t+1}} \right\} \right), \quad (6)$$

where  $\tilde{U}_{D,t}$  denotes the marginal increase in utility from an extra unit of dwellings.  $\zeta_{B,t}$  is a stationary AR(1) shock representing a near rational bubble process in housing prices as in In't Veld et al. (2011). In the spirit of Bernanke and Gertler (1999), this disturbance temporarily shocks the housing Euler Equation, which is the relevant asset Equation, and drives a wedge between the expected house price and the counterpart value under fully rational expectations. Hence, for housing investors, such a bubble is similar to a risk premium that is unrelated to fundamentals. By allowing only for small deviations from rational expectations on future fundamentals, we are able to introduce this stationary, non-fundamental disturbance and still can solve for the unique rational expectations equilibrium. Overall,  $\zeta_{B,t}$  captures the ideas promoted, inter alia, in Shiller (2005, 2007), who calls for explanations of housing cycles beyond fundamentals and describes housing bubbles as periods of optimism followed by panic reactions, i.e., pessimism regarding future housing market conditions.

Finally, the demand for domestic and foreign produced non-durables read  $\tilde{C}_{H,t} = \tau(P_{C,t}/P_{H,t})^\iota \tilde{C}_t$  and  $\tilde{C}_{F,t} = (1 - \tau)(P_{C,t}/P_{F,t})^\iota \tilde{C}_t$ , with  $P_{H,t}$  and  $P_{F,t}$  denoting the price of consumption goods produced in country  $i = H, F$ . Thus domestic consumers' price index is a composite, i.e.,  $P_{C,t} = (\tau P_{H,t}^{1-\iota} + (1 - \tau)P_{F,t}^{1-\iota})^{\frac{1}{1-\iota}}$ .

### 3.1.2 Savers' program

The continuum of saving households is  $s \in [\omega, 1]$ , where each saver ( $s$ ) has the lifetime utility function

$$\mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \zeta_{\beta,t} \beta^t \left( \alpha \log(C_t(s) - hC_{t-1}) + (1 - \alpha) \log D_t(s) - \frac{L_t(s)^{1+\eta}}{1 + \eta} \right) \right\}, \quad (7)$$

and maximizes it subject to the following sequence of nominal budget constraints

$$\begin{aligned} P_{C,t}C_t(s) + P_{D,t}X_t(s) + P_{I,t} \sum_j^{C,D} I_{j,t}(s) + S_t(s) + B_t(s) &= \sum_j^{C,D} \frac{W_{j,t}}{\mathcal{M}_{j,t}} L_{j,t}(s) \\ + \sum_j^{C,D} R_{j,t} Z_{j,t}(s) K_{j,t-1}(s) - P_{I,t} \sum_j^{C,D} a(Z_{j,t}(s)) K_{j,t-1}(s) &+ R_{l,t} l(s) + R_{t-1} S_{t-1}(s) \\ + R_{t-1} B_{t-1}(s) + \Pi_t''(s) + \Pi_t'''(s). & \end{aligned} \quad (8)$$

Savers have access to international bond markets,  $B_t(s)$ , which is not the case for domestic, borrowing households.  $R_{l,t}l(s)$  are revenues from renting out land,  $l(s)$ , to producers in the construction sector at rate  $R_{l,t}$ .  $\Pi_t''(s)$  and  $\Pi_t'''(s)$  denote dividends obtained from intermediate goods firms and labor unions, respectively.<sup>7</sup> Moreover, savers invest in non-residential capital,  $K_{j,t}(s)$ , of sector  $j = C, D$ , where  $I_{j,t}(s)$  is a composite of home and foreign non-durable investment goods defined as  $I_{j,t}(s) = (\tau^{\frac{1}{\iota}} I_{H,t}^j(s)^{\frac{\iota-1}{\iota}} + (1-\tau)^{\frac{1}{\iota}} I_{F,t}^j(s)^{\frac{\iota-1}{\iota}})^{\frac{\iota}{\iota-1}}$ . As the home country's weight,  $\tau$ , is the same as in the counterpart index for consumption goods, it holds that  $P_{I,t} = P_{C,t}$ . Building on, e.g., Christiano et al. (2005) and Smets and Wouters (2007), saving households optimally decide on the capital utilization rate,  $Z_{j,t}(s)$ . Adjusting this intensive margin of capital is subject to cost,  $a(Z_{j,t}(s))$ , where the cost function has the properties as in Pariès and Notarpietro (2008).  $R_{j,t}$  is the rental price of capital in nominal terms, which determines savers' income from supplying the effectively used capital stock,  $Z_{j,t}(s)K_{j,t-1}(s)$ , to producers in sector  $j = C, D$ . Sector-specific capital accumulates over time as follows

$$K_{j,t}(s) = (1 - \delta_j)K_{j,t-1}(s) + \left[ 1 - S \left( \frac{I_{j,t}(s)}{I_{j,t-1}(s)} \right) \right] I_{j,t}(s), \quad (9)$$

and depreciates with rate  $\delta_j$ . Following Christiano et al. (2005), varying investment is costly, where  $S(\cdot)$  is a cost function with  $S(1) = S'(1) = 0$  and  $S''(1) = \rho > 0$ .

The solution to savers' decision problems with respect to their optimal choices of non-durable consumption and bond holdings results in the following FOC's

$$U_{C,t} = P_{C,t} \lambda_t \quad \text{and} \quad R_t^{-1} = \beta \mathbb{E}_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \right\}. \quad (10)$$

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<sup>7</sup>Definitions of non-durable consumption goods and labor supply indices as well as consumption demand are analogue to those of borrowing households.

Optimal consumption of the housing good implies

$$\zeta_{B,t} \frac{U_{D,t}}{U_{C,t}} = \frac{P_{D,t}}{P_{C,t}} - \beta(1 - \delta) \mathbb{E}_t \left\{ \frac{U_{C,t+1} P_{D,t+1}}{U_{C,t} P_{C,t+1}} \right\}. \quad (11)$$

Furthermore, savers optimize the stock of capital and its utilization rate as well as investment into sector-specific capital, which amounts to the subsequent FOC's

$$Q_{j,t} = \beta \mathbb{E}_t \left\{ \frac{U_{C,t+1}}{U_{C,t}} \left[ (1 - \delta_j) Q_{j,t+1} + \left( \frac{R_{j,t+1}}{P_{C,t+1}} Z_{j,t+1} - a(Z_{j,t+1}) \right) \right] \right\}, \quad (12)$$

$$Q_{j,t} \left[ 1 - S \left( \frac{I_{j,t}}{I_{j,t-1}} \right) - S' \left( \frac{I_{j,t}}{I_{j,t-1}} \right) \left( \frac{I_{j,t}}{I_{j,t-1}} \right) \right] = 1 - \beta \mathbb{E}_t \left\{ Q_{j,t+1} \frac{U_{C,t+1}}{U_{C,t}} S' \left( \frac{I_{j,t+1}}{I_{j,t}} \right) \left( \frac{I_{j,t+1}}{I_{j,t}} \right)^2 \right\}, \text{ and} \quad (13)$$

$$\frac{R_{j,t}}{P_{C,t}} = a'(Z_{j,t}), \quad (14)$$

where the real value of the existing capital stock, namely, Tobin's Q is  $Q_{j,t}$ .

### 3.1.3 Labor market

Households supply homogeneous labor, which monopolistically competitive unions differentiate as in Smets and Wouters (2007) and Iacoviello and Neri (2010). There is one union for each sector and country, where savers govern the unions as in Quint and Rabanal (2014). Unions sell labor services to wholesale labor packers that, ultimately, supply composite labor services to intermediate firms. Building on Erceg et al. (2000), unions face nominal wage rigidities in the form of a Calvo (1983) style lottery, where the fraction of unions receiving a wage setting signal is  $\theta_{W,j}$ , for  $j = C, D$ . Moreover, unions partially index wages to last period's price inflation of non-durable consumption goods as in Smets and Wouters (2003), with  $\gamma_{W,j}$  measuring the sector-specific degree of indexation.

Unions' wage setting behavior yields the following Phillips curve for sectoral wages

$$\log \left( \frac{\omega_{j,t}}{\Pi_{C,t-1}^{\gamma_{W,j}}} \right) = \beta \mathbb{E}_t \left\{ \log \left( \frac{\omega_{j,t+1}}{\Pi_{C,t}^{\gamma_{W,j}}} \right) \right\} - \frac{(1 - \theta_{W,j})(1 - \beta \theta_{W,j})}{\theta_{W,j}} \log \left( \frac{\mathcal{M}_{j,t}}{\mathcal{M}_j} \right). \quad (15)$$

$\Pi_{C,t} = P_{C,t}/P_{C,t-1}$  and  $\omega_{j,t} = W_{j,t}/W_{j,t-1}$  are price inflation of non-durable consumption goods and gross wage inflation in sector  $j = C, D$ , respectively. Nominal, sectoral wages,  $W_{j,t}$ , include non-competitive wage markups,  $\mathcal{M}_{j,t}$ , which result from unions' monopoly power over wage setting and read for savers

$$\mathcal{M}_{C,t} = \frac{W_{C,t}}{P_{C,t}} \frac{U_{C,t}}{(1 - \varrho)^{-\iota_L} L_t^{\eta - \iota_L} L_{C,t}^{\iota_L}} \quad \text{and} \quad \mathcal{M}_{D,t} = \frac{W_{D,t}}{P_{C,t}} \frac{U_{C,t}}{\varrho^{-\iota_L} L_t^{\eta - \iota_L} L_{D,t}^{\iota_L}}. \quad (16)$$

Thus the markups represent deviations of savers' marginal rate of substitution from

sector-wide real wages.

By contrast, borrowing households are merely members of unions with no governing power. Therefore, they only adjust the amount of supplied labor services to the prescribed wage. Their sectoral optimality conditions read

$$\mathcal{M}_{C,t} = \frac{W_{C,t}}{P_{C,t}} \frac{\tilde{U}_{C,t}}{(1-\varrho)^{-\iota_L} \tilde{L}_t^{\eta-\iota_L} \tilde{L}_{C,t}^{\iota_L}} \quad \text{and} \quad \mathcal{M}_{D,t} = \frac{W_{D,t}}{P_{C,t}} \frac{\tilde{U}_{C,t}}{\varrho^{-\iota_L} \tilde{L}_t^{\eta-\iota_L} \tilde{L}_{D,t}^{\iota_L}}. \quad (17)$$

### 3.1.4 Final goods firms

Final goods bundlers operate under perfect competition with fully flexible prices. They buy intermediate goods  $i \in [0, n]$  from firms of sector  $j = C, D$  and combine them according to aggregator function

$$Y_{j,t} = \left(\frac{1}{n}\right)^\lambda \left(\int_0^n Y_{j,t}(i)^{\frac{1}{1+\lambda}} di\right)^{1+\lambda}. \quad (18)$$

$Y_{j,t}(i)$  represents type  $i$  intermediate goods, which bundlers employ for the production of the final goods,  $Y_{j,t}$ .  $\lambda$  is the net price markup (see, e.g., Smets and Wouters, 2003). Cost minimization of bundling firms gives rise to the following sector-specific demand Equations

$$Y_{C,t}(i) = \frac{1}{n} \left(\frac{P_{H,t}}{P_{H,t}(i)}\right)^{\frac{1+\lambda}{\lambda}} Y_{C,t} \quad \text{and} \quad Y_{D,t}(i) = \frac{1}{n} \left(\frac{P_{D,t}}{P_{D,t}(i)}\right)^{\frac{1+\lambda}{\lambda}} Y_{D,t}. \quad (19)$$

$P_{j',t}(i)$  and  $P_{j',t}$ , for  $j' = H, D$ , are domestic prices of sectoral intermediate and final products, respectively. Under zero profits in the final goods market the latter read

$$P_{j',t} = \left(\frac{1}{n}\right)^{-\lambda} \left(\int_0^n P_{j',t}(i)^{-\frac{1}{\lambda}} di\right)^{-\lambda}. \quad (20)$$

### 3.1.5 Intermediate goods firms

Building on Davis and Heathcote (2005) and Iacoviello and Neri (2010), we allow for sectoral heterogeneity of intermediate goods firms, which operate under monopolistic competition. The model introduces endogenous sectoral dynamics as a result of sector-specific production technologies

$$Y_{C,t}(i) = K'_{C,t}(i)^{\mu_C} L_{C,t}(i)^{1-\mu_C}, \quad Y_{D,t}(i) = \zeta_{AD,t} l(i)^{\mu_l} K'_{D,t}(i)^{\mu_D} L_{D,t}(i)^{1-\mu_l-\mu_D}. \quad (21)$$

$K'_{j,t}(i) = Z_{j,t}(i) K_{j,t-1}(i)$  denotes sectoral capital, effectively used in production, i.e., the accumulated stock of productive capital adjusted for time-varying capital utilization (see Smets and Wouters, 2007).  $\mu_j$ , for  $j = C, D$ , are sectoral capital shares, and  $\mu_l$  is the land share in the housing sector.  $\zeta_{AD,t}$  is an AR(1) housing technology shock.

Firms in the intermediate goods sector solve a standard cost minimization prob-

lem, which results in the following sectoral marginal cost Equations

$$MC_{C,t}(i) = \frac{R_{C,t}^{\mu_C} W_{C,t}^{1-\mu_C}}{\mu_C^{\mu_C} (1-\mu_C)^{1-\mu_C}}, \quad MC_{D,t}(i) = \frac{R_{l,t}^{\mu_l} R_{D,t}^{\mu_D} W_{D,t}^{1-\mu_l-\mu_D}}{\mu_l^{\mu_l} \mu_D^{\mu_D} (1-\mu_l-\mu_D)^{1-\mu_l-\mu_D} \zeta_{AD,t}}. \quad (22)$$

The stock of land is fixed, i.e.,  $l_t = l$ , and the interest for renting out land,  $R_{l,t}$ , is

$$R_{l,t} = \frac{\mu_l}{1-\mu_l-\mu_D} \frac{W_{D,t} L_{D,t}(i)}{l}, \quad (23)$$

where we choose  $l$  to yield equal sectoral wages as in Aspachs-Bracons and Rabanal (2011). Firms in the intermediate products sector earn subsequent profits

$$\Pi_{C,t}(i) = (P_{H,t}(i) - MC_{C,t}(i)) \left(\frac{1}{n}\right) \left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\frac{1+\lambda}{\lambda}} Y_{C,t} \quad \text{and} \quad (24)$$

$$\Pi_{D,t}(i) = (P_{D,t}(i) - MC_{D,t}(i)) \left(\frac{1}{n}\right) \left(\frac{P_{D,t}(i)}{P_{D,t}}\right)^{-\frac{1+\lambda}{\lambda}} Y_{D,t}, \quad (25)$$

where they maximize the expected value of these profits. In analogy to unions' wage setting process, intermediate firms face nominal rigidities. Thus in each sector a fraction of firms,  $\theta_{P,j}$ , is not able to set the profit maximizing price,  $\dot{P}_{H,t}(i)$ , as in Calvo (1983), but is allowed to partially index prices to sectoral price inflation as in Smets and Wouters (2003). The solution to non-durable sector firms' program is

$$\mathbb{E}_t \left\{ \sum_{k=0}^{\infty} \Lambda_{t,t+k} \theta_{P,C} Y_{C,t+k}(i) \left( \frac{\dot{P}_{H,t}(i)}{P_{H,t}} \frac{P_{H,t-1+k}^{\gamma_{P,C}}}{P_{H,t-1}^{\gamma_{P,C}}} \frac{P_{H,t}}{P_{H,t+k}} - (1+\lambda) \frac{MC_{C,t+k}(i)}{P_{H,t+k}} \right) \right\} = 0, \quad (26)$$

where firms discount future profits with factor  $\Lambda_{t,t+k} = \beta^k (\lambda_{t+k}/\lambda_t)$ , and  $\gamma_{P,C}$  denotes the intensity of price indexation. The counterpart optimality condition for housing sector firms is analogue and reads

$$\mathbb{E}_t \left\{ \sum_{k=0}^{\infty} \Lambda_{t,t+k} \theta_{P,D} Y_{D,t+k}(i) \left( \frac{\dot{P}_{D,t}(i)}{P_{D,t}} \frac{P_{D,t-1+k}^{\gamma_{P,D}}}{P_{D,t-1}^{\gamma_{P,D}}} \frac{P_{D,t}}{P_{D,t+k}} - (1+\lambda) \frac{MC_{D,t+k}(i)}{P_{D,t+k}} \right) \right\} = 0. \quad (27)$$

Finally, we obtain the law of motion for domestic prices in the non-durable sector

$$P_{H,t}^{-\frac{1}{\lambda}} = \theta_{P,C} \left[ P_{H,t-1} \left( \frac{P_{H,t-1}}{P_{H,t-2}} \right)^{\gamma_{P,C}} \right]^{-\frac{1}{\lambda}} + (1-\theta_{P,C}) \dot{P}_{H,t}(i)^{-\frac{1}{\lambda}}, \quad (28)$$

and the housing sector

$$P_{D,t}^{-\frac{1}{\lambda}} = \theta_{P,D} \left[ P_{D,t-1} \left( \frac{P_{D,t-1}}{P_{D,t-2}} \right)^{\gamma_{P,D}} \right]^{-\frac{1}{\lambda}} + (1-\theta_{P,D}) \dot{P}_{D,t}(i)^{-\frac{1}{\lambda}}. \quad (29)$$

### 3.1.6 Market equilibrium

In equilibrium, home country production of non-durables equals borrowers' consumption demand as well as savers' consumption and investment demand

$$Y_{C,t} = n \left( \omega \tilde{C}_{H,t} + (1 - \omega) (C_{H,t} + I_{H,t}^C + I_{H,t}^D) \right) + (1 - n) \left( \omega^* \tilde{C}_{H,t}^* + (1 - \omega^*) (C_{H,t}^* + I_{H,t}^{C*} + I_{H,t}^{D*}) \right) + \Omega_t, \quad (30)$$

with  $\Omega_t$  denoting resource cost, which result from time-varying utilization of the capital stock. The housing market clears under the following condition

$$Y_{D,t} = n \left( \omega \tilde{X}_t + (1 - \omega) X_t \right). \quad (31)$$

With the definitions of housing and non-housing supply at hand, we obtain domestic GDP in real terms, i.e.,  $Y_t = Y_{C,t} + Y_{D,t}$ . Sectoral labor markets clear as follows  $\omega \tilde{L}_{j,t} + (1 - \omega) L_{j,t} = \int_0^n L_{j,t}(i) di$ , for  $j = C, D$ , and the equilibrium conditions of domestic and international debt markets are

$$\omega \tilde{S}_t = (1 - \omega) S_t \quad \text{and} \quad n(1 - \omega) B_t + (1 - n)(1 - \omega^*) B_t^* = 0. \quad (32)$$

Ultimately, the evolution of the domestic country's net foreign assets is

$$\begin{aligned} n(1 - \omega) B_t &= n(1 - \omega) R_{t-1} B_{t-1} \\ &\quad + (1 - n) P_{H,t} \left[ \omega^* \tilde{C}_{H,t}^* + (1 - \omega^*) (C_{H,t}^* + I_{H,t}^{C*} + I_{H,t}^{D*}) \right] \\ &\quad - n P_{F,t} \left[ \omega \tilde{C}_{F,t} + (1 - \omega) (C_{F,t} + I_{F,t}^C + I_{F,t}^D) \right]. \end{aligned} \quad (33)$$

### 3.1.7 Monetary policy

The monetary authority perfectly controls the riskless bond rate in the monetary union,  $R_t^*$ , and follows an empirically motivated Taylor (1993) type instrument rule

$$\frac{R_t^*}{R^*} = \left( \frac{R_{t-1}^*}{R^*} \right)^{\mu_R} \left( \frac{\Pi_t^*}{\Pi^*} \right)^{\mu_\Pi(1-\mu_R)} \left( \frac{Y_t^*}{Y_{t-1}^*} \right)^{\mu_{\Delta Y}} \left( \frac{\Pi_t^*}{\Pi_{t-1}^*} \right)^{\mu_{\Delta \Pi}} \exp(\epsilon_{R,t}^*). \quad (34)$$

The central bank engages in interest rate smoothing, where  $\mu_R$  measures the smoothness of interest rate policy. Moreover, the policy instrument reacts to deviations of the union-wide consumer price inflation, from its steady state,  $\Pi_t^*/\Pi^*$ , and to changes in output as well as the inflation rate as in Christoffel et al. (2008).  $\mu_\Pi$ ,  $\mu_{\Delta \Pi}$ , and  $\mu_{\Delta Y}$  are the reaction coefficients.  $\epsilon_{R,t}^*$  is a white noise monetary policy shock.

## 3.2 Deriving restrictions

As in Peersman and Straub (2009), we simulate the DSGE model 10,000 times by drawing uniformly distributed, random values for the structural parameters within

specified intervals (Table 1).<sup>8</sup> Then we present median impulse responses together with 10 and 90 percent percentiles from all draws. For a pairwise comparison of shocks, finding at least one common and one opposed endogenous response that is robustly predicted by the different structural models, yields mutually exclusive restrictions, i.e., orthogonal shocks.

### 3.2.1 Exogenous processes

We implement the four shocks from Section 2 in the DSGE model as follows.

- *Savings glut shock in the rest of the Eurozone.* Rest of union households become more patient compared to home country households. As in Sá and Wieladek (2015), we model the savings glut shock as a positive discount factor shock,  $\zeta_{\beta,t}$ , in Equations (1) and (7), describing lifetime utility of borrowers and savers, respectively.
- *Risk premium shock in the rest of the Eurozone.* This disturbance increases preferences of rest of union investors for home country bonds. It corresponds to a negative risk premium shock,  $\zeta_{RP,t}$ , in the net foreign asset Equation (4).
- *Financial easing shock in Spain.* This shock enhances credit availability against housing collateral of domestic borrowers and equals a positive shock,  $\zeta_{LTV,t}$ , in the collateral constraint Equation (3) and the housing Euler Equation (6).
- *Housing bubble shock in Spain.* As in In't Veld et al. (2011), this is a shock disturbing the risk premium on housing values and appears as  $\zeta_{B,t}$  in domestic borrowers' and savers' housing Euler Equations (6) and (11).

### 3.2.2 Calibration strategy

For parameters governing nominal rigidities in goods and labor markets, we draw on the 90 percent posterior intervals of Smets and Wouters (2003). Calvo parameters,  $\theta_{W,C}$  and  $\theta_{P,C}$ , range from 0.6 to 0.9.<sup>9</sup> Parameters capturing wage and price indexation,  $\gamma_{W,C}$  and  $\gamma_{P,C}$ , vary from 0.5 to 0.9 and 0.3 to 0.9, respectively (see Aspachs-Bracons and Rabanal, 2011). We draw wage and price markups from 1.1 to 1.5, corresponding to elasticities of substitutions for differentiated goods and labor services ranging from 3 to 11 (Coenen et al., 2008). Following Sá and Wieladek (2015), Calvo housing parameters,  $\theta_{P,D}$  and  $\theta_{W,D}$ , vary from 0 to 0.3 and indexation parameters,  $\gamma_{P,D}$  and  $\gamma_{W,D}$ , from 0 to 0.4, implying a more flexible housing compared to the non-durables sector. The degree of habit formation,  $h$ , ranges from 0.4 to 0.8 (see Smets and Wouters, 2003; In't Veld et al., 2014). For the inverse Frisch elasticity,  $\eta$ , we allow for variations from 1.5 to 2.5 (Coenen et al., 2008), while we set discount factors of savers,  $\beta$ , to 0.99 and borrowers,  $\tilde{\beta}$ , to 0.98. We rely on Smets and Wouters (2003) and Aspachs-Bracons and Rabanal (2011) for the capital bloc.

<sup>8</sup>We draw on empirical DSGE models like, e.g., Smets and Wouters (2003), Aspachs-Bracons and Rabanal (2011), In't Veld et al. (2014), and Coenen et al. (2008) to specify parameter ranges.

<sup>9</sup>We expand the lower bound to 0.6 as the posterior intervals in Smets and Wouters (2003) do not include the popular values of  $\theta_{W,C} = \theta_{P,C} = 0.75$ .

Investment and capital utilization adjustment cost coefficients,  $\rho$  and  $\nu$ , range from 1 to 7 and 0.1 to 0.5, respectively. The annual depreciation rate in the housing sector is 1 percent, and 10 percent in the non-durables sector. The capital share is 30 percent in the non-durables and 20 percent in the housing sector, while the land share is 10 percent in the housing sector. As in Aspachs-Bracons and Rabanal (2011), the cost coefficient of labor reallocation,  $\iota$ , is 1.28, and the construction sector accounts for 10 percent of GDP in steady state. The LTV ratio,  $1 - \chi$ , is 0.8 (Akin et al., 2014) and the share of borrowing households,  $\omega$ , is 0.4 (Hristov et al., 2012). The GDP weight of Spain in the Eurozone,  $n$ , is 0.1. Consistently, the fraction of Eurozone imports,  $1 - \tau$ , is 0.15, while the fraction of imports from Spain,  $\tau^*$ , is 0.0167. Domestic bonds' risk premium elasticity with respect to the net foreign asset position,  $\kappa$ , varies from 0.002 to 0.007 (Quint and Rabanal, 2014) and the Taylor coefficients intervals encompass 90 percent of the posterior distributions from the ECB's New Area-Wide Model (Christoffel et al., 2008). As in Sá and Wieladek (2015), AR shock coefficients vary in persistent regions (Table 1), with standard deviations as in Aspachs-Bracons and Rabanal (2011).

### 3.2.3 Shock propagation

Figure 5 displays a financial easing shock.<sup>10</sup> A shock to the collateral constraint allows home country borrowers to increase credit against the expected value of housing, which raises borrowers' demand. Additionally, a relaxation of borrowing constraints fuels domestic absorption, in particular, in the non-durables sector.<sup>11</sup> Thus imports from the union increase, while exports shrink due to adverse terms of trade effects, i.e., the current account turns negative. A financial easing shock does not predict a boom in residential investment as enhanced borrowing capacities, predominantly, cause purchases of non-durables. Beyond, savers invest in housing, when prices are low. As house prices increase at short horizons due to the enhanced housing demand by borrowers, savers' residential investment drops, which overcompensates borrowers' investment in housing and, ultimately, also the house price increase. Furthermore, the central bank reacts to the financial easing shock by raising the policy rate, which translates into an increase of long-term bond rates in the home country.

In contrast, a housing bubble shock can account for a positive co-movement of residential investment and real house prices (see Figure 6). Furthermore, while the ratio of consumption to residential investment increases following a financial easing shock, it decreases after a housing bubble shock. We use this feature to disentangle the two shocks (see Figure 7). Overall, both pull shocks imply an increase in consumer price inflation and, accordingly, an increase in the policy instrument, which depresses consumption demand in the rest of the monetary union.

Figure 8 traces out the adjustment patterns following a risk premium shock. Rest of union investors have greater preferences for home country assets and invest to a larger extent into these bonds. Capital inflows cause bond rates to fall, which

<sup>10</sup>We calculate home country bond rates as a geometric average of short-term interest rates over a 10-year horizon as in Sá and Wieladek (2015).

<sup>11</sup>We analyze the dynamics for consumption instead of GDP, which allows us to isolate the impact on net exports – reflected by the current account – as well as on domestic absorption.



distinguishes the risk premium shock from the alternative pull disturbances. Lower interest rates, in turn, increase domestic absorption as savers and borrowers increase consumption and housing demand. The central bank responds to the home country boom with higher interest rates, which mildly depresses rest of union consumption.

Closely related to the risk premium shock is the savings glut shock (see Figure 9). However, in contrast to the risk premium shock, the simulations robustly predict a decline of short-term interest rates in the face of a savings glut shock. The surge of the discount factor in the rest of the union implies higher saving rates that in turn depress current economic activity, i.e., the savings glut shock represents a recessionary shock in the rest of the monetary union associated with a significant fall in consumer prices, and thus calls upon the central bank to decrease the policy instrument. As a consequence of the recession in the rest of the union with pronounced disinflationary effects, the CPI in the home country falls due to lower prices of imported goods – a facet of the savings glut shock, which further distinguishes this shock from the risk premium shock. Overall, due to asymmetric business cycles in the union, domestic interest rates are ‘too low’ triggering a boom in this economy. Lower interest rates, in addition, decrease borrowers’ cost of financial services and relax borrowing constraints. This effect supports domestic absorption and reinforces a deterioration of the home country’s current account.

As a robustness check, we consider two further disturbances to ensure orthogonality of the analysis with respect to these shocks. First, we simulate a monetary policy stimulus as a negative  $\epsilon_{R,t}^*$  shock in Taylor rule Equation (34). As we calibrate deep parameter intervals in the currency union symmetrically, a cut in interest rates triggers no net capital flows. Moreover, the decline in interest rates leads to a consumption boom in both parts of the union as well as to higher union-wide consumer price inflation (Figure 10). Thus a monetary policy shock is inconsistent with the qualitative dynamics of the other disturbances. Second, we study an increase in home country’s housing sector-specific technology,  $\zeta_{AD,t}$ , in Equation (21). Again, all considered structural models robustly predict an increase in domestic and foreign consumption making this shock orthogonal to the shocks under consideration.

In summary, Table 2 displays the set of robust sign restrictions that assure orthogonality between the considered shocks and which we employ in the empirical analysis. As, e.g., in Sá and Wieladek (2015), we impose the restrictions for three quarters and do not impose restrictions on both housing market variables. For the current account, we only restrict the impact quarter in line with the DSGE model predictions to ensure that we isolate shocks, which coincide with a current account deterioration. In Section 5, we relax the restriction on the current account and test how our results are affected by this identification assumption.

## 4 Empirical methodology

In this section, we empirically analyze the effects of savings glut, risk premium, financial easing, and housing bubble shocks on the current account and the housing market in Spain. We begin with a description of the data and the estimation strategy. Using a Gibbs sampler, we estimate a mixed frequency VAR and draw efficient

likelihood inference as in Eraker et al. (2014). In particular, the mixed frequency VAR approach is helpful given the short period of the housing cycle in Spain. Then we present the identification of structural shocks via sign restrictions as proposed in Uhlig (2005) and summarize the empirical findings.

## 4.1 Estimation, data, and inference

The analysis builds on the following reduced form open-economy VAR model

$$\mathbf{y}_t = \mathbf{c} + \sum_{l=1}^p \Phi_l \mathbf{y}_{t-l} + \boldsymbol{\varepsilon}_t, \text{ where } \mathbb{E}[\boldsymbol{\varepsilon}_t] = 0 \text{ and } \mathbb{E}[\boldsymbol{\varepsilon}_t \boldsymbol{\varepsilon}_t'] = \boldsymbol{\Sigma}_\varepsilon. \quad (35)$$

$\mathbf{c}$  is a vector of intercepts,  $\Phi_l$  is a  $n \times n$  matrix including AR coefficients at lag  $l = 1, \dots, p$ , and  $\boldsymbol{\Sigma}_\varepsilon$  is a  $n \times n$  variance-covariance-matrix.  $\boldsymbol{\varepsilon}_t$  represents one step ahead forecasting errors, and  $\mathbf{y}_t$  comprises the following  $n$  endogenous variables

$$\mathbf{y}_t = [ \mathbf{C}_t \ \mathbf{C}_t^* \ \text{CPI}_t \ \text{EONIA}_t \ \text{BOND}_t \ \text{BOND}_t^* \ \text{LOANS}_t \ \text{CA}_t \ \text{RINV}_t \ \text{CPIH}_t ]'. \quad (36)$$

The open-economy VAR framework is increasingly employed to study spillover effects from domestic shocks into foreign country aggregates, et vice versa (see, e.g., Fratzscher et al., 2010; Sá and Wieladek, 2015). Accordingly, we include Spanish data and time series for the rest of the Euro Area in  $\mathbf{y}_t$ .<sup>12</sup>  $\text{CPI}_t$  is the log level of the Harmonized Index of Consumer Prices (HICP).  $\mathbf{C}_t$  denotes the  $\text{CPI}_t$  deflated log level of private consumption expenditures, and  $\text{BOND}_t$  measures nominal 10-year sovereign bond yields in percent. To calculate rest of Euro Area counterparts (indicated with \*), we apply the household expenditure weights used by the HICP. These weights are updated annually and range from a share of 8.8 percent to 12.7 percent for Spain at Euro Area expenditures.<sup>13</sup>  $\text{EONIA}_t$  represents interest rates in percent for unsecured, overnight lending in Euro Area interbank markets. As in Ciccarelli et al. (2015), we use  $\text{EONIA}_t$  instead of the interest rate on the ECB's main refinancing operations as proxy for the monetary policy stance. Following the financial turmoil of 2008 the ECB adopted various credit enhancing policies for banks, e.g., liquidity provisions with fixed interest rates and full allotment as well as longer-term refinancing operations, which temporarily pushed  $\text{EONIA}_t$  toward the ECB's deposit facility interest rate (see Lenza et al., 2010). Therefore,  $\text{EONIA}_t$ , in contrast to the official policy rate, implicitly accounts for these liquidity management programs making it a reasonable policy measure especially since the financial crisis (Ciccarelli et al., 2015). As a measure of bank lending by Spanish banks, we include  $\text{LOANS}_t$ , which represents the outstanding stock of Euro denominated bank loans to the non-financial private sector in real terms.  $\text{CA}_t$  stands for the Spanish current account to GDP ratio in percent.  $\text{RINV}_t$  and  $\text{CPIH}_t$  are log levels of real residential investment and a real house price index measuring residential property prices of all Spanish dwellings, respectively. Except for  $\text{CPIH}_t$ , which we obtain from the BIS, all data come from Eurostat, the Bank of Spain, or the ECB. Consumption, price, and interest rate se-

<sup>12</sup>An alternative is to specify data as country differentials by assuming symmetry across countries.

<sup>13</sup>See, e.g., Dees et al. (2007), who compare fix country weights with continuously varying weighting schemes in a GVAR analysis.

ries primarily enter the VAR due to the identification of shocks, while we include the current account, loan volume, and housing variables to study the effects of capital inflows on the Spanish housing market. To pick up the EMU convergence period, we start the sample in 1995 M1 (see Crespo-Cuaresma and Fernández-Amador, 2013). We confine the estimation to 2013 M12 to avoid non-linearities caused by the zero lower bound on the nominal interest rate and provide robustness for the sample choice in Section 5.

Since the data sample is short, we employ a Bayesian mixed frequency approach for estimation and inference. In particular, for the case of short samples, Eraker et al. (2014) demonstrate that combining high frequency with low frequency time series yields efficiency gains compared to an estimator that discards high frequency information by relying on the coarsest data frequency for all variables. Thus we use  $n_z$  quarterly series,  $\mathbf{z}_t$ , and, provided that they are available,  $n_x$  monthly series,  $\mathbf{x}_t$ , where  $n_z + n_x = n$ . Concretely, the subsets of  $\mathbf{y}_t$  read

$$\mathbf{x}_t = [\text{CPI}_t \text{ EONIA}_t \text{ BOND}_t \text{ BOND}_t^* \text{ LOANS}_t] \text{ and } \mathbf{z}_t = [\text{C}_t \text{ C}_t^* \text{ CA}_t \text{ RINV}_t \text{ CPIH}_t]'. \quad (37)$$

Following the Bayesian mixed frequency approach, we assume high frequency elements in  $\mathbf{z}_t$  to be latent and hence consider them as missing realizations.<sup>14</sup> Using Markov-Chain-Monte-Carlo methods, the estimator alternately samples from latent observations and model parameters. Let  $\widehat{\mathbf{z}}^i$  include low frequency data, observed as well as latent, for Markov-Chain-Monte-Carlo iteration  $i$ , where the sampled data are  $\widehat{z}_1^i, \widehat{z}_2^i, \widehat{z}_4^i \dots \widehat{z}_{T-1}^i$ . Furthermore, let  $\widehat{\mathbf{z}}_{-t}^i$  represent the complete vector  $\widehat{\mathbf{z}}^i$  except for element  $\widehat{z}_t^i$ . As in Eraker et al. (2014), we proceed as follows. First, given initial values and using a conjugate Normal inverse Wishart prior for the parameters, we draw  $\widehat{\mathbf{z}}_t^i$  from a multivariate normal density, while conditioning on  $\mathbf{x}_t, \widehat{\mathbf{z}}_{-t}^{i-1}, \mathbf{c}^{i-1}, \mathbf{\Phi}_l^{i-1}$ , and  $\mathbf{\Sigma}_\varepsilon^{i-1}$ . Second, we draw  $\mathbf{c}^i$  and  $\mathbf{\Phi}_l^i$  for given  $\mathbf{x}_t, \widehat{\mathbf{z}}^i$ , and  $\mathbf{\Sigma}_\varepsilon^{i-1}$ , and third, we obtain  $\mathbf{\Sigma}_\varepsilon^i$  by conditioning on  $\mathbf{x}_t, \widehat{\mathbf{z}}^i, \mathbf{c}^i$ , and  $\mathbf{\Phi}_l^i$ . Taking the temporal aggregation structure of low frequency variables in the VAR(p) into account, we computationally follow Qian (2013) and draw blocks of latent observations (aggregation cycle). We estimate the VAR with  $p = 6$  lags, i.e., 2 quarters after linearly de-trending all series and provide robustness on the VAR specification in Section 5.<sup>15</sup> Note that the de-trending is motivated by the mixed frequency approach, which requires non-trending data. We experimented with different de-trending procedures, where results are robust to the concrete choice of methods.

## 4.2 Identification

From the VAR model in Equation (35), we derive impulse response functions to structural shocks by imposing sign restrictions (see, e.g., Faust, 1998; Canova and de Nicolò, 2002; Uhlig, 2005). Reduced form forecasting errors,  $\boldsymbol{\varepsilon}_t$ , linearly map

<sup>14</sup>See Ghysels (2015) for an alternative method of estimating mixed frequency VAR models within the mixed data sampling regression framework. In addition, Foroni and Marcellino (2013) offer a survey of mixed frequency data methods, in general.

<sup>15</sup>We analyzed the sensitivity of the results with respect to the choice of the lag length by running the estimation for  $p = 3, 9$ , and 12 lags. For these specifications, the qualitative behavior of the key variables is not markedly affected. The results of these exercises are available upon request.

structural shocks,  $\boldsymbol{\eta}_t$ , through  $\tilde{\boldsymbol{P}}\boldsymbol{\eta}_t = \boldsymbol{\varepsilon}_t$ , with  $\mathbb{E}[\boldsymbol{\eta}_t] = 0$  and  $\mathbb{E}[\boldsymbol{\eta}_t\boldsymbol{\eta}_t'] = \boldsymbol{\Sigma}_\eta$ .  $\boldsymbol{\Sigma}_\eta$  is diagonal ensuring orthogonality of the structural shocks. Furthermore,  $\tilde{\boldsymbol{P}} = \boldsymbol{P}\boldsymbol{Q}$ , where  $\boldsymbol{P}$  represents one Cholesky factor from the Bayesian estimation. Hence, we can rewrite the variance-covariance-matrix of the reduced form model as  $\mathbb{E}[\boldsymbol{\varepsilon}_t\boldsymbol{\varepsilon}_t'] = \boldsymbol{\Sigma}_\varepsilon = \boldsymbol{P}\boldsymbol{Q}\boldsymbol{Q}'\boldsymbol{P}'$ , where  $\boldsymbol{Q}$  is an ortho-normal matrix, i.e.,  $\boldsymbol{Q}\boldsymbol{Q}' = \boldsymbol{I}$ . We obtain  $\boldsymbol{Q}$  by applying the QR decomposition to a matrix  $\boldsymbol{Z}$ , which is sampled from a  $\mathcal{N}(0, 1)$  density. Each  $\boldsymbol{Q}$  determines a different structural model and thus different impulse response functions. According to the sign restrictions approach, we derive impulse response functions for various structural models saving only those draws that are consistent with the imposed restrictions. As summary statistics, we then present the 16th, 50th, and 84th percentile of all accepted draws as in, e.g., Peersman (2005), Uhlig (2005), and Fratzscher et al. (2010).

We simultaneously identify four types of macroeconomic shocks by imposing sign restrictions as summarized in Table 2 for nine months, i.e., three quarters (see, e.g., Sá and Wieladek, 2015). A broad class of open-economy DSGE models robustly predicts these restrictions. They are sufficient to disentangle the four shocks, and they ensure orthogonality to other disturbances (Section 3). As demonstrated in Paustian (2007) and Canova and Paustian (2011), we sharpen the identification by imposing more than the minimum set of sign restrictions, which increases the probability to isolate the shocks of interest. However, by leaving the responses of the housing market variables unrestricted, we remain agnostic about their dynamics.

### 4.3 Results

Figures 12 to 15 trace out the propagation of the identified shocks through the variables in  $\boldsymbol{y}_t$ . The shaded area denotes the 68 percent credible set from the Bayesian estimation and the solid line represents the median impulse response function. We report the dynamics for 48 months, i.e., for four years. We define all monthly shocks to reduce consumption in the rest of the Euro Area, i.e.,  $\mathbf{C}_t^*$  falls, as well as to incur a Spanish consumption boom, i.e.,  $\mathbf{C}_t$  increases.

After a savings glut shock, the current account is significantly negative in the impact quarter in line with the imposed restriction (see Figure 12). Then, the response is insignificant for four months before significantly falling again for three and a half years. The unrestricted housing variables follow a sluggish increase, with median impulse responses being positive over the whole forecast horizon. Residential investment and house prices are, however, only significant at the margin. Furthermore, the unrestricted bank loans feature a slowly building rise, which remains significant from the second year onwards. Figure 13 displays adjustment patterns after a risk premium shock on Spanish bonds. This macroeconomic disturbance produces housing market and current account dynamics quantitatively similar to the savings glut shock. Though, this shock reveals more inertia with respect to the current account, which stays significantly different from zero over the entire forecast horizon. Beyond, the risk premium shock predicts significant increments for both housing variables after one and a half years. The bank loan response largely mirrors the dynamics after a savings glut shock, i.e., loans slowly build up and remain significantly positive after a year. The financial easing shock from Figure 14 only forces the current account into

negative territory as long as we impose the sign restrictions, i.e., for three months. Then, the current account response is insignificant, with the median impulse response even overshooting the pre-shock level after one and a half years. Interestingly, the shock does not predict a boom with respect to both housing variables. While house prices are insignificant over the entire impulse horizon, residential investment even falls significantly in the first year after the shock and bank loans do not exhibit a significant reaction. Nevertheless, the DSGE model predicts this impact on housing markets (see Figure 5). From a theoretical perspective, financial easing shocks generally need not entail a housing boom as savers consume less housing, whereas borrowers increase the demand for housing. The overall impact on housing markets thus crucially hinges on the composition of households and their discount factors (see Justiniano et al., 2015). Altogether, the negative impulse response dynamics of residential investment together with the negative reaction of house prices (albeit insignificant) after a financial easing shock are hard to reconcile with the Spanish housing boom. As opposed to the financial easing shock, the housing bubble shock is capable of generating a negative correlation between the current account and all housing market variables in the VAR (see Figure 15). Most notably, residential investment immediately builds up in a statistically significant fashion for 20 months after the shock and house prices also increase at short horizons. Bank loans feature a hump-shaped increase which, however, is statistically insignificant.

Finally, we evaluate the relative importance of the shocks through the lens of a forecast error variance decomposition, which considers the estimated magnitude of the structural disturbances. For the variables of interest, entries in Table 4 reveal the fractions of the forecast error variance, which can be attributed to the respective shocks over various forecast horizons in percent. We present all  $k$ -step ahead forecast revisions for the median draw and report 68 percent credible sets. Overall, in terms of explanatory power for the housing market variables and the current account, we find fairly homogeneous results for the four identified shocks, with explained variance shares ranging in orders of magnitude similar to Sá and Wieladek (2015), who employ US data and use a similar identification scheme. With a share of 7.5 percent explained variation in real house prices, the savings glut shock has most explanatory power compared to the other disturbances for this variables, where its effect, primarily, is operative for the impact period. Furthermore, the savings glut shock explains more than 6 percent of the current account after 6 months and more than 5 percent of residential investment at longer horizons. The risk premium shock accounts for a similar share of fluctuations in house prices as the savings glut shock, however, the risk premium shock exerts its influence on house prices predominantly over longer forecast horizons. With respect to residential investment, the risk premium shock explains most variations of all shocks considered, with a maximum share of explained forecast revisions of more than 8.5 percent after four years. Albeit, the financial easing shock falls short in explaining the negative correlation of housing markets and the current account in Spain, this shock reveals some explanatory power for the key variables. With explanatory power of up to 8 percent for the current account, more than 7 percent for real house prices, and nearly 8 percent for residential investment, the magnitude of this shock is similar to both push disturbances. Ultimately, the housing bubble shock accounts for roughly 7 percent of the variation in real house

prices after 6 months, while its explanatory power for the remaining variables and horizons is somewhat smaller than for the other shocks considered.

In general, the analysis leaves substantial fractions of the forecast revisions in the key variables undeclared, i.e., explained by structural shocks that we do not identify. Our analysis, for instance, is orthogonal to macroeconomic disturbances emerging from, e.g., asymmetric housing technology dynamics or monetary policy shocks (see Section 3).<sup>16</sup>

## 5 Robustness

In this section, we extend the empirical analysis along several dimensions and review the robustness of our findings with respect to the modifications considered. First, we compare the findings with the so-called median target solution proposed in Fry and Pagan (2011). Second, for the identification of structural shocks, we allow for a different set of sign restrictions, which leaves the response of the current account unrestricted and, third, we analyze the shock propagation for a different data sample that stops in 2012 to filter out possible effects of Mario Draghi’s “*whatever it takes*” speech in London on 26 July 2012.

### 5.1 Median target solution

Until this point, we rely on the median of all accepted impulse responses in the VAR to draw inference on. Yet, since the impulse responses of these point-wise posterior statistics need not necessarily be generated by the same structural model, we now calculate the median target solution as in Fry and Pagan (2011) and study the model dynamics for this particular model. The median target hereby refers to a single model producing impulses, which minimize the weighted distance to the median. Consequently, this model renders an interpretation feasible from a structural perspective.

Figure 16 displays the adjustment patterns of the key variables (columns) following the four identified shocks (rows) for the median model (solid line) together with the median target solution (broken line), where we – here and in what follows – omit the remaining variables to conserve space. The impulse response functions of the median target model resemble the dynamics of the posterior median fairly close. Only for a small number of months, the median target response lies outside the 68 percent credible set (shaded regions) and thus is different from the median model in a statistical sense. Therefore, we conjecture that our inference as well as our main findings are not materially affected by considering the median instead of the median target solution.

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<sup>16</sup>Furthermore, our modeling device of, e.g., the financial easing shock as a LTV shock in the DSGE model represents a lending shock in terms of quantities and thus excludes an also conceivable relaxation of bank lending standards in terms of prices, i.e., mortgage rates. Therefore, the easing shock is not able to explicitly capture all facets of eased lending standards emerging from, e.g., stronger competition within the banking sector.

## 5.2 Alternative set of sign restrictions

The benchmark set of sign restrictions from Table 2 imposes restrictions on the current account, while leaving both housing market variables unrestricted. As a consequence, only the magnitude of the response is informative for the current account in the restricted impact quarter. In line with the DSGE model simulations from Figures 5 to 9, we can allow for an alternative identification strategy, which leaves the current account unrestricted over the whole forecast horizon. Instead, we impose a positive reaction on real house prices for all shocks in the impact quarter. We refrain from restricting higher impulse response horizons as such a restriction does not hold for the financial easing shock. The set of sign restrictions for this alternative identification scheme is summarized in Table 3.

Figure 17 plots the VAR dynamics for the new identification scheme. Confirming the findings of the benchmark identification restrictions, the evidence of Figure 17 closely resembles the impulse responses of Figure 16. Due to the positive impact restriction on house prices, though, the latter rise significantly following a savings glut shock and remain significantly positive over the whole forecast horizon, while the residential investment response is little affected by the different identification scheme. Interestingly, for the savings glut shock, the unrestricted current account falls significantly after some quarters – a finding that, in particular, holds for the risk premium shock, which forces the current account to fall already in the impact period. The house price reaction is significant over a longer horizon for the risk premium shock, while the residential investment response, again, largely mirrors the results of the benchmark identification. For the housing bubble shock, the qualitative behavior of the impulse response functions does not change substantially for any of the key variables. Yet, for the financial easing shock, we now impose a positive impact reaction on house prices – a restriction for which we find no support in the benchmark specification where house prices are unrestricted and tend to fall in the data following the financial easing shock. Consistently, the imposed house price increase in the new identification scheme only holds for the impact quarter. Then, house prices overshoot the pre-shock level and turn negative, albeit insignificant. Residential investment still declines and, most notably, the financial easing shock predicts no current account deterioration, which resonates with the benchmark identification, where the current account turns positive after some quarters. In summary, our main findings are robust to this alternative identification assumptions.

## 5.3 Different sample: Excluding Draghi’s speech

Ultimately, we assess the main findings of the paper against a modification of the data sample. During the Euro crisis, one particular moment stands out as being a game changer within the crisis. Namely, ECB president Draghi’s speech at the Global Investment Conference in London on 26 July 2012. Explicitly stating that the Euro was “*irreversible*”, Draghi tended to convince market participants to view the Euro as an economic restriction, which should no longer be called into question, i.e., a given restriction around which market participants should optimize. Says Draghi: “*Within our mandate, the ECB is ready to do whatever it takes to preserve the euro.*”

*And believe me, it will be enough*".<sup>17</sup> Following the speech, among others, risk premia on sovereign bonds of countries in the southern periphery of the Euro Area tumbled (see also Figure 3) contributing to a temporary calming of financial markets. We test to what extent our results are affected by the post-Draghi-speech sub-sample and re-run the regression with an ending date in June 2012, both, for the benchmark identification (Figure 18) and the identification scheme with an unrestricted current account and a positive impact restriction on house prices (Figure 19). Observing both figures, no notable differences compared to the benchmark sample emerge.

## 6 Conclusion

Since the late 1990's, two macroeconomic cycles, which hampered policy makers and attracted great interest of academics and the news media, have been characterizing the Spanish economy: The persistent build-up of a housing bubble and the pronounced deterioration of the current account. With the onset of the Great Recession, both developments reverted sharply. To our knowledge, we are the first to put different hypotheses to a test by quantitatively studying this joint co-movement in the data through the lens of an open-economy VAR that explicitly takes into account the specifics of a monetary union by deriving robust sign restrictions from a single currency area DSGE model. Savings glut, risk premium, and housing bubble shocks are able to generate the imbalances of Spain vis-à-vis the rest of the Eurozone and, at the same time, a housing boom in Spain. In contrast, financial easing shocks are neither capable of generating a distinct deterioration of the Spanish current account, nor of triggering a housing boom in Spain. In contrast, financial easing shocks are counterfactual to the housing boom, as a loosening of lending standards coincides with a cooling down in housing markets in our structural VAR analysis.

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<sup>17</sup>See <https://www.ecb.europa.eu/press/key/date/2012/html/sp120726.en.html> for the complete speech.



## References

- Acharya, V. V., Schnabl, P., 2010. Do global banks spread global imbalances? Asset-backed commercial paper during the financial crisis of 2007-09. *IMF Economic Review* 58 (1), 37–73.
- Adam, K., Kuang, P., Marcet, A., 2012. House price booms and the current account. *NBER Macroeconomics Annual* 26 (1), 77 – 122.
- Akin, O., Montalvo, J., Villar, J. G., Peydró, J.-L., Raya, J., 2014. The real estate and credit bubble: Evidence from Spain. *SERIEs* 5 (2), 223–243.
- Aspachs-Bracons, O., Rabanal, P., 2011. The effects of housing prices and monetary policy in a currency union. *International Journal of Central Banking* 7 (1), 225–274.
- Bassett, W. F., Chosak, M. B., Driscoll, J. C., Zakrajšek, E., 2014. Changes in bank lending standards and the macroeconomy. *Journal of Monetary Economics* 62 (C), 23–40.
- Bernanke, B. S., 2005. The global saving glut and the U.S. current account deficit. Speech 77, Board of Governors of the Federal Reserve System (U.S.).
- Bernanke, B. S., Gertler, M., 1999. Monetary policy and asset price volatility. *Economic Review* (Q IV), 17–51.
- Calvo, G., Leiderman, L., Reinhart, C., 1993. Capital inflows and real exchange rate appreciation in latin america: The role of external factors. *IMF Staff Papers* Vol. 40, No. 1, 108-151.
- Calvo, G. A., 1983. Staggered prices in a utility-maximizing framework. *Journal of Monetary Economics* 12 (3), 383–398.
- Canova, F., de Nicro, G., 2002. Monetary disturbances matter for business fluctuations in the G-7. *Journal of Monetary Economics* 49 (6), 1131–1159.
- Canova, F., Paustian, M., 2011. Business cycle measurement with some theory. *Journal of Monetary Economics* 58 (4), 345–361.
- Catão, L. A., Milesi-Ferretti, G. M., 2014. External liabilities and crises. *Journal of International Economics* 94 (1), 18–32.
- Cheng, I.-H., Raina, S., Xiong, W., 2014. Wall street and the housing bubble. *American Economic Review* 104 (9), 2797–2829.
- Christiano, L. J., Eichenbaum, M., Evans, C. L., 2005. Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of Political Economy* 113 (1), 1–45.
- Christoffel, K., Coenen, G., Warne, A., 2008. The New Area-Wide Model of the Euro Area: A micro-founded open-economy model for forecasting and policy analysis. Working Paper Series 0944, European Central Bank.

- Ciccarelli, M., Maddaloni, A., Peydro, J. L., 2015. Trusting the bankers: A new look at the credit channel of monetary policy. *Review of Economic Dynamics*, in press.
- Coenen, G., McAdam, P., Straub, R., August 2008. Tax reform and labour-market performance in the Euro Area: A simulation-based analysis using the New Area-Wide Model. *Journal of Economic Dynamics and Control* 32 (8), 2543–2583.
- Crespo-Cuaresma, J., Fernández-Amador, O., 2013. Business cycle convergence in EMU: A first look at the second moment. *Journal of Macroeconomics* 37 (C), 265–284.
- Davis, M. A., Heathcote, J., 2005. Housing and the business cycle. *International Economic Review* 46 (3), 751–784.
- Dees, S., di Mauro, F., Smith, L. V., Pesaran, M. H., 2007. Exploring the international linkages of the Euro Area: A global VAR analysis. *Journal of Applied Econometrics* 22 (1), 1–38.
- Eraker, B., Chiu, C. W. J., Foerster, A. T., Kim, T. B., Seoane, H., 2014. Bayesian mixed frequency VARs. *Journal of Financial Econometrics* (forthcoming).
- Erceg, C. J., Henderson, D. W., Levin, A. T., 2000. Optimal monetary policy with staggered wage and price contracts. *Journal of Monetary Economics* 46 (2), 281–313.
- Faust, J., 1998. The robustness of identified VAR conclusions about money. *Carnegie-Rochester Conference Series on Public Policy* 49, 207–244.
- Fernández-Villaverde, J., Garicano, L., Santos, T., 2013. Political credit cycles: The case of the Eurozone. *Journal of Economic Perspectives* 27 (3), 145–66.
- Forni, C., Marcellino, M., 2013. A survey of econometric methods for mixed-frequency data. *Economics Working Papers ECO2013/02*, European University Institute.
- Fratzscher, M., 2012. Capital flows, push versus pull factors and the global financial crisis. *Journal of International Economics* 88 (2), 341–356.
- Fratzscher, M., Juvenal, L., Sarno, L., 2010. Asset prices, exchange rates and the current account. *European Economic Review* 54 (5), 643–658.
- Fry, R., Pagan, A., 2011. Sign restrictions in structural vector autoregressions: A critical review. *Journal of Economic Literature* 49 (4), 938–60.
- Ghysels, E., 2015. Macroeconomics and the reality of mixed frequency data. *Journal of Econometrics*, forthcoming.
- Giavazzi, F., Spaventa, L., 2011. Why the current account may matter in a monetary union: Lessons from the financial crisis in the Euro Area. *The Euro Area and the Financial Crisis*, in D. Cobham (ed.), Cambridge University Press.

- Goddard, J., Molyneux, P., Wilson, J. O., Tavakoli, M., 2007. European banking: An overview. *Journal of Banking & Finance* 31 (7), 1911–1935.
- Gonzalez, L., Ortega, F., 2013. Immigration and housing booms: Evidence from Spain. *Journal of Regional Science* 53 (1), 37–59.
- Hale, G. B., Obstfeld, M., 2014. The Euro and the geography of international debt flows. CEPR Discussion Papers 9937, C.E.P.R. Discussion Papers.
- Helbling, T., Huidrom, R., Kose, M. A., Otrok, C., 2011. Do credit shocks matter? A global perspective. *European Economic Review* 55 (3), 340–353.
- Hristov, N., Hülsewig, O., Wollmershäuser, T., 2012. Loan supply shocks during the financial crisis: Evidence for the Euro Area. *Journal of International Money and Finance* 31 (3), 569–592.
- Hristov, N., Hülsewig, O., Wollmershäuser, T., 2014. Financial frictions and inflation differentials in a monetary union. *Manchester School* 82 (5), 549–595.
- Iacoviello, M., 2005. House prices, borrowing constraints, and monetary policy in the business cycle. *American Economic Review* 95 (3), 739–764.
- Iacoviello, M., Neri, S., 2010. Housing market spillovers: Evidence from an estimated DSGE model. *American Economic Journal: Macroeconomics* 2 (2), 125–64.
- In't Veld, J., Kollmann, R., Pataracchia, B., Ratto, M., Roeger, W., 2014. International capital flows and the boom-bust cycle in Spain. *Journal of International Money and Finance* 48 (PB), 314–335.
- In't Veld, J., Raciborski, R., Ratto, M., Roeger, W., 2011. The recent boom-bust cycle: The relative contribution of capital flows, credit supply and asset bubbles. *European Economic Review* 55 (3), 386–406.
- Justiniano, A., Primiceri, G., Tambalotti, A., 2014. The effects of the saving and banking glut on the U.S. economy. *Journal of International Economics* 92, S52–S67.
- Justiniano, A., Primiceri, G., Tambalotti, A., 2015. Household leveraging and deleveraging. *Review of Economic Dynamics* 18 (1), 3–20.
- Kiyotaki, N., Moore, J., 1997. Credit cycles. *Journal of Political Economy* 105 (2), 211–48.
- Laibson, D., Mollerstrom, J., 2010. Capital flows, consumption booms and asset bubbles: A behavioural alternative to the savings glut hypothesis. *Economic Journal* 120 (544), 354–374.
- Lenza, M., Pill, H., Reichlin, L., 2010. Monetary policy in exceptional times. *Economic Policy* 25, 295–339.

- Ling, D., C., Ooi, J., Le, T., 2014. Explaining house price dynamics: Isolating the role of non-fundamentals. *Journal of Money, Credit, and Banking*, forthcoming.
- Mayer, E., Gareis, J., 2013. What drives Ireland's housing market? A Bayesian DSGE approach. *Open Economies Review* 24 (5), 919–961.
- Mendoza, E. G., Quadrini, V., Ríos-Rull, J.-V., 2009. Financial integration, financial development, and global imbalances. *Journal of Political Economy* 117 (3), 371–416.
- Monacelli, T., 2009. New Keynesian models, durable goods, and collateral constraints. *Journal of Monetary Economics* 56 (2), 242–254.
- Obstfeld, M., 2012. Financial flows, financial crises, and global imbalances. *Journal of International Money and Finance* 31 (3), 469–480.
- Pariès, M. D., Notarpietro, A., 2008. Monetary policy and housing prices in an estimated DSGE model for the US and the Euro Area. Working Paper Series 972, European Central Bank.
- Paustian, M., 2007. Assessing sign restrictions. *The B.E. Journal of Macroeconomics* 7 (1), 1–33.
- Peersman, G., 2005. What caused the early millennium slowdown? Evidence based on vector autoregressions. *Journal of Applied Econometrics* 20 (2), 185–207.
- Peersman, G., Straub, R., 2009. Technology shocks and robust sign restrictions in a Euro Area SVAR. *International Economic Review* 50 (3), 727–750.
- Qian, H., 2013. Vector autoregression with mixed frequency data. Munich personal repec archive, No. 57856.
- Quint, D., Rabanal, P., 2014. Monetary and macroprudential policy in an estimated DSGE model of the Euro Area. *International Journal of Central Banking* 10 (2), 169–236.
- Rabanal, P., 2009. Inflation differentials between Spain and the EMU: A DSGE perspective. *Journal of Money, Credit and Banking* 41 (6), 1141–1166.
- Sá, F., Wieladek, T., 2015. Capital inflows and the US housing boom. *Journal of Money, Credit and Banking* 47, 221–256.
- Schmitt-Grohé, S., Uribe, M., 2003. Closing small open economy models. *Journal of International Economics* 61 (1), 163–185.
- Shiller, R. J., 2005. *Irrational exuberance*. Princeton University Press.
- Shiller, R. J., 2007. Understanding recent trends in house prices and home ownership. NBER Working Papers 13553, National Bureau of Economic Research, Inc.
- Shin, H. S., 2012. Global banking glut and loan risk premium. *IMF Economic Review* 60 (2), 155–192.

- Smets, F., Wouters, R., 2003. An estimated dynamic stochastic general equilibrium model of the Euro Area. *Journal of the European Economic Association* 1 (5), 1123–1175.
- Smets, F., Wouters, R., 2007. Shocks and frictions in US business cycles: A Bayesian DSGE approach. *American Economic Review* 97 (3), 586–606.
- Taylor, J. B., 1993. Discretion versus policy rules in practice. *Carnegie-Rochester Conference Series on Public Policy* 39 (1), 195–214.
- Uhlig, H., 2005. What are the effects of monetary policy on output? Results from an agnostic identification procedure. *Journal of Monetary Economics* 52 (2), 381–419.

## Tables

Table 1: Parameter Intervals

Parameter	Description	Range
$\theta_{W,C}$	Wage stickiness: non-durable sector	[0.60, 0.90]
$\theta_{W,D}$	Wage stickiness: durable sector	[0.00, 0.30]
$\gamma_{W,C}$	Wage indexation: non-durable sector	[0.50, 0.90]
$\gamma_{W,D}$	Wage indexation: durable sector	[0.00, 0.40]
$\mathcal{M}_C$	Wage markup in steady state: non-durable sector	[1.10, 1.50]
$\mathcal{M}_D$	Wage markup in steady state: durable sector	[1.10, 1.50]
$1 + \lambda$	Price markup in steady state	[1.10, 1.50]
$h$	Habit parameter	[0.40, 0.80]
$\eta$	Inverse Frisch elasticity	[1.50, 2.50]
$\rho$	Adjustment cost: investment	[1.00, 7.00]
$v$	Degree of capital utilization	[0.10, 0.50]
$\theta_{P,C}$	Price stickiness: non-durable sector	[0.60, 0.90]
$\theta_{P,D}$	Price stickiness: durable sector	[0.00, 0.30]
$\gamma_{P,C}$	Price indexation: non-durable sector	[0.30, 0.90]
$\gamma_{P,D}$	Price indexation: durable sector	[0.00, 0.40]
$\mu_{\Pi}$	Reaction coefficient: inflation	[1.15, 3.00]
$\mu_R$	Interest rate smoothing	[0.50, 0.90]
$\mu_{\Delta Y}$	Reaction coefficient: change in output	[0.00, 0.30]
$\mu_{\Delta \Pi}$	Reaction coefficient: change in inflation	[0.00, 0.25]
$\rho_B$	Persistence: housing bubble shock	[0.95, 0.99]
$\rho_{LTV}$	Persistence: financial easing shock	[0.95, 0.99]
$\rho_{\beta}$	Persistence: savings glut shock	[0.40, 0.60]
$\rho_{RP}$	Persistence: risk premium shock	[0.95, 0.99]
$\rho_{AD}$	Persistence: housing technology shock	[0.95, 0.99]

*Notes:* The Table displays the parameter ranges employed to simulate the model.

Table 2: Benchmark Sign Restrictions

	Savings Glut	Financ. Easing	Risk Premium	Housing Bubble
Real Consumption	↑	↑	↑	↑
Real Consumption*	↓	↓	↓	↓
Prices	↓	↑	↑	↑
EONIA	↓	↑	↑	↑
Bond Rate	↓	↑	↓	↑
Bond Rate*				
Loans				
Current Account/GDP	↓	↓	↓	↓
Real House Prices				
Real Res. Investment				
Cons.-to-Investm.		↑		↓

*Notes:* Except for the current account, where we only restrict the impact quarter, we impose the restrictions for three quarters, i.e., 9 months as  $\leq 0$  or  $\geq 0$  (see, e.g., Sá and Wieladek, 2015).

Table 3: Alternative Sign Restrictions

	Savings Glut	Financ. Easing	Risk Premium	Housing Bubble
Real Consumption	↑	↑	↑	↑
Real Consumption*	↓	↓	↓	↓
Prices	↓	↑	↑	↑
EONIA	↓	↑	↑	↑
Bond Rate	↓	↑	↓	↑
Bond Rate*				
Loans				
Current Account/GDP				
Real House Prices	↑	↑	↑	↑
Real Res. Investment				
Cons.-to-Investm.		↑		↓

*Notes:* Except for real house prices, where we only restrict the impact quarter, we impose the restrictions for three quarters, i.e., 9 months as  $\leq 0$  or  $\geq 0$  (see, e.g., Sá and Wieladek, 2015).

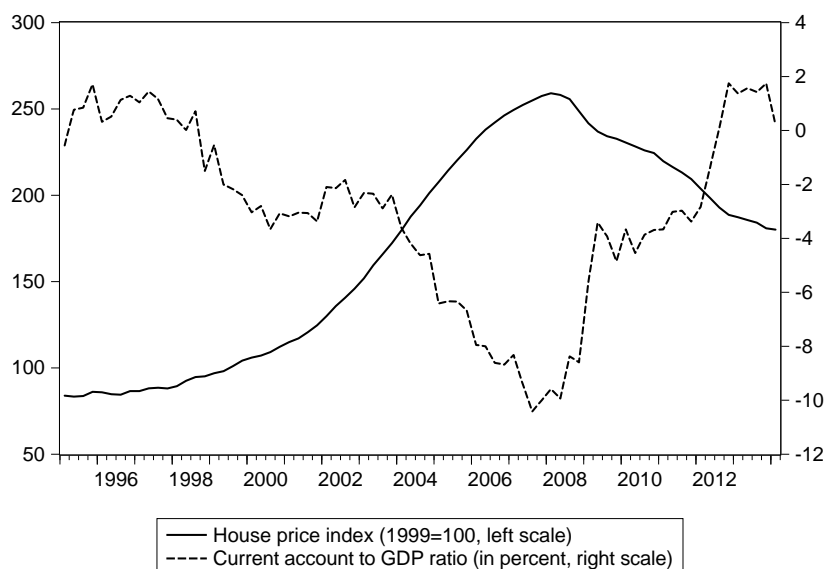
Table 4: Forecast Error Variance Decomposition

	Horizon	Current Account	House Prices	Res. Investment
Savings Glut Shock	Impact	3.88 (0.34, 17.60)	7.49 (0.79, 26.54)	5.00 (0.37, 21.8)
	6 Months	6.34 (1.91, 16.68)	5.35 (1.27, 15.14)	4.39 (0.87, 18.90)
	12 Months	6.01 (1.51, 18.17)	5.04 (1.22, 16.38)	4.69 (0.94, 18.73)
	24 Months	5.61 (1.19, 17.34)	5.28 (1.18, 16.47)	4.88 (1.16, 18.32)
	48 Months	5.05 (1.18, 16.40)	4.97 (1.30, 16.17)	5.07 (1.28, 17.62)
	Risk Premium Shock	Impact	5.63 (0.69, 22.49)	4.79 (0.55, 19.92)
6 Months		7.78 (2.51, 19.57)	5.97 (1.05, 24.67)	7.98 (1.56, 22.65)
12 Months		7.50 (1.98, 19.89)	6.48 (1.16, 23.76)	7.63 (1.76, 22.80)
24 Months		6.63 (1.42, 21.53)	6.76 (1.16, 22.56)	8.16 (2.13, 22.43)
48 Months		6.76 (1.53, 21.54)	7.04 (1.37, 21.04)	8.53 (2.31, 21.94)
Financial Easing Shock		Impact	6.72 (0.53, 18.59)	6.23 (0.61, 21.77)
	6 Months	7.84 (1.98, 28.52)	6.09 (1.04, 20.36)	7.44 (1.45, 25.48)
	12 Months	7.88 (2.04, 17.88)	6.19 (1.08, 20.29)	7.52 (1.40, 24.94)
	24 Months	7.02 (1.81, 19.00)	6.65 (1.25, 20.62)	7.93 (1.75, 23.14)
	48 Months	7.29 (1.72, 20.90)	7.35 (1.32, 20.96)	7.79 (2.16, 22.59)
	Housing Bubble Shock	Impact	3.84 (0.31, 17.35)	4.98 (0.54, 19.68)
6 Months		5.92 (1.66, 15.04)	5.76 (1.34, 19.91)	4.72 (0.81, 18.97)
12 Months		5.88 (1.70, 16.11)	5.61 (1.55, 18.82)	4.83 (0.82, 18.14)
24 Months		5.79 (1.29, 17.63)	5.65 (1.37, 18.70)	5.23 (1.07, 17.74)
48 Months		5.88 (1.19, 18.56)	6.07 (1.64, 18.93)	5.33 (1.41, 17.95)

*Notes:* Results are in percent for the median draw and we report the 68 percent credible sets in brackets.

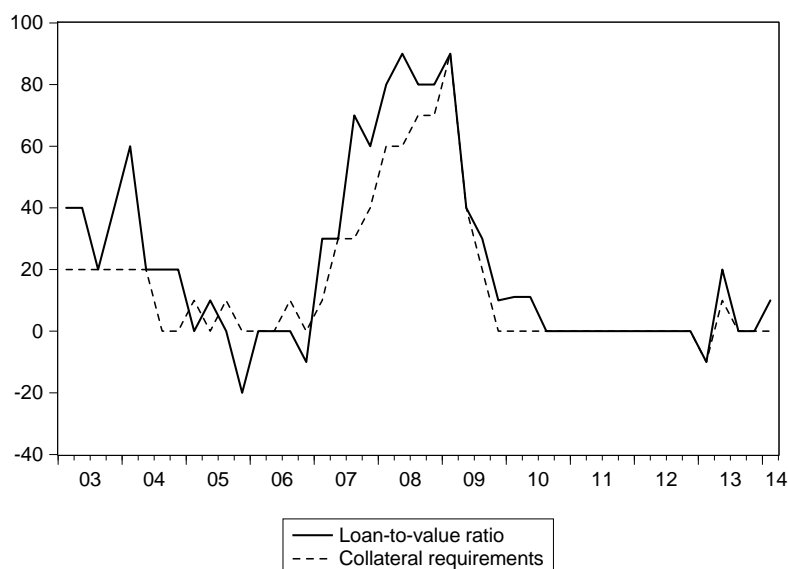
# Figures

Figure 1: Current Account and House Price Dynamics



*Notes:* The figure presents the current account to GDP ratio and house prices for Spain. We obtain the data from Eurostat and BIS.

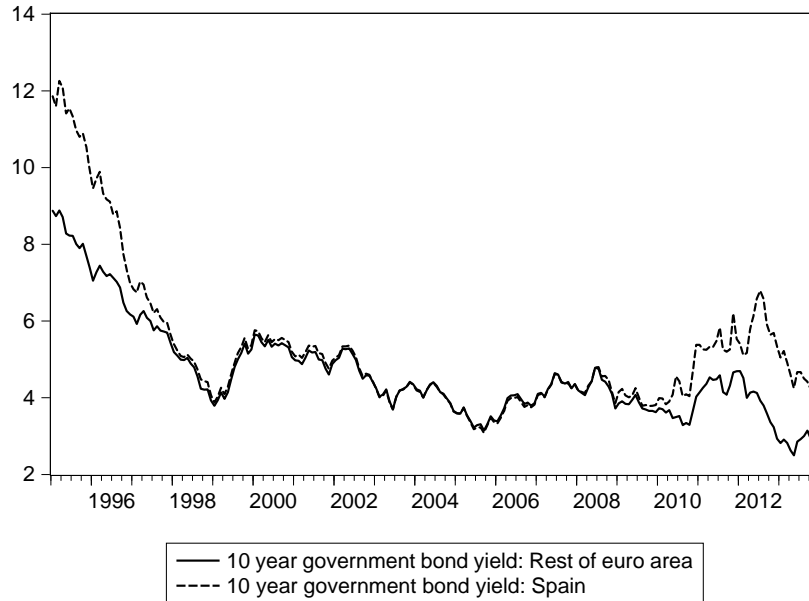
Figure 2: Changes in Spanish Banks' Lending Standards



*Notes:* The figure shows the change in banks' conditions for housing loans to households over the past three months (frequency of tightened minus eased lending standards). We obtain the data from the ECB's bank lending survey, which is available since 2003.

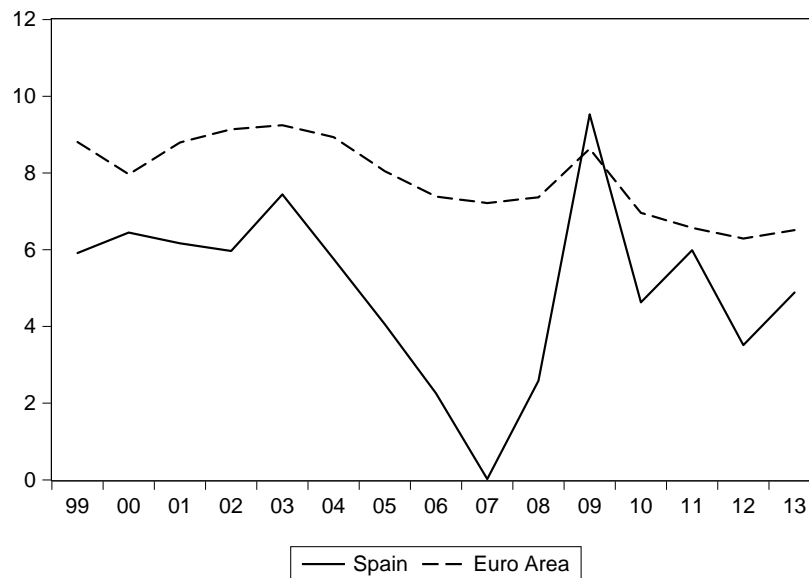


Figure 3: 10-Year Government Bond Yields



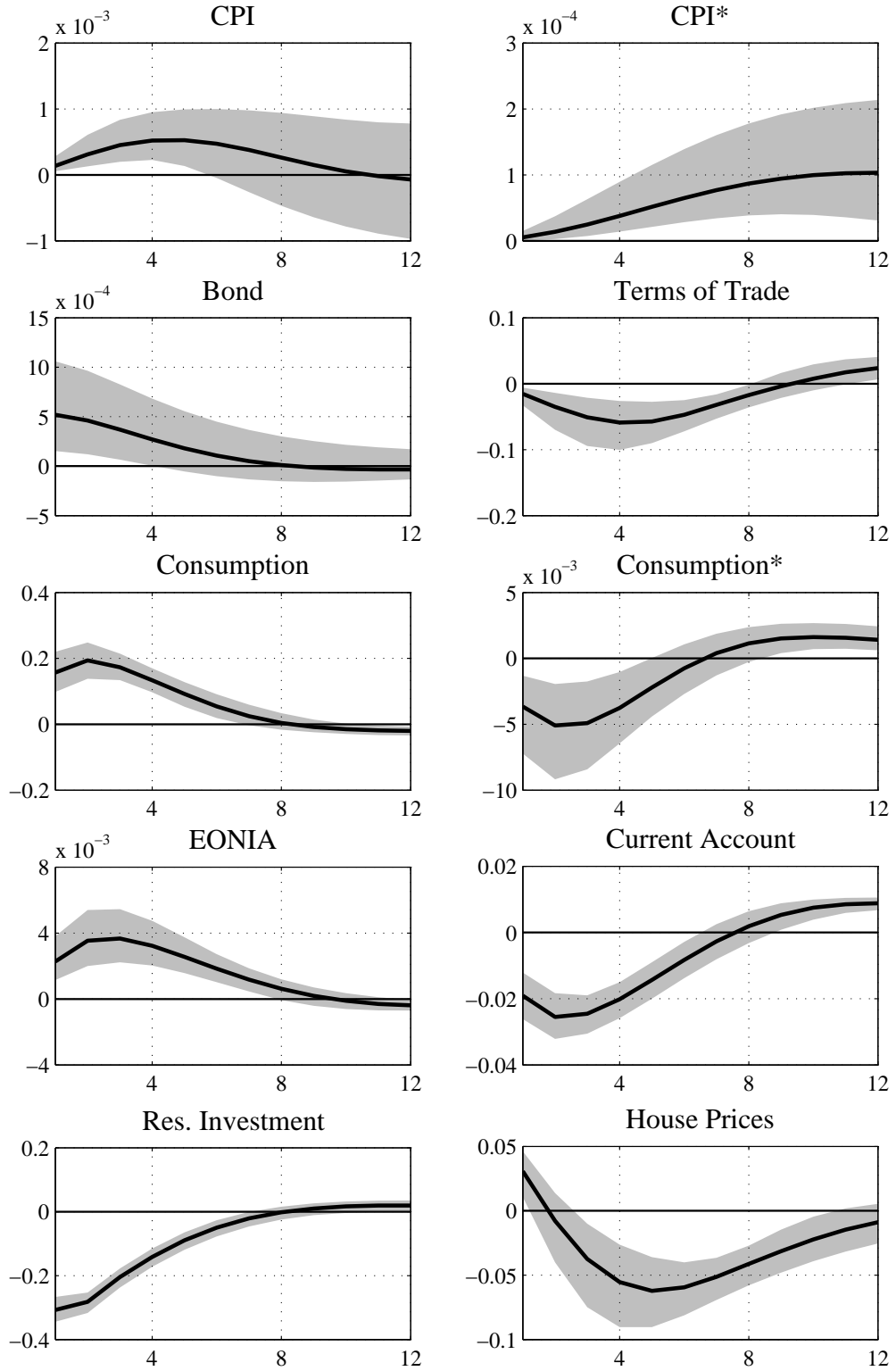
*Notes:* The figure depicts the development of 10-year government bond yields for Spain and the rest of the Euro Area. We obtain the data from Eurostat.

Figure 4: Net Household Saving as Percentage of Net Disposable Income



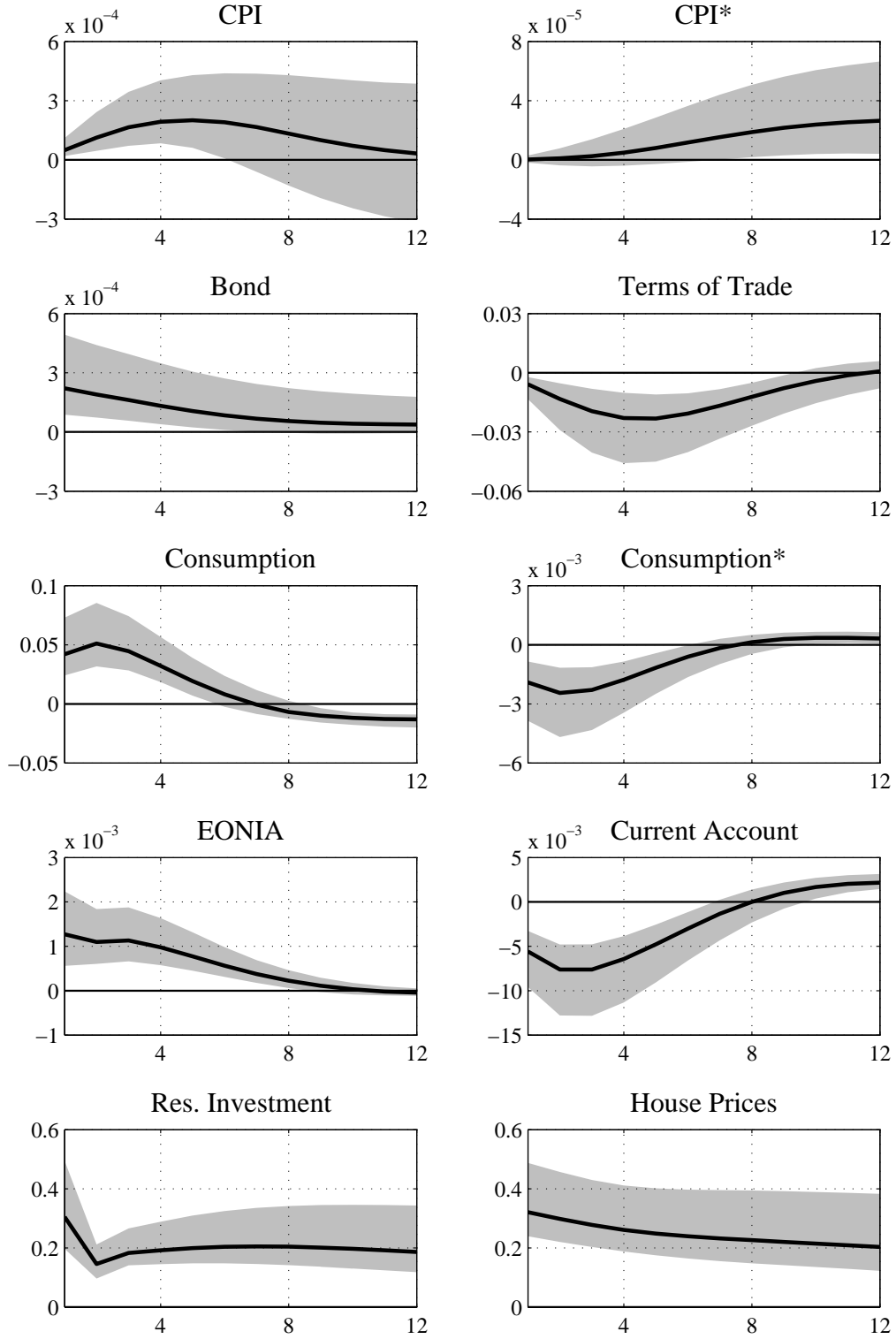
*Notes:* The figure portrays net household saving as a percentage of net disposable income for Spain and the rest of the Euro Area. We obtain the data from the OECD.

Figure 5: Financial Easing Shock



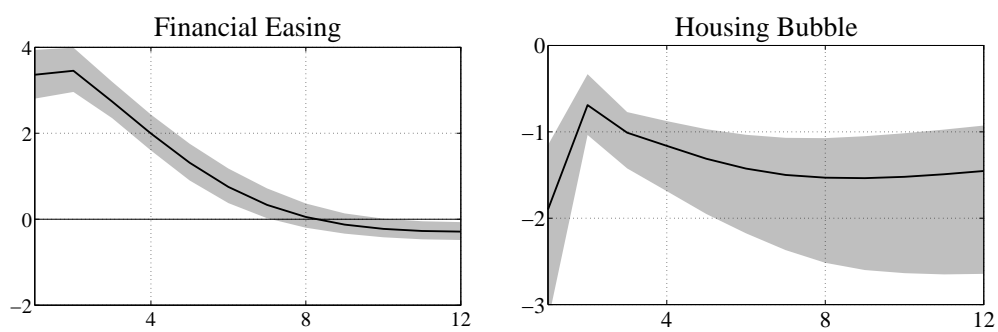
*Notes:* The x-axis is in quarters. The y-axis measures percent deviations from steady state. The solid line represents the median impulse response. Shaded areas display 10% and 90% percentiles of the simulated impulse responses.

Figure 6: Housing Bubble Shock



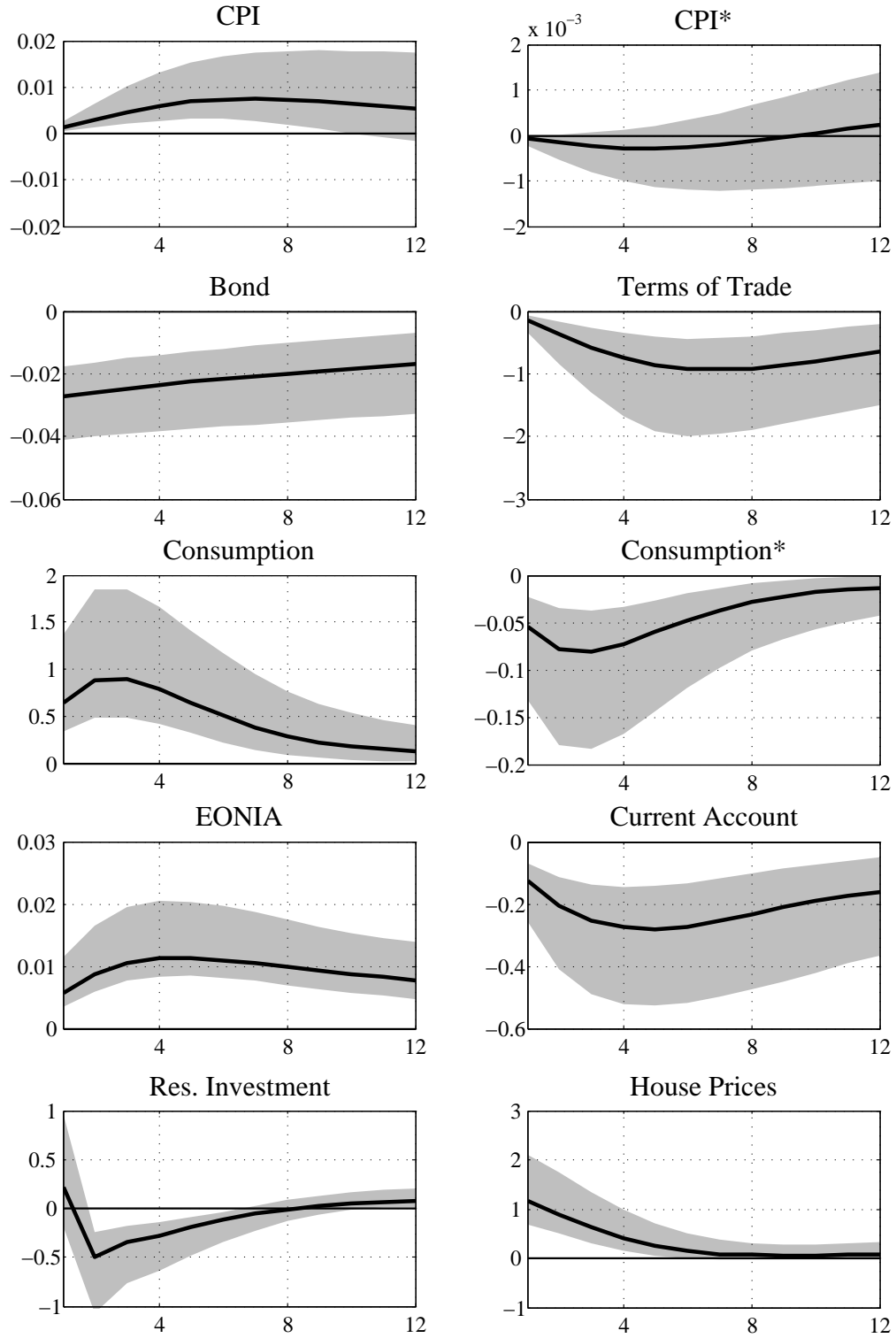
*Notes:* The x-axis is in quarters. The y-axis measures percent deviations from steady state. The solid line represents the median impulse response. Shaded areas display 10% and 90% percentiles of the simulated impulse responses.

Figure 7: Consumption to Residential Investment Ratio



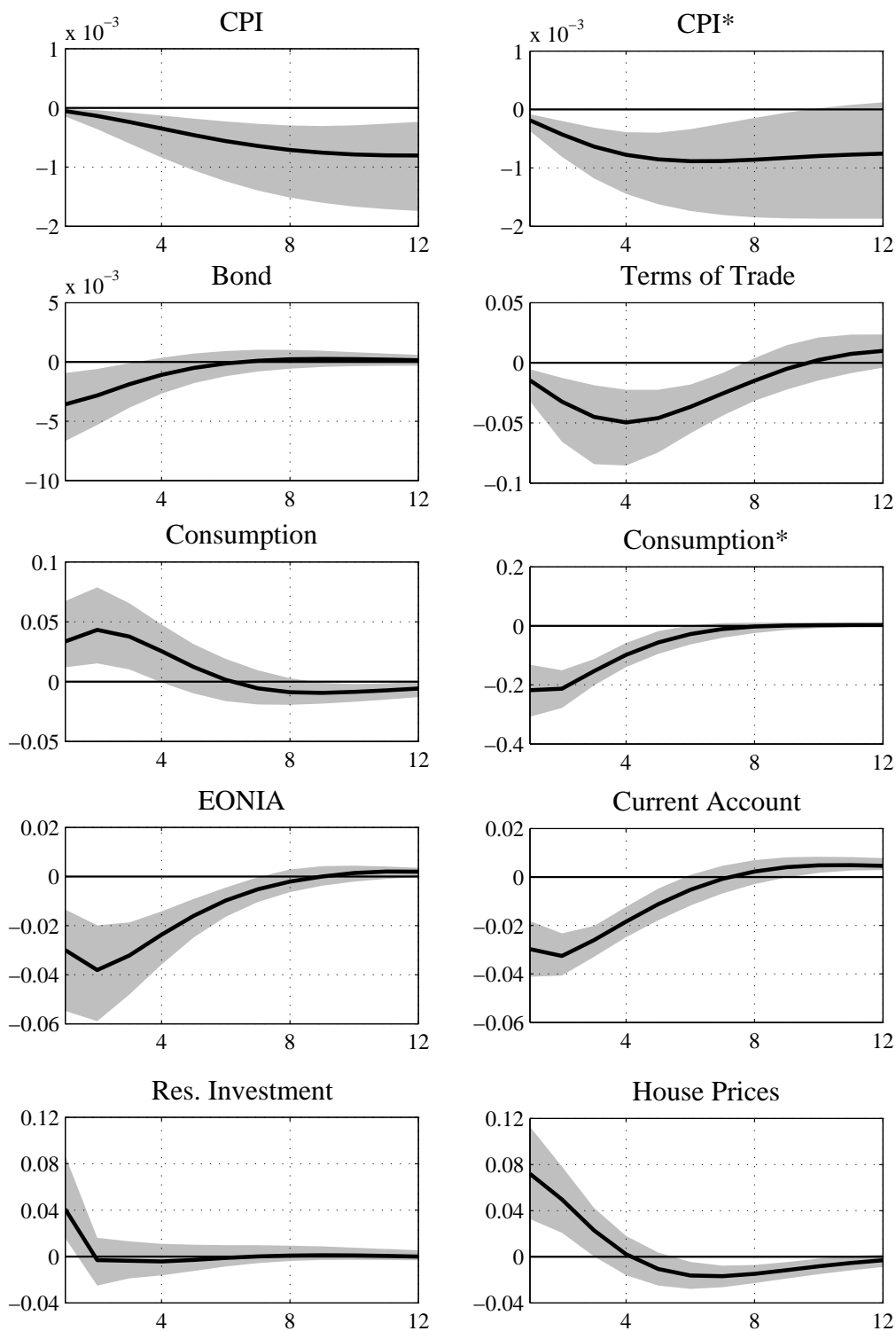
*Notes:* The x-axis is in quarters. The y-axis measures percent deviations from steady state. The solid line represents the median impulse response. Shaded areas display 10% and 90% percentiles of the simulated impulse responses.

Figure 8: Risk Premium Shock



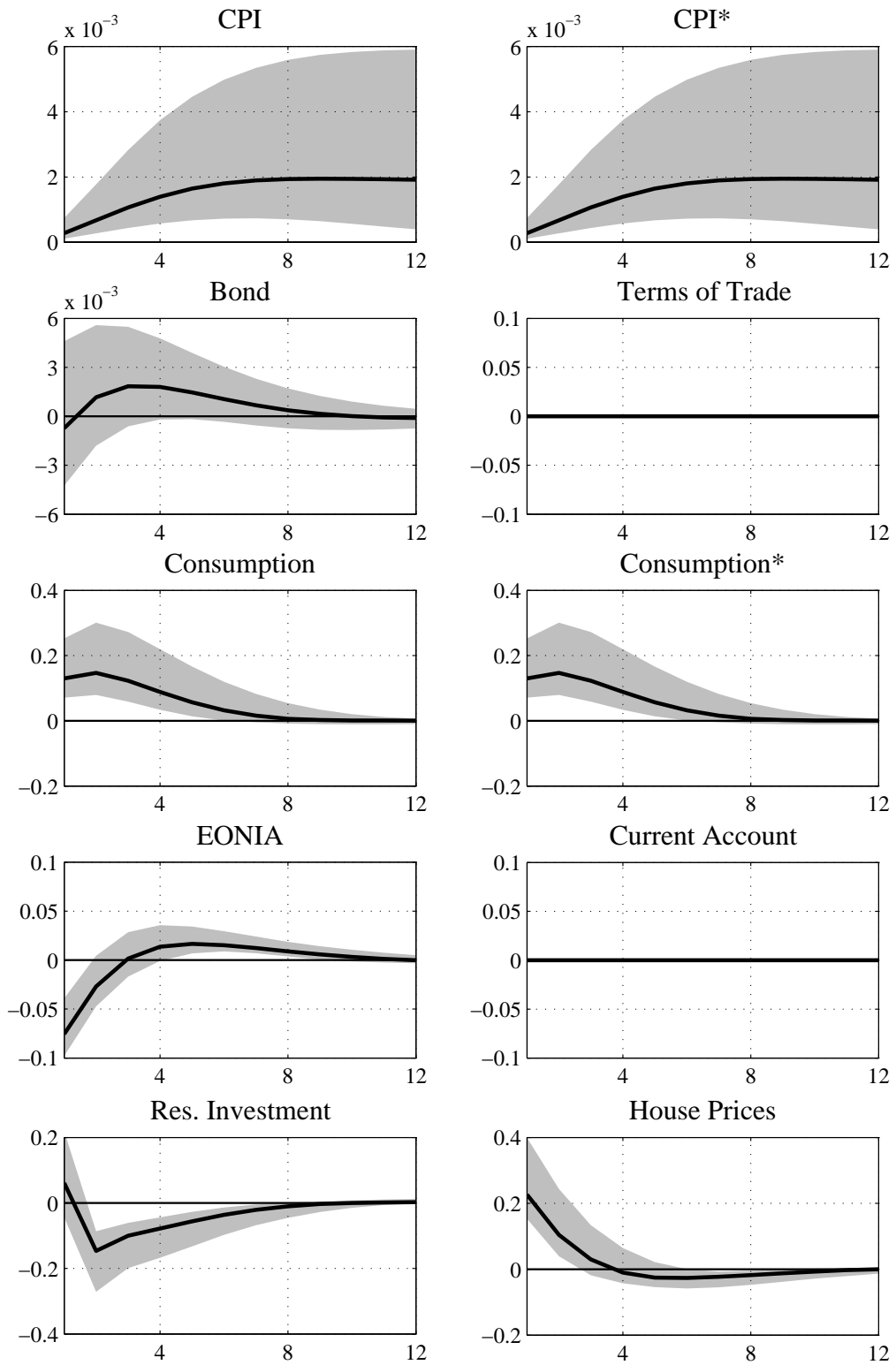
*Notes:* The x-axis is in quarters. The y-axis measures percent deviations from steady state. The solid line represents the median impulse response. Shaded areas display 10% and 90% percentiles of the simulated impulse responses.

Figure 9: Savings Glut Shock



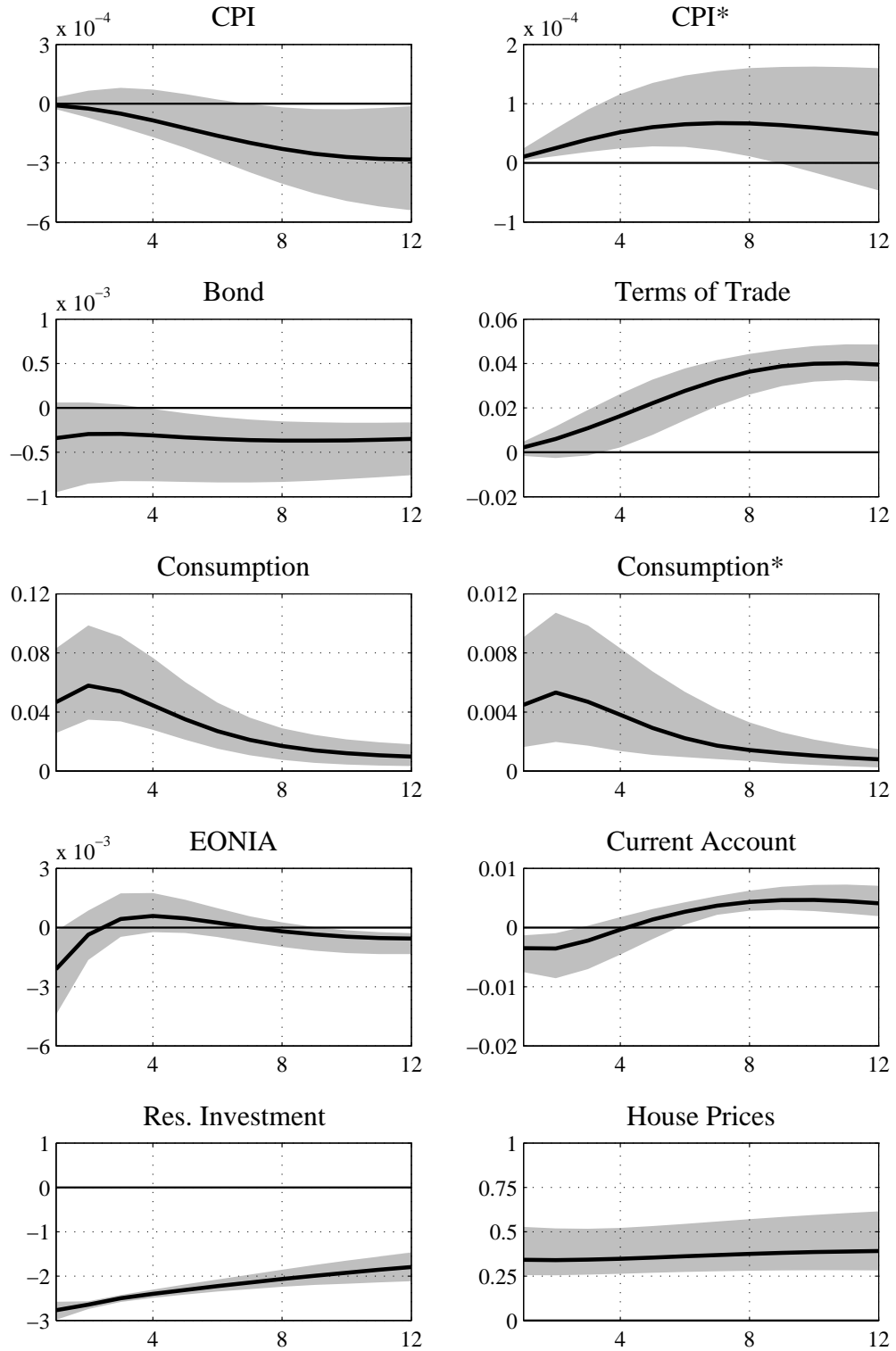
*Notes:* The x-axis is in quarters. The y-axis measures percent deviations from steady state. The solid line represents the median impulse response. Shaded areas display 10% and 90% percentiles of the simulated impulse responses.

Figure 10: Monetary Policy Shock



*Notes:* The x-axis is in quarters. The y-axis measures percent deviations from steady state. The solid line represents the median impulse response. Shaded areas display 10% and 90% percentiles of the simulated impulse responses.

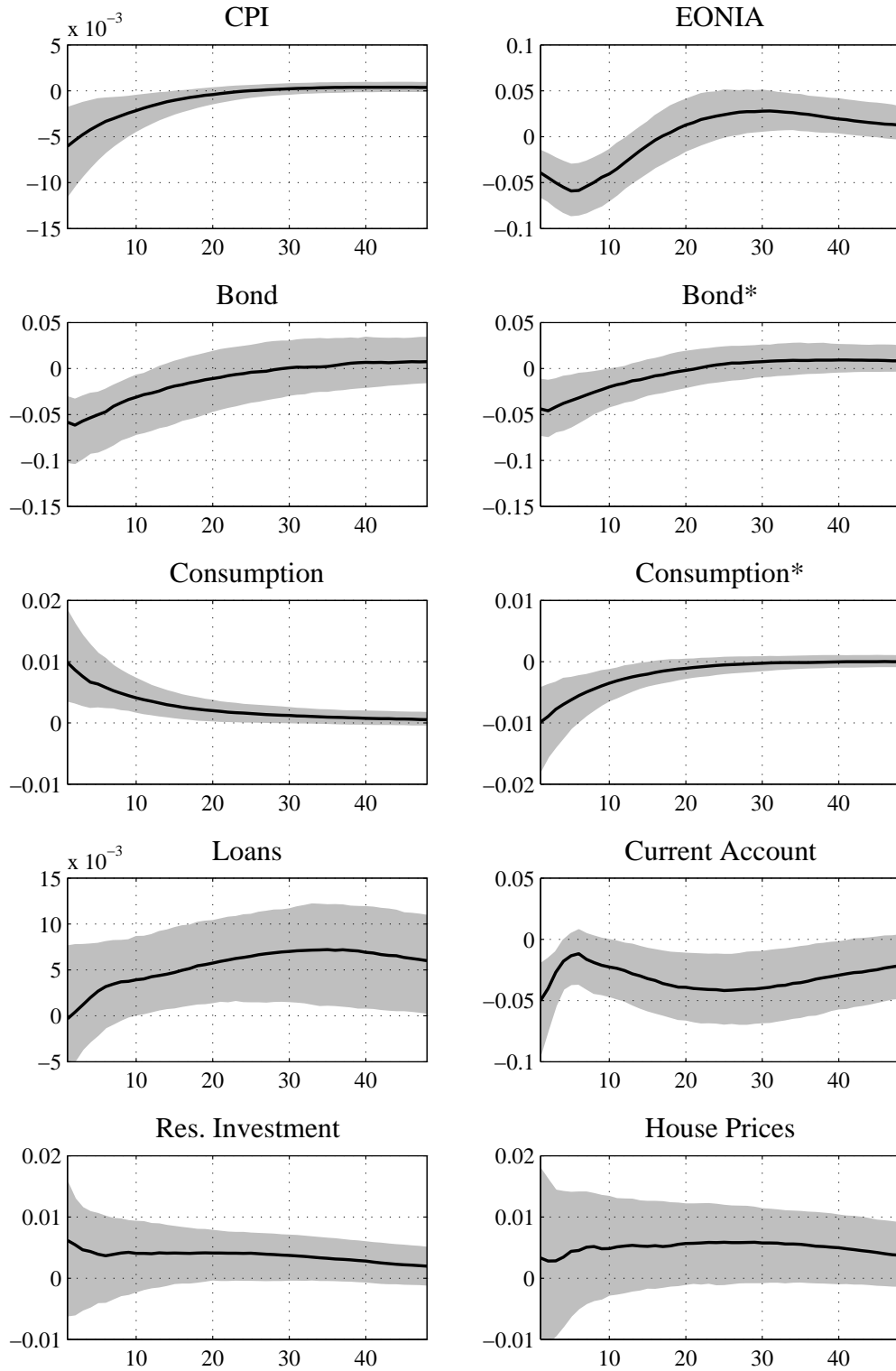
Figure 11: Housing Technology Shock



*Notes:* The x-axis is in quarters. The y-axis measures percent deviations from steady state. The solid line represents the median impulse response. Shaded areas display 10% and 90% percentiles of the simulated impulse responses.

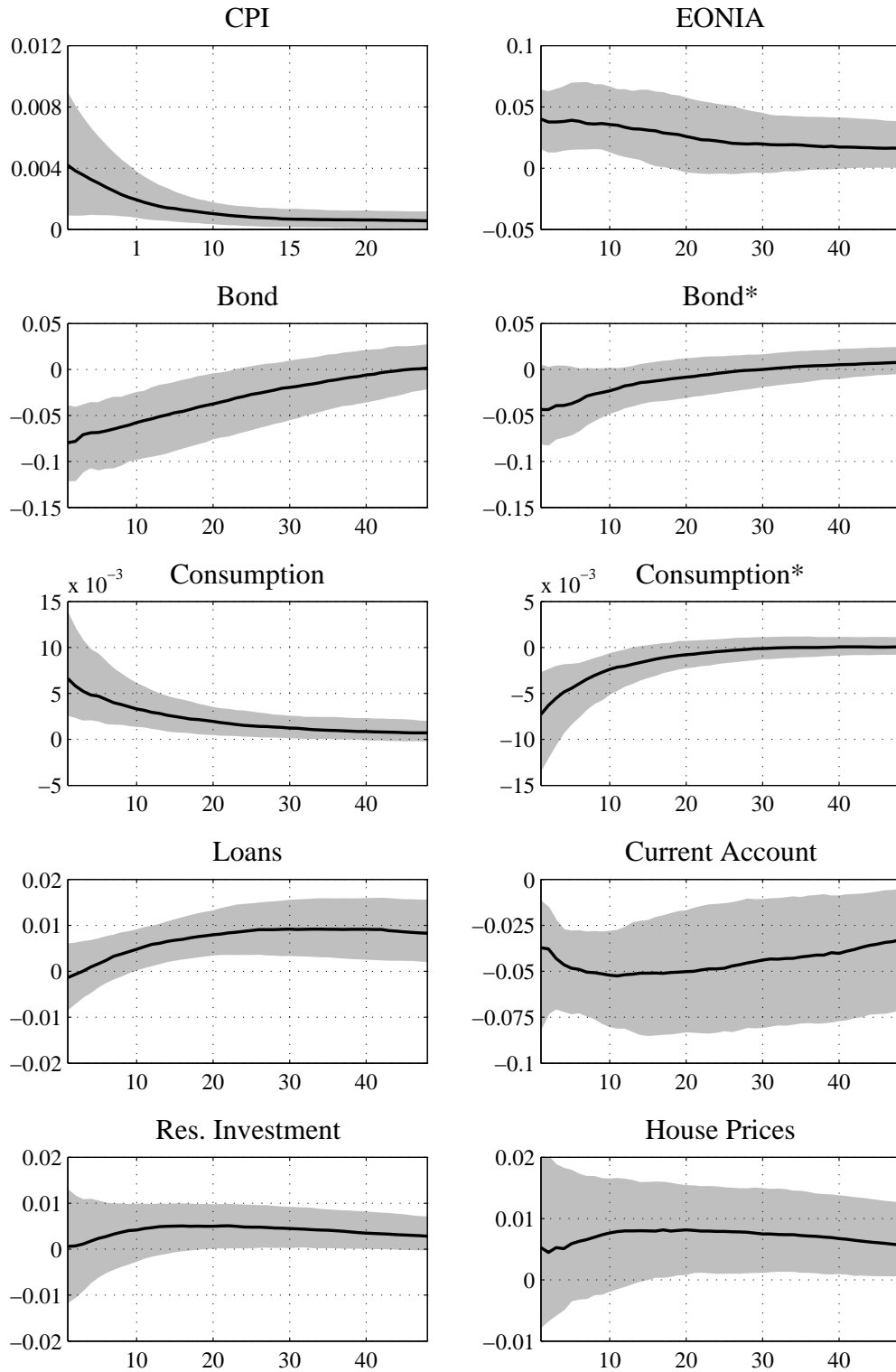


Figure 12: Savings Glut Shock



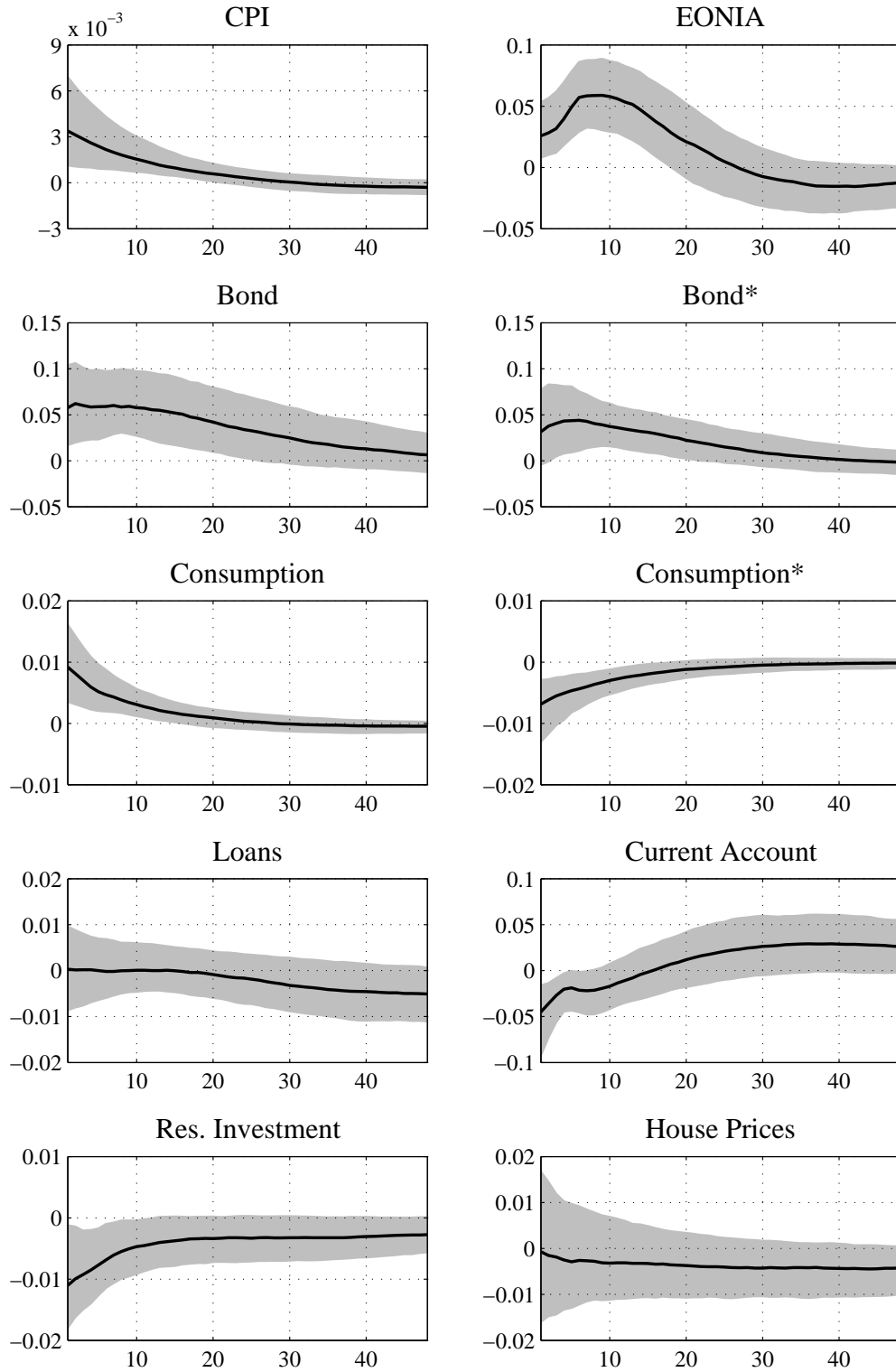
*Notes:* The x-axis is in months. The solid line represents the median impulse response functions from the BVAR. Shaded areas display 16% and 84% percentiles of the posterior distribution.

Figure 13: Risk Premium Shock



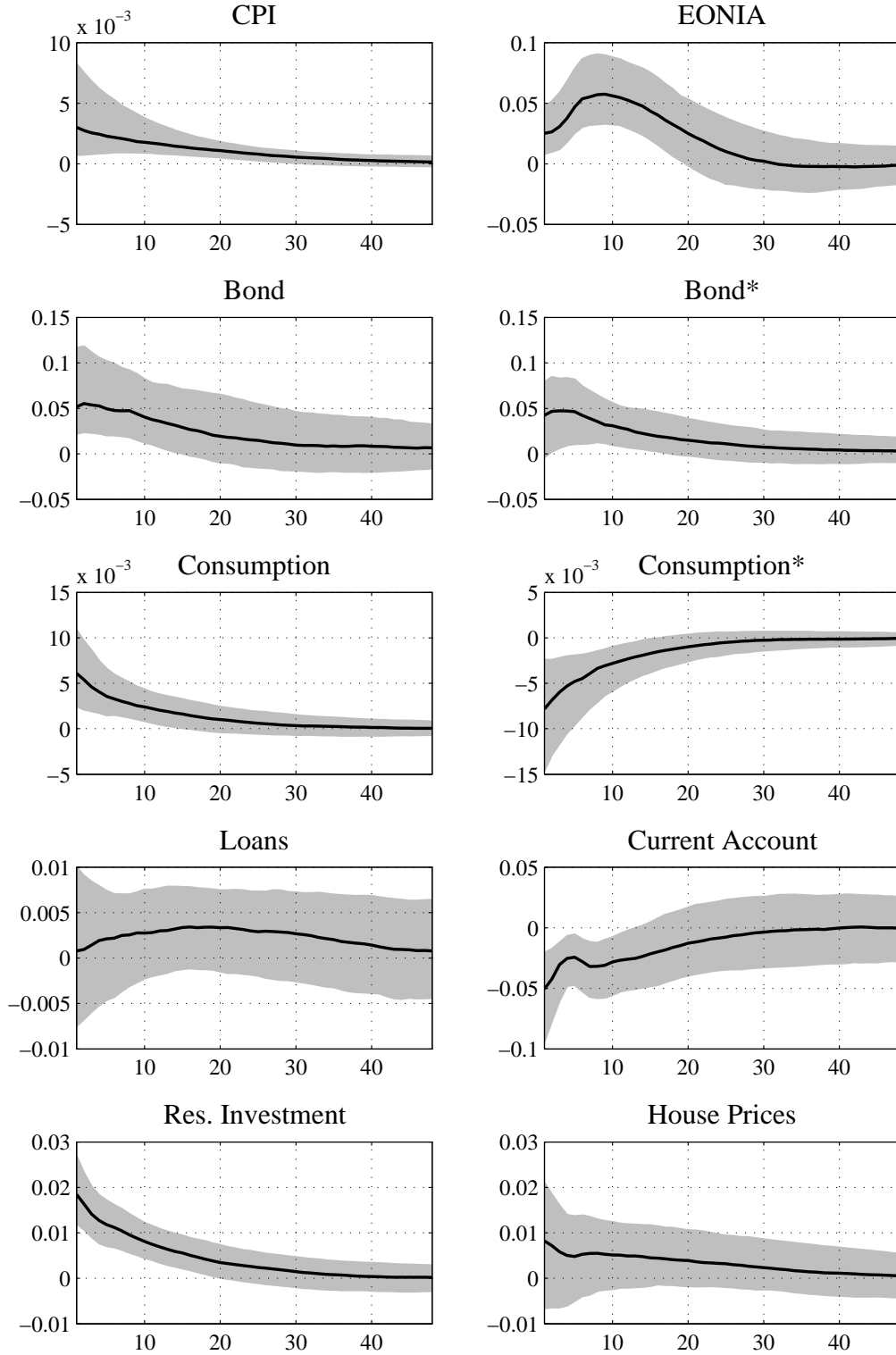
*Notes:* The x-axis is in months. The solid line represents the median impulse response functions from the BVAR. Shaded areas display 16% and 84% percentiles of the posterior distribution.

Figure 14: Financial Easing Shock



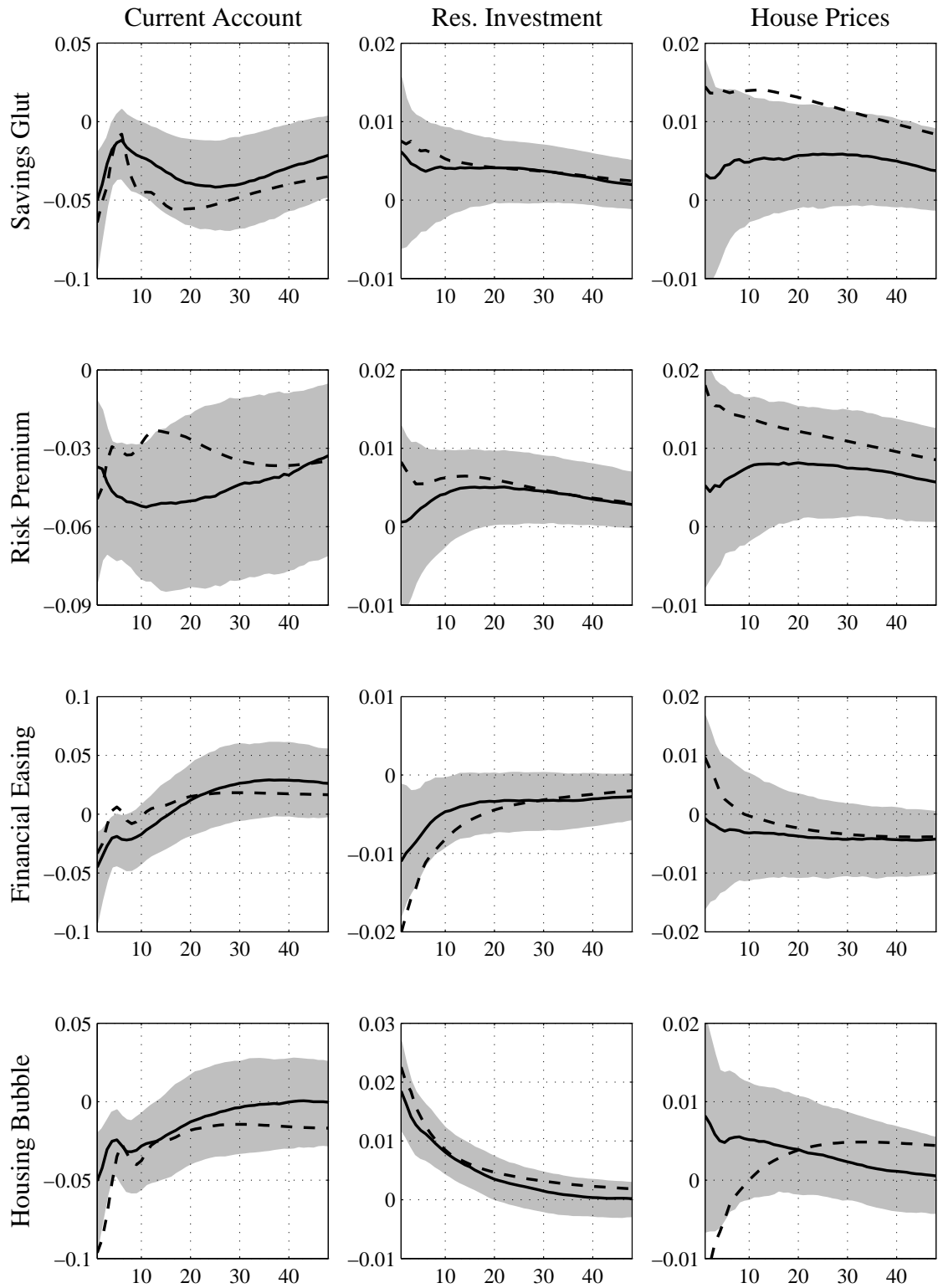
*Notes:* The x-axis is in months. The solid line represents the median impulse response functions from the BVAR. Shaded areas display 16% and 84% percentiles of the posterior distribution.

Figure 15: Housing Bubble Shock



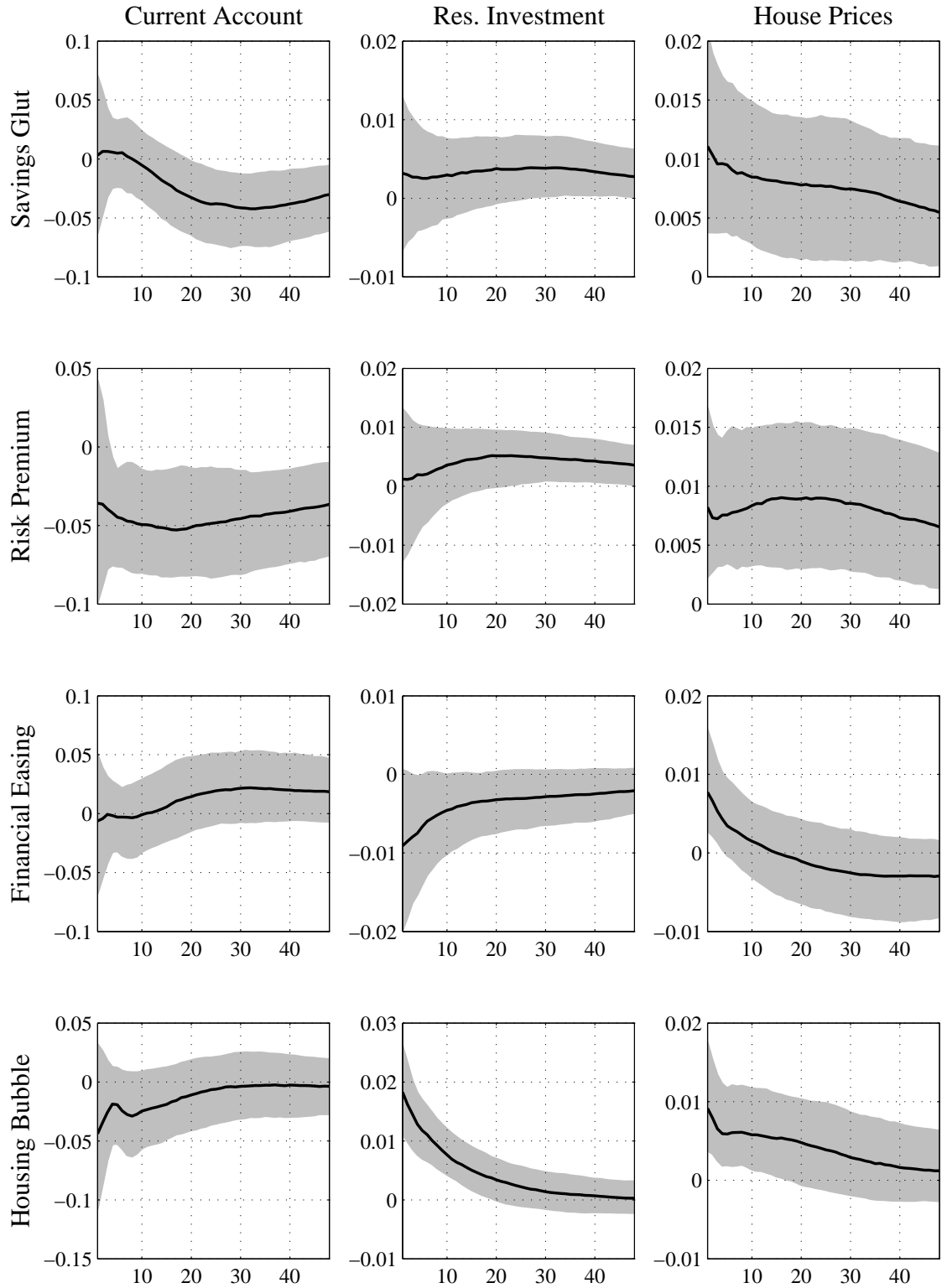
*Notes:* The x-axis is in months. The solid line represents the median impulse response functions from the BVAR. Shaded areas display 16% and 84% percentiles of the posterior distribution.

Figure 16: Key Variables and the Median Target Model



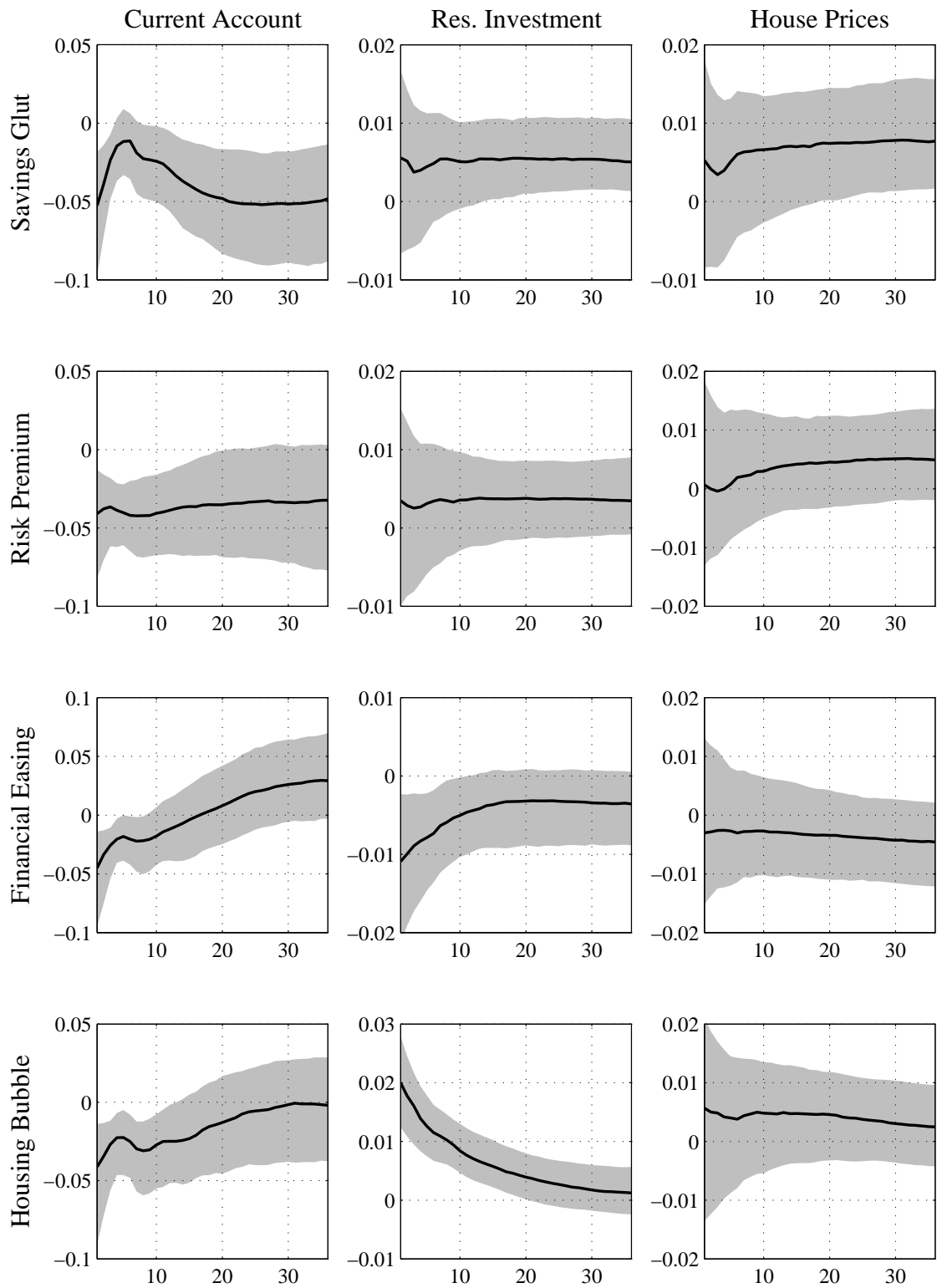
*Notes:* The x-axis is in months. The solid line represents the median impulse response functions from the BVAR. Shaded areas display 16% and 84% percentiles of the posterior distribution and the dashed line denotes the median target (see Fry and Pagan, 2011).

Figure 17: Key Variables in a Different Identification Scheme



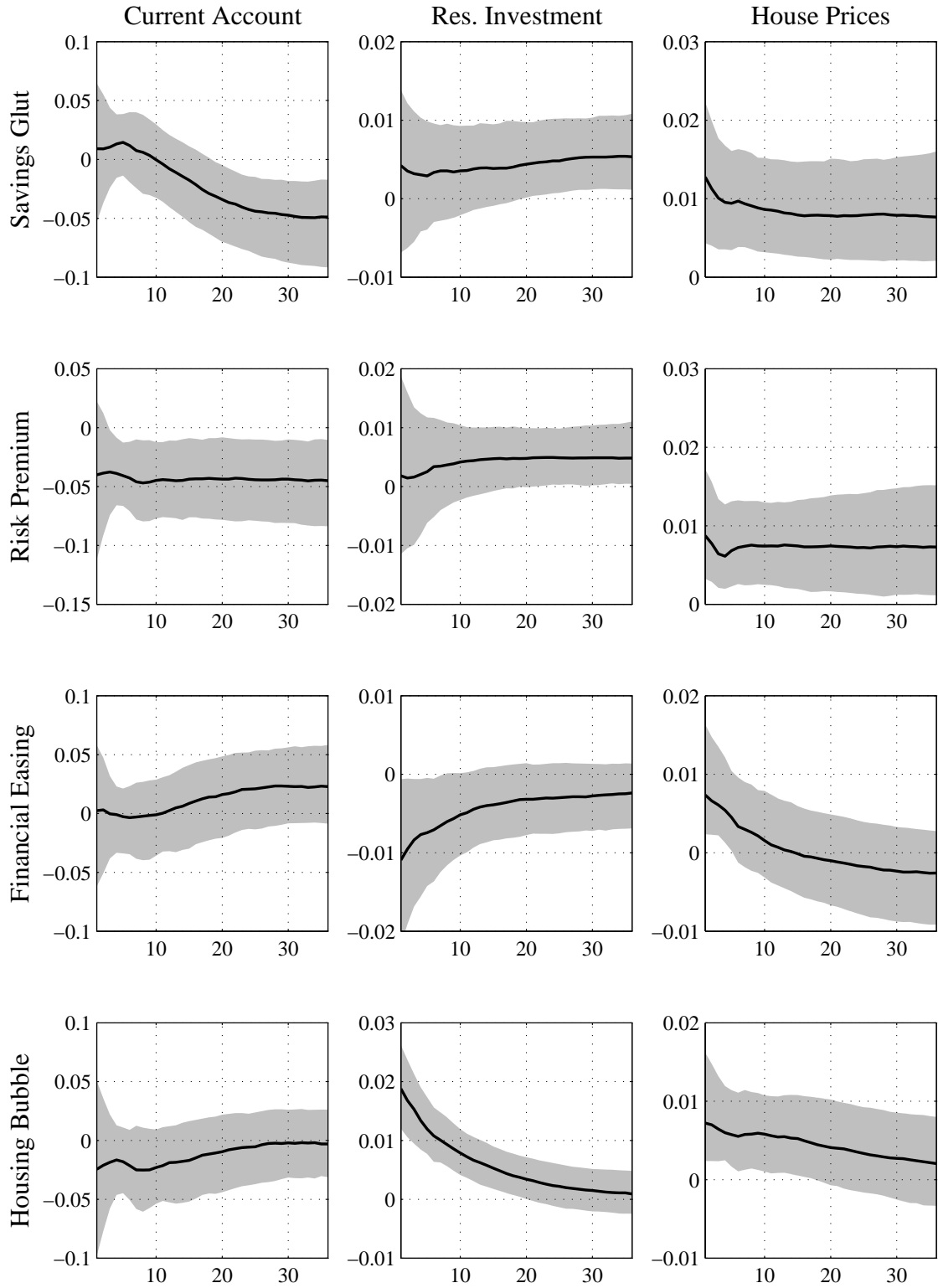
*Notes:* The x-axis is in months. The solid line represents the median impulse response functions from the BVAR. Shaded areas display 16% and 84% percentiles of the posterior distribution.

Figure 18: Ex Draghi Speech Sample: Benchmark Identification



*Notes:* The x-axis is in months. The solid line represents the median impulse response functions from the BVAR. Shaded areas display 16% and 84% percentiles of the posterior distribution.

Figure 19: Ex Draghi Speech Sample: Alternative Identification



Notes: The x-axis is in months. The solid line represents the median impulse response functions from the BVAR. Shaded areas display 16% and 84% percentiles of the posterior distribution.