News-driven housing booms: Spain vs. Germany

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Abstract

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Keywords   investment-specific technical change; news shocks; housing booms; wealth effects.

Jel Classification   C32, D84, E22, E32

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In this paper we investigate how the economy responds to anticipated (news) shocks to future investment decisions. Using structural vector autoregressions (SVARs), we show that news about the future relative price of residential investment explains a high fraction of the variance of output, aggregate investment and residential investment for Spain. In contrast, for Germany it is the news shocks on business structures and equipment that explain a higher fraction of the variance of output, consumption and non-residential investment. To interpret our empirical findings we propose a stylized two-sector model of the willingness to substitute current consumption for future investment in housing, structures or equipment. The model combines a wealth effect driven by the expectation of rising house prices, with frictions in labour reallocation. We find that the model calibrated for Spain displays a response to anticipated house price shocks that stimulate residential investment, whereas for Germany those shocks enhance investment in equipment and structures. The results stress that the propagation mechanism of anticipated shocks to future investment is consistent with the housing booms in Spain.

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1 Introduction

Spain is just one of the many European countries that experienced a housing boom in the early 2000s. The economic expansion in Spain by that time was particularly characterized by sustained growth of residential investment, as Aspachs-Bracons and Rabanal (2009) discuss. In fact, Díaz and Franjo (2016) show that in spite of stagnant TFP, the Spanish economic growth has been generally driven by an inefficiently high investment rate in residential structures. In contrast, Germany, a peer Euro Zone economy, have had an economic performance very different, and even during the years of the 2000s expansion did not experience a housing boom. Moreover, Fernández-Villaverde and Ohanian (2010) document that in the previous three decades, the German housing prices have been more stable than elsewhere in Europe [cf. also OECD (2014)].

An important fact is that home ownership rates in Spain are much higher than in Germany.[1] One reason behind this circumstance is that households and investors in Spain may consider real estate as a mean of storage of wealth superior to alternatives. This might be due to either a lack of deepness in the stock market or to the workings of the financial sector, among other.[2] Another important fact is the key role of the tourism sector in Spain whose consequences spread all over the sectoral composition of the economy.[3] Thus, fundamental empirical evidence illustrates key differences in the pattern of residential investment in Spain vs. Germany.

Notwithstanding, there are particular patterns in common to be highlighted at the aggregate level. Figure 1 shows the relative prices of investment (RPIs) for residential, business structures, and equipment, respectively, for Spain and Germany from 1970 to 2015. Data are annual from the *EU KLEMS* 2017 release (see Appendix A). It is apparent that until 1998 all three factor prices in both countries shared a common trend. Clearly though, the amplification in the movements of the relative price of residential investment in Spain has always been a key business cycle feature. After 1998, however, both the residential and business structures RPIs diverge in the two economies, with

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[1]In Spain the house ownership reached 86.28% in 2005 (see Encuesta Continua de Presupuestos Familiares. Base 1997. Resultados anuales 2005. http://www.ine.es/jaxi/Datos.htm?path=/t25/e437/p02/a2005/l0/&file=04001.px); in Germany the house ownership was at 48% in 2008 (see Sample survey of income and expenditure (EVS). https://www.destatis.de/EN/FactsFigures/SocietyState/IncomeConsumptionLivingConditions/AssetsDebts/Tables/HouseholdOwningRealProberty_EVS.html)

[2]See Akin et al. (2014) and the references therein on the the importance of mortgages as a source of financing for banks while building-up the credit and the real state bubble in Spain. A counterfactual for the euro scenario with consequences for the monetary transmission mechanism is explored in Gómez-Gónzalez and Rees (2018).

[3]The importance of the tourism sector in Spain has been recently highlighted by Almunia et al. (2019) who use a measure of exposure to the flows of foreign tourists as an instrument for changes in demand comparable to changes in the stock of vehicles per capita to address the patterns of export flows.

a gap that widens until 2012, but fully disappears by the end of our sample.[4] We find compelling the fact that fluctuations in the relative price of residential investment (and business structures) are synchronized in the 80s and the 90s, but they decouple after the introduction of the euro, in the late 90s, despite the ECB's price stability mandate. This feature can be added to the list of well documented patterns in data that were altered with the euro. Here, however, we further ask whether the amplification in the prices of residential investment for Spain (and some other European countries) may have specifically contributed to the lack of response observed in Germany during the 2000s. We comment on the patterns of the different capital to GDP ratios in Appendix A.

Overall, the discussed evidence suggests movements in the relative prices of the different types of investment (RPIs) that are related within and between countries. However, we do not find evidence supporting that a traditional surprise shock drives the data. The question is then whether there are anticipated shocks to future investment decisions underlying those comovements. To answer this question, we extract news about future investment decisions in Spain and Germany from the observed movements in the RPIs. Notice that the RPIs are generally taken as measures of Investment-Specific Technical Change (ISTC). Thus, we follow Fisher (1997) and Canova et al. (2007) by assuming that investment-specific shocks are the sole driver of long-run movements in the RPI. As such, the identification framework implies that two shocks drive the long-run variation in RPIs, one being the traditional unanticipated (surprise) ISTC shock and the other being the ISTC news shock. The identified news shock is the one that has no effect on current ISTC, but that predicts future changes in it. The key mechanism is that a positive shock to the relative price of residential investment today may anticipate rising prices of residential structures in the future, which stimulates residential investment today.

The hypothesis is then, that the extent to which ISTC news shocks contribute to housing booms depends on the household's willingness to substitute consumption for investment in residential structures, business structures or equipment. The mechanism builds upon Díaz and Franjo (2016) and Huo and Ríos-Rull (2019) and combines a housing wealth effect driven by the expectation of rising prices of residential investment, with a reduced-form for frictions in labour reallocation. Thus, an

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[4]The euro was introduced to financial markets on 1 January 1999. Just before that major event there was "The Spanish Land Law from 1998," which involves two acts. The first, Act 7/1997, set liberalizing measures on land: to make land cheaper and guarantee access to housing. Measures were aimed at increasing the supply of land available for development. For this purpose, it eliminated the distinction between programmed and non-scheduled developable land, making all of it developable. Also, it simplified procedures by shortening deadlines. With the second Act, the Land Law of 1998, the federal government took part of the competences of the Autonomous Communities and Town Councils on the monopoly of land development. Act 6/1998 confirmed the liberalizing measures fixed by Act 7/1997.
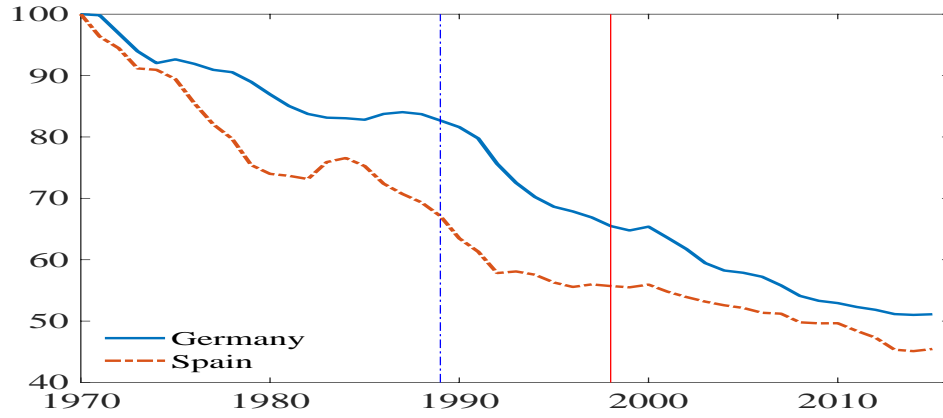
Figure 1: **Relative Prices of Investment - Spain vs Germany**
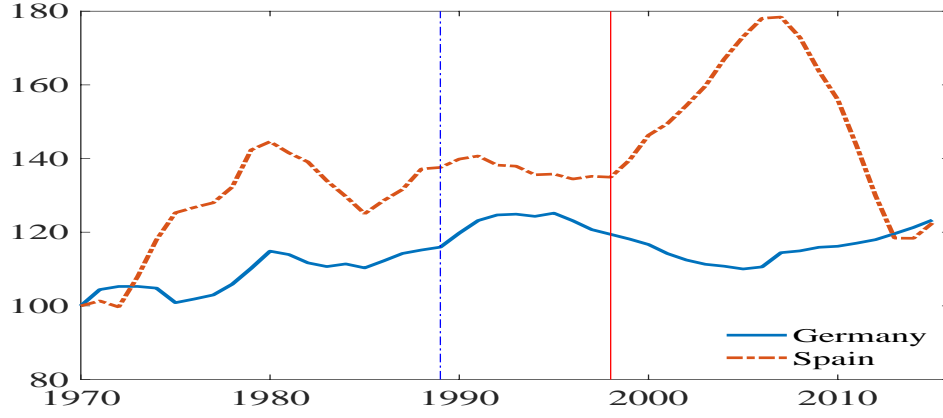
(a) Residential Investment
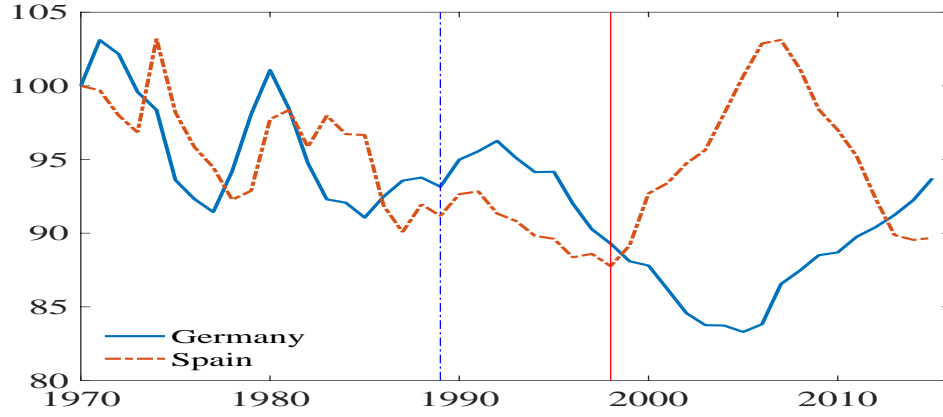
(b) Business Structures

(c) Equipment

Note: Relative prices of investment (RPIs) for (a) residential, (b) business structures and (c) equipment investment; All RPIs are in units of non durable consumption goods and services, and they are normalized so that 1970 is the base year for both countries. Notice the different Y scales. Vertical lines mark the dates of fall of Berlin Wall (blue), and Spanish Land Law (red).

anticipation of rising house prices brings about residential investment in Spain in exchange of consumption (maybe because it means "a spot by the sea"), whereas it fuels investment substitution in Germany, so that more resources and more labour are reallocated to business structures and equipment. Clearly though, the observed debt imbalances in the euro area during the Great Recession must underlie part of the amplification of the cyclical asymmetries we illustrate in this paper, as well as some of the differences in wealth effects that are discussed for instance in Guerrieri and Mendicino (2018). We leave to make them explicit for further research.

First, we identify news shocks using structural vector autoregressions (SVARs). Our approach imposes minimum theoretical restrictions as in Barsky and Sims (2011). We estimate the model and identify the news shock as the one that best anticipates the relative price of investment in the long-run, and does not move it on impact. Then, we quantify how the news shock propagates to the economy, and how it affects households' investment decisions. The finding for the Spanish economy is that the news shock to the relative price of residential investment accounts for 59% of the forecast-error variance of output and for 65% of aggregate investment, while it explains 80% of the forecast-error variance of residential investment. The impulse response functions (IRFs) show that on impact, output, aggregate investment and consumption have a statistically significant positive response, which confirms the role of news shocks as a source of aggregate fluctuations. The effects are similar to those obtained by Beaudry and Portier (2004) who find shock-induced aggregate comovement. In contrast, for Germany, the effects are reversed: the news shocks to the relative prices of business structures and equipment in Germany are those that explain the highest fraction of the variance of output, consumption, and investment in business structures and equipment.

To interpret the propagation mechanisms of the identified news shocks, we propose a stylized version of a two-sector model economy as in Díaz and Franjo (2016). The preference specification however follows Jaimovich and Rebelo (2009), augmented with home production as in Benhabib et al. (1991), Greenwood and Hercowitz (1991) and McGrattan et al. (1997). This extension brings about the housing sector as a home production sector that reallocates labor and capital between market and non-market activities. This has consequences for households consumption and investment decisions in the three types of capital: equipment, business structures and residential structures. The news shocks effects on each country depend critically on the parameters that control the elasticities of substitution, between housing and market variables in utility and production functions, and those that control the labour supply elasticity. The model generates two important forms

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of comovement in response to news shock. The first one is the aggregate variables comovement: output, consumption and aggregate investment rise and fall together. The other is the sectoral comovement: output, employment, investment and capital accumulation rise and fall together on each of the two sectors of the model economy. Finally, in an extension of the model to a small open economy setting, we show that the propagation of the news shock helps to achieve an anticipated response of residential investment driven by the possibility to access international markets.

This paper is linked with three literatures. First, it is related to the empirical literature suggesting news about the future might be an important driver of the business cycle, after Beaudry and Portier (2006).[5] Part of this literature relies on reduced form time series techniques, while other part uses dynamic stochastic general equilibrium (DSGE) models. In the context of vector autoregressive (VAR) methodologies, Beaudry and Portier (2006) and Beaudry and Lucke (2010) find that total factor productivity (TFP) news shocks are important drivers of the US business cycles, while Barsky and Sims (2011) and Forni et al. (2014) find that they are not. The estimated DSGE methodology [Fujiwara et al. (2011); Khan and Tsoukalas (2012); Schmitt-Grohé and Uribe (2012)], find news shocks to be negligible sources of fluctuations. Recently, Angeletos et al. (2019) rule out news about future productivity to be a main business-cycle driver, but remain silent on the role of news shocks to relative price of investment, while suggesting a route for models accommodating "demand-driven cycles under flexible prices."

Secondly, it connects with a literature that studies investment-specific technical change (ISTC) in a general equilibrium environment.[6] Díaz and Franjo (2016) show that low Spanish TFP is due to low ISTC, and that the highly inefficient residential investment in Spain is driven by explicit and implicit subsidies to the housing sector (see, among others, Akin et al. (2014) for the banking channel and Díaz-Giménez and Puch (1998) for the endemic low down payment requirements). Closely related to our research are Ben Zeev and Khan (2015) and Ben Zeev (2018), which identify ISTC news shocks using a VAR methodology, and their relative importance. Ben Zeev and Khan (2015) provide strong support for ISTC news shocks when investigating their role in driving the U.S. business cycle. Although our paper focus on news shocks to the relative price of residential

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[5]Many recent papers document the importance of news shocks as in Beaudry and Portier (2014); Schmitt-Grohé and Uribe (2012); Jaimovich and Rebelo (2009); Christiano et al. (2008); Fujiwara et al. (2011); Barsky and Sims (2011); Kurmann and Otrok (2013); Forni et al. (2014) among others.

[6]Greenwood et al. (1988) suggest investment shocks as a complement to neutral technology shocks for business cycle fluctuations, while Greenwood et al. (1997) show that investment-specific technical change is responsible for a major share of growth in post-war U.S. data. Again, Fisher (2006) identifies in a structural VAR framework that unanticipated ISTC shocks have accounted for over two-thirds of business cycle fluctuations in output over 1982-2000.

investment, they find similar variance decomposition for the aggregate variables in the U.S. as the one we present for the Spanish economy: in the U.S., the news shocks account for 70% of the business cycle variation in output, hours, and consumption, and 60% of the variation in investment.

Finally, our paper is related to the recent literature on household housing wealth effects. In particular, Huo and Ríos-Rull (2019) build a model in which both wealth shocks and financial shocks to households generate recessions, like those in southern Europe. In our setting, though, the specification of the home production sector is key for the propagation mechanism in the model to be in conformity with the evidence we found in data. More generally, Berger et al. (2018) and Kaplan et al. (2019) identify housing booms driven by shift in beliefs on housing prices and rents from micro data (PSID). Also, Arouba et al. (2018) investigate the effect of declining house prices on household consumption behavior during 2006-2009 in the U.S.

Our results provide evidence that news shocks to residential investment-specific technical change (ISTC) constitute a significant force behind the Spanish business cycle. Also, and even though the news shocks affect in a lesser extent to the aggregate fluctuations in Germany, the finding is that they do seem to account well for the investment and capital accumulation increase in equipment and business structures over the business cycle. Overall, an important contribution of the paper is to show that anticipated shocks are a driver of the housing boom in the Spanish economy. Our paper suggests these anticipated shocks to the relative price of residential investment may contribute to explaining the swings of investment in residential structures, as well as the signs of bulimia in economic growth patterns of the Spanish economy since the early 80s.

The rest of this paper is organized as follows. Section 2 reviews the news shocks identification scheme and reports the empirical evidence. Section 3 outlines the baseline theoretical model and describes the calibration, while Section 4 reports the quantitative results of the theoretical model. Section 5 presents the small open economy's extension. Section 6 concludes.

2   The Empirical Approach

The key insight is to show that news about future relative prices of investment (RPIs) leads to predictable changes in investment decisions. To prove this case, we focus on three RPIs, say q_{it}, with $i = r, s$, and e, that is, residential, q_{rt}, business structures, q_{st}, and equipment, q_{et}. To proceed,

we estimate a vector autoregression (VAR) model on Spanish and German annual data for the period 1970 - 2015. We follow Barsky and Sims (2011) methodology to identify the news shock. This implies the combination of VAR prediction errors that have zero contemporaneous impact on RPIs, but that account for the maximum share of the forecast-error variance (MFEV) of RPIs over a ten year horizon.[7] Compared to Beaudry and Portier (2006) news shocks identification strategy, we consider the maximum forecast error variance (FEV) identification approach instead, due to several reasons. [8] First, the approach allows, but does not require, that either the contemporaneous shock or the news shock or both have a permanent impact on RPIs. Second, the approach does not make any restriction about common trends for the different variables in the VAR. Third, because it is a partial identification method, the approach can be applied to VARs in many variables without imposing additional assumptions about other shocks.

2.1 Identification Strategy

As we follow Barsky and Sims (2011) approach, we just outline here the methodology, and we leave the details to Appendix B. We assume that each relative price of investment (RPI) series follows a stochastic process driven by two shocks. First, an unanticipated shock which impacts the investment price in the same period in which agents observe it. Secondly, a shock which agents observe in advance, but that impacts the level of investment prices in the future. We refer to this latter shock as the RPI news shock, q_{it}. This identifying assumption can be expressed in terms of the univariate moving average representation:

$$\log q_{it} = [B_{11}(L) \quad B_{12}(L)] \begin{bmatrix} \varepsilon_t \\ \nu_t^n \end{bmatrix}, \tag{2.1}$$

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[7] Barsky and Sims (2011) apply the strategy proposed by Uhlig (2004b) to identify a news shock maximizing over an horizon 40 of quarters. Their methodology is based on the FEV maximization approach of Uhlig (2004a) who chooses the shock that maximally explains a weighted average of future levels of productivity. We attach equal weights to the various horizons over which news shocks are to be explained. Caldara et al. (2016) similarly use the penalty function approach in Uhlig (2004b) to identify financial and uncertainty shocks.

[8] Beaudry and Portier (2006) use bivariate VAR, imposing two identifying restrictions: first, that one shock has no long-run effects on TFP and label the orthogonal shock as the news shock; second, that one shock has zero short-run effect and label that shock as the news shock. As it turns out, the two restrictions lead to similar results. They find that the identified news shock leads to positive conditional comovement among macroeconomic aggregates on impact, that aggregate variables strongly anticipate movements in technology, and that news shocks account for a large fraction of the variance of aggregate variables at business cycle frequencies.

where ε_t is the traditional surprise relative price shock - that impacts in the same period in which agents see it, while ν_t^n is the news shock - which agents observe in advance.

The only restriction on the moving average representation is that $B_{12}(0) = 0$, so that news shocks have no contemporaneous effect on relative prices. The following is an example of a process satisfying this assumption:

$$\log q_{it} = g + \log q_{it-1} + \varepsilon_t + \nu_{t-j}^n, \tag{2.2}$$

where $\log q_{it}$ follows a random walk with drift, g, and ε_t is the conventional surprise shock. On the other hand, the news shock, ν_t^n, has no immediate impact on the level of q_{it}, but it has impact j periods into the future.

In a univariate context, it is not possible to separately identify ε_t and ν_{t-j}^n. Therefore, the identification of the news shock must come from surprise movements in variables other than q_{it}. As such, the estimation of a vector autoregression (VAR) is an adequate strategy in this context. Thus, in a system featuring an empirical measure of q_{it} and macro variables, we identify the surprise shock as the reduced-form innovation in q_{it}. The news shock is then identified as the shock that best explains future movements in q_{it} not accounted for by its own innovation.

2.2 Empirical evidence of news shocks

In this section we present the main results of the VAR model for Spain and Germany. The benchmark VAR includes the logs of eight variables: one at a time of the three RPIs, q_{it}; total output, GDP_t; consumption, C_t; aggregate investment, X_t; hours worked, H_t; residential investment, X_{rt}; business structures investment, X_{st}; and equipment investment, X_{et}. A detailed explanation of the data is given in the Appendix A. Notice that here we present only results for the q_{rt} news shock (i.e. one which portends future increase in residential RPI). In Appendix C are shown the estimations of the news shocks on business structures and equipment RPIs. We also report in this appendix our findings that rule out unanticipated (surprise) shocks as a business-cycle driver.[9]

We estimate a Bayesian VAR (BVAR) system in levels[10]. The Akaike criteria, the Hannan-

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[9]In Appendix D, we show the results for estimated news shocks on an alternative VAR which includes the logs of eight other variables: RPI, q_{it}, GDP, GDP_t, consumption, C_t, aggregate investment, X_t, equipment investment, X_{et}, business structures investment, X_{st}, residential investment, X_{rt}, and IBEX 35 for Spain, or DAX for Germany.

[10]We use the MATLAB main program routine provided by Kurmann and Otrok (2013)

Quinn information and Schwartz criteria favor two lags. As a benchmark, we choose to estimate a VAR with two lags. The results are robust to using a different number of lags, and any order of the variables in the VAR. We contrast for each realization (2500) the existence of unit roots and test the residuals to be white noise.

In the figures representing the impulse response functions, (IRF), and the forecast error variance, (FEV), the solid lines correspond to the posterior median estimates, while the gray bands display the 16%-84% posterior coverage intervals. These bands are constructed from a residual based bootstrap procedure repeated 2500 times. As described above, we extract the shocks that maximize the fraction of the FEV of q_{it} explained by the news shocks over the forecast horizon of 10 periods, weighting the importance of each of the forecasts equally.[11] This choice is motivated by the fact that we want to capture short- and medium-run movements of q_{it} while providing at the same time reliable estimates at the long end of the forecasting horizon.

2.3 Impulse Response Functions and Forecast Error Variance

Figures (a) in Appendix C display the Impulse Response Functions (IRFs) of the benchmark VAR explained by the q_{rt} shock correspondingly. Figure (b) in Appendix C display the fraction of the Forecast Error Variance (FEV) of the benchmark VAR explained by the relative price of residential investment shock, q_{rt}, for the Spanish (SP) and the German (GER) economies. We show the results for both news and surprise shocks. We consider that a positive realization of the news shock means an expected future increase in residential RPI.

2.3.1 Aggregate effects of q_{rt} news shocks

Figures (a) in Appendixes C.1 and C.3 show the estimated IRFs of the Spanish and German variables to a positive one standard deviation of the residential RPI news shock from the benchmark VAR. Following a positive realization of the news shock, residential investment prices do not change on impact by construction, but they grow gradually and peak after 6 years. The Spanish output, investment and consumption jump on impact, with highly statistically significant responses. Output, consumption, and investment reach their peak after three periods. Hours worked response

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[11]When using the method of Barsky and Sims to identify future q_{it} news shocks, we find that the results are not sensitive to the choice of forecast horizons (i.e. the results are very similar regardless of the forecast horizons used).

is insignificant. Output and aggregate investment, are particularly persistent, with hump-shaped effects. For Germany, output, consumption, investment and hours worked jump on impact with statistically significant responses. After the initial jump, all four variables exhibit low persistence, decaying rapidly and becoming insignificant after 4-5 periods. Contrary to Spain for which the hours response is not significant, the German hours worked response is statistically significant just for the first period. It is evident that a positive news shock on the residential RPI, q_{rt}, increases significantly on impact all the real aggregates, and displays persistent dynamics, even though they are different for Spain than for Germany.

Figures (b) in Appendixes C.1 and C.3 depict the contribution to FEV at horizons up to 10 years. For the Spanish economy, the news shock explains 80% of the variation of residential RPI, 59% of output, and 65% of aggregate investment.[12] The hump-shaped pattern of the news shock variance decomposition of output, aggregate investment, and consumption, suggests that the news effect is accumulating in time. The residential RPI news shock explain very little of consumption, only 15%. On the other hand, the fraction of variation explained by the news shock in Germany shows a very different picture than in Spain. The news shock explains less of the variation of output compared with the Spanish economy: 51% for Germany against 59% for Spain,[13] and even less for aggregate investment: 39%, while for hours worked it explains a higher percentage than for Spain: 11%. Contrary to the Spanish case, the highest fraction of variation is explained for consumption, 48%, and the effect is on impact.

2.3.2   The q_{rt} news shocks effects on the investment categories

Figures (a) in Appendixes C.1 and C.3 show the estimated IRFs for the Spanish and German variables to a positive one standard deviation q_{rt} news shock from the benchmark VAR. The picture of decomposed IRFs for investment in residential structures, business structures and equipment shows that all three responses are statistically significant, and all three jump on impact. Residential investment is the one that presents the highest amplitude and persistence, being significant even after 10 periods. It reaches the peak in the third period, at a level more than 6.5% higher than its pre-shock value. In contrast, although the equipment investment reaches the peak rapidly, it shows the lowest degree of amplitude and persistence. The news shock effects of residential RPI on

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[12]Table C.1 shows the median impact percentile and the forecast horizon period in which that is achieved for Spain

[13]Table C.3 in Appendix C shows the median impact percentile and the forecast horizon period in which that is achieved for Germany

different investment categories for the Spanish and German economies are the following: for Spain, the residential investment variance explained by the news shock is 80%, while the fraction of FEV for equipment investment and business structures is much lower, around 43% and 46% respectively.

For the German data, in its turn, residential investment is not statistically significant. However, business structures and equipment IRFs are statistically significant, and both jump on impact and decay shortly after that. The investment in business structures IRF shows the highest degree of persistence to a news shock.

2.4   Benchmark VAR results interpretation

The key finding here is that a positive residential RPI q_{rt} news shock implies a positive comovement among macroeconomic aggregates in line with the positive unconditional comovement of these series in the data. For both countries, a positive realization of the q_{rt} news shock (i.e. one which portends a future increase in residential RPI) is associated to an initial increase of output, investment and consumption. Compared with the German responses, the Spanish case exhibits a much higher persistence and amplitude. The results match closely the findings in Beaudry and Portier (2006) who find comovement following, in their case, a TFP news shock. According to them, an initial comovement of output, investment and consumption is consistent with the news-driven business cycle hypothesis.

A number of interesting results emerge from this analysis. From the IRFs and FEV decomposition analysis between Spain and Germany, we conclude the q_{rt} news is a driver of the business cycle, with a strong reaction for Spain, and a softer reaction for Germany. There is an important difference of the effects of a q_{rt} news shock at the level of the different investment categories. In Spain, a q_{rt} news shock, beside increasing all aggregate variables, it increases strongly residential investment, and therefore, it confirms the fact that the Spanish economy has been booming due to the housing sector. It turns out that a news shock on residential RPI has the effect of increasing residential investment, and mildly its complements: business structures and equipment. In Germany, on the contrary, the same news shock propagates itself stimulating equipment and business structures investment, with an effect that seems to indicate a substitution effect out of residential investment and in favour of investment in business structures, and especially, equipment.

All those findings hold across different VAR specifications. In Appendix D are included the IRFs

and FEVs of the news shock estimated on business structures RPI, q_{st}, and equipment RPI, q_{et}, that are enforcing the results. There is also an alternative VAR estimation, where we include a forward-looking variable: IBEX 35 for Spain and DAX for Germany. The alternative VAR specification also confirms the benchmark VAR results.

Figure 2 depicts the news shock from the empirical identification together with the first difference of the log of Spanish GDP. It can be seen that the news shock has predictability characteristics for business cycle fluctuations. The contemporaneous correlation between news shock and the Spanish growth rate is 0.02, whereas the correlation at one lag is -0.18, and -0.16 at two lags (see Table 1). The negative correlation indicates that within a period of two years the news shock is anticipating a change towards a peak or a trough. The Spanish crises in '92, '08 and '11 are anticipated by the news shock one period in advance (a year).

3 A two-sectors model with home production and ISTC

We propose a two-sector RBC type model to interpret the news propagation mechanism of the empirical SVARs. The model builds upon a stylized version of Díaz and Franjo (2016) augmented to incorporate Jaimovich and Rebelo (2009) preferences, home production, and news shocks. The model has a market sector and a home production sector. The market production function distinguishes between two different capital categories: equipment and structures, and includes labour market hours. The home production sector provides home goods to consumers with home labour hours and residential capital. Key assumptions for the model are that home production is not a perfect substitute for market goods and services, and it is not tradable in the market.

The driving forces for the business cycle model include country-specific stochastic stationary contemporaneous shocks and news shocks. The anticipated (news) shocks are hitting the residential, business structures, and equipment Investment-Specific Technical Change (ISTC). In particular, as the empirical analysis suggests, the ISTC news shock has different long-run implications, but the contemporaneous effects are essentially zero. Therefore, the specification, through persistence parameters, ρ_i, that are relative price- and country-specific, captures well the propagation mechanism in response to the q_{it} shock in each economy; although this is a common shock, it propagates differently to the ISTC processed in each economy.

Figure 2: Spain: q_r news shock against 1st diff log GDP
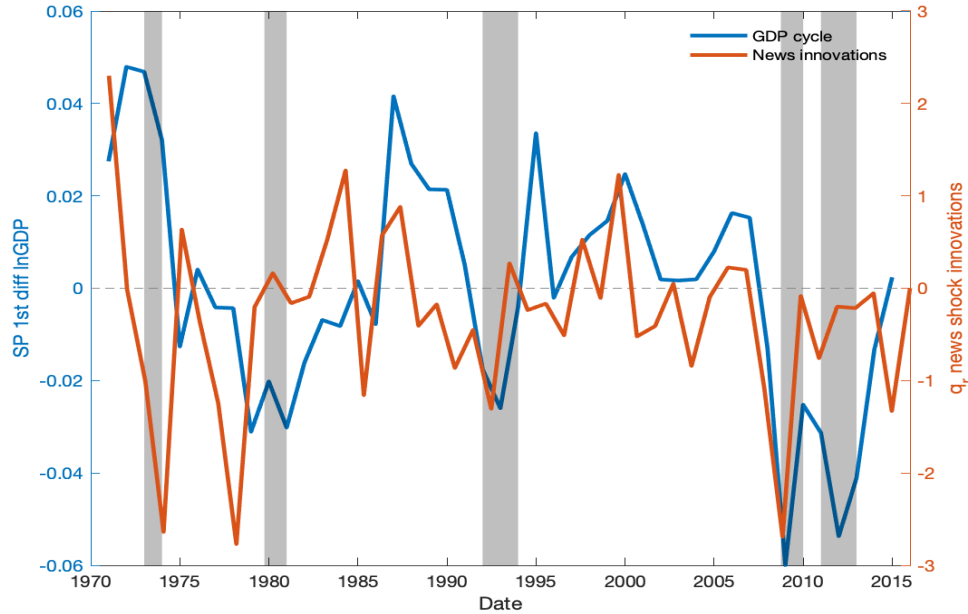
Note: The shaded areas correspond to recession dates for Spain; The units of the left vertical axes is the log difference of GDP per capita.

Table 1: Correlation at lags and leads of GDP growth rate and the news shock

Cross-Correlation of GDP growth rate:					
Lags & Leads	-2	-1	0	1	2
News shock	- 0.16	-0.18	0.02	0.5	0.4

As it is standard in growth and business cycle models, the decentralized competitive equilibrium can be characterized by the solution of a planning problem. The planner chooses the representative household's stochastic sequences of consumption and leisure to maximize preferences of the representative agent, subject to the technological constraints of the economy.

3.1 Preferences

There is a continuum of households indexed by $j \in (0, 1)$. Each household consumes, supplies labour, and makes investment and capital utilization decisions. The preferences are defined as

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follows:

$$E_t \sum_{t=0}^{\infty} \beta^t U\left[C_t\left(C_{mt}, C_{rt}(K_{rt}, N_{rt})\right), N_{mt} + N_{rt}, \chi_t\right] \tag{3.1}$$

Total consumption, C_t, is a composite of market goods and services, C_{mt}, and residential consumption, C_{rt}. It is assumed that total consumption is given by a CES function of the form:

$$C_t = (\omega C_{mt}^{\eta} + (1 - \omega)C_{rt}^{\eta})^{1/\eta}, \quad \eta \in (-\infty, 1] \tag{3.2}$$

Note that ω is the proportion of each good in total consumption, and η is the parameter measuring the willingness to substitute between the market consumption good and the home consumption good. The parameter η is key for the relationship between the two activities since the elasticity of substitution between market goods and home production goods is defined as $\epsilon = 1/(1 - \eta)$.

Following Jaimovich and Rebelo (2009), the presence of the χ_t factor makes preferences non-time-separable in consumption and hours worked, allowing to parameterize the strength of short-run wealth effects on the labor supply:

$$\chi_t = C_t^{\gamma} \chi_{t-1}^{1-\gamma}; \quad \gamma \in [0, 1] \tag{3.3}$$

Jaimovich and Rebelo (2009) preferences nest two of the most popular utility functions in the business cycle literature. When $\gamma = 1$, preferences are those proposed by King et al. (1988), which we refer as KPR. Rather, when $\gamma = 0$ the preferences are those proposed by Greenwood et al. (1988), which we refer as GHH. The characteristics of the GHH preferences are that labor effort is determined independently of the intertemporal consumption-saving choice. Therefore χ_t becomes:

$$\chi_t = \left(\omega C_{mt}^{\eta} + (1 - \omega)C_{rt}^{\eta}\right)^{\frac{\gamma}{\eta}} \chi_{t-1}^{1-\gamma} \tag{3.4}$$

Households supply labour to the market, N_{mt}, and to home (residential) production, N_{rt}, so that $N_t = N_{mt} + N_{rt}$. They combine residential capital with labour hours according to the home production function:

$$C_{rt} = A_t K_{rt+1}^{1-\theta_r} N_{rt}^{\theta_r}, \tag{3.5}$$

where A_t is the home production productivity, which is assumed to follow a stochastic process driven by a shock, $\varepsilon_{A,t}$, which is an i.i.d. process with zero mean and standard deviation σ_ε, say,

$$\log A_t = (1 - \rho_A) \ \log \bar{A} + \rho_A \ \log A_{t-1} + \varepsilon_{A,t}.$$

K_{rt} denotes residential structures. The parameter θ_r represents the labour share in the home production function. The constraint says that home consumption must be produced at home and cannot be bought or sold on the market.

Therefore, preferences are parameterized as

$$U(C_t, N_t, \chi_{t-1}) = \frac{\left(C_t - \psi N_t^\theta \left(\omega C_{mt}^\eta + (1-\omega)C_{rt}^\eta\right)^{\frac{\gamma}{\eta}} \chi_{t-1}^{1-\gamma}\right)^{1-\sigma} - 1}{1 - \sigma} \tag{3.6}$$

3.2   Technology

The production of final output, Y_t, requires market labour, N_{mt}, and two types of capital, equipment and business structures. The production technology is described by:

$$Y_t = Z_t K_{et}^{\alpha_e} K_{st}^{\alpha_s} N_{mt}^{1-\alpha_e-\alpha_s}, \quad 0 < \alpha_e, \alpha_s; \ \alpha_e + \alpha_s < 1, \tag{3.7}$$

where Z_t is the total factor productivity (TFP). The state of technology is assumed to follow a stochastic process driven by a shock, $\varepsilon_{Z,t}$, which is assumed to be an i.i.d. process with zero mean and standard deviation σ_ε: $\log Z_t = (1 - \rho_Z)\log \bar{Z} + \rho_Z \log Z_{t-1} + \varepsilon_{Z,t}$.

The household owns the total capital, K_t, which is split between the capital used to produce market goods and services and the home production capital as follows:

$$K_t = K_{et} + K_{st} + K_{rt}, \tag{3.8}$$

The capital for market goods and services is both equipment, K_{et}, and business structures, K_{st}, while the share of capital used in the home production function corresponds to residential structures, K_{rt}. Each type of household's capital stock evolves according to a law of motion:

$$K_{it+1} = (1 - \delta_i)K_{it} + \Theta_{it}X_{it}, \ \text{where } 0 < \delta_i < 1, \tag{3.9}$$

where X_{it} is investment, and the $i's$ stand for equipment, X_{et} , business structures, X_{et}, and residential structures, X_{rt}. Θ_{it}, in its turn, represents the state of the investment-specific technology. Following Greenwood et al. (1997), Θ_{it} determines the amount of capital that can be purchased for one unit of output. Changes in Θ_{it} represent investment-specific technical change and we assume that they affect to all types of capital. The higher Θ_{it}, the greater the amount of capital that can be incorporated into the economy with an investment unit, reflecting the fact that the quality of capital has increased. A technological news shock that increases Θ_{it} is associated with expectations of future reduction of the cost of producing investment capital goods with respect to the cost of producing consumption goods. In equilibrium, the inverse of the investment-specific technology shock, $q_{it} = 1/\Theta_{it}$, could be thought of as the relative price of capital in terms of consumption.

Final output, Y_t, can be used for four purposes: market consumption, C_{mt}, investment in equipment, X_{et}, investment in business structures, X_{st}, or residential investment, X_{rt}:

$$Y_t = C_{mt} + X_{et} + X_{st} + X_{rt} \tag{3.10}$$

This is a closed economy.

The representative household maximizes utility subject to the global constraint of resources :

$$C_t + X_t = Z_t K_{et}^{\alpha_e} K_{st}^{\alpha_s} N_{mt}^{1-\alpha_e-\alpha_s}, \tag{3.11}$$

where $X_t = X_{et} + X_{st} + X_{rt}$.

3.3 News shocks

In this setting, the news shocks on q_{it} are introduced as follows:

$$\log q_{rt} = (1 - \rho_{q_r}) \log \bar{q}_r + \rho_{q_r} \log q_{rt-1} + \varepsilon_{q_r t} + \varepsilon_{news,t-4},$$

where q_{rt} stands for the relative price of residential investment. Although we report only results for the news shock on the relative prices of residential investment, $\varepsilon_{news,t-4}$, we also consider a contemporaneous i.i.d. shock, $\varepsilon_{q_r t}$. Likewise, we consider the news shocks on the relative prices of investment in equipment and business structures, that is,

$$\log q_{et} = (1 - \rho_{q_e}) \log \bar{q}_e + \rho_{q_e} \log q_{et-1} + \varepsilon_{q_e t} + \varepsilon_{news,t-4},$$

where q_{et} stands for the relative price of equipment, and correspondingly,

$$\log q_{st} = (1 - \rho_{q_s}) \log \bar{q}_s + \rho_{q_s} \log q_{st-1} + \varepsilon_{q_s t} + \varepsilon_{news,t-4},$$

where q_{st} stands for the relative price of business structures.

The news shock hits the economy in steady state. Agents receive news about a one percent increase in the relative prices of residential investment up to four periods ahead: $\varepsilon_{news,t-4}$ is an innovation to the level of q_{rt} that materializes in period t, but that agents learn about in period $t - 4$.

3.4   The Social Planner's Problem

The planner chooses $\{Y_t, C_t, N_m, N_r, X_t\}$ to maximize (3.6) subject to (3.7) - (3.11) given $K_{i,0}$ and the stochastic processes for the exogenous variables in the model. We solve for the first-order conditions of equilibrium around the non-stochastic steady state of the model, and we solve numerically the dynamic system of stochastic difference equations in DYNARE.

3.5   Calibration

This section discusses the choice of parameter values we consider useful in studying the propagation mechanism of news shocks. Our strategy is to calibrate parameters so that the steady state of the model economy matches the average values in the Spanish and German annual data for the 1970-2015 period. The stochastic structure that governs the evolution of the news shocks is taken from the time series properties of the corresponding price data in the *EU KLEMS* data base 2017 release.[14] The goal of the quantitative experiments next is to provide an interpretation of the responses we estimated in data.

Table 2 summarizes the calibrated parameters. As indicated above most parameters are in conformity with either the long-run or the stochastic properties of the data. Precisely, we choose the elasticities of equipment and structures in the final good production technology as in Díaz and Franjo (2016), but here we distinguish between market output, Y_m, and home production,

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[14]Appendix A describes the sources of the data, and in particular, the construction of the relative prices of investment for each investment category. Díaz and Franjo (2016) use also the *EU KLEMS* data for the Spanish economy.

Table 2: Calibration - Spain vs Germany

Param.	Target			Description	Value	
	data var.	**Spain**	**Germany**		**Spain**	**Germany**
β	risk-free r	0.05	0.024	discount factor	0.95	0.98
α_e	K_e/Y_m	0.43	0.5	equipment capital share	0.13	0.14
α_s	K_s/Y_m	1.2	1.26	structures capital share	0.10	0.11
$1-\theta_r$	K_r/Y_r	6.9	5.76	capital share in home production	0.20	0.18
δ_e	X_e/K_e	0.18	0.22	equipment depreciation	0.11	0.13
δ_s	X_s/K_s	0.058	0.065	structures depreciation	0.03	0.04
δ_r	X_r/K_r	0.04	0.039	residential depreciation	0.02	0.02
$\bar{Z}$	Eq. (3.7)			average Neutral progress	0.65	0.89
$\bar{A}$	Eq. (3.5)			average home prod. process	0.81	0.71
ρ_Z	Estimated			autocorr. Neutral prog. process	0.85	0.95
ρ_A	Estimated			autocorr. home prod. process	0.98	0.93
$\bar{q_e}$	Estimated			average equipment RPI	0.15	0.5
ρ_{q_e}	Estimated			autocorr. equipment RPI process	0.88	0.96
$\bar{q_s}$	Estimated			average structures RPI	0.35	0.42
ρ_{q_s}	Estimated			autocorr. structures RPI process	0.94	0.92
$\bar{q_r}$	Estimated			average residential RPI	0.38	0.42
ρ_{q_r}	Estimated			autocorr. residential RPI process	0.78	0.94

Note: Averages for the period 1995-2015; Y_r = measured GDP - $Y_m = C_r + q_r K_r$, where C_r computed from consumption expenditures in housing services taken from EUROSTAT. $\bar{Z}$ computed from eq. (3.7), while $\bar{A}$ is calculated from eq. (3.5).

Y_r.[15] Then we use *EU KLEMS* to construct the time series for the relative prices of investment in residential structures, q_{rt}, business structures, q_{st}, and equipment, q_{et}, as well as each investment category, X_{it} (see, again, Appendix A). Thus, depreciation rates of each type of capital are calibrated so that in steady state the model economy matches the average values of the $I_i/q_i K_i$ in the Spanish and German data. Finally, productivity parameters, $\bar{Z}$ and $\bar{A}$ are averages for their definition in detrended data, whereas the rest of the parameters for the shock processes are estimated from the corresponding data. The discount factor, β, is consistent with risk-free interest averages at ECB.

In addition, to compare the two economies, we make them equal along certain dimensions unifying the parameters that are not essential for the argument. First, we fix the intertemporal elasticity of substitution (IES) to be the same in both economies. In the literature, it is fairly

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[15]We follow, for instance, Díaz and Luengo-Prado (2008), in that total GDP is the sum of market output, Y_m ($= C_m + X_e + X_s$), and home production, Y_r (so the value of housing services, C_r plus residential investment, X_r).

Table 3: Common specification

Param.	Value	Description	Target/Source
σ	1	Intertemporal Elasticity of Substitution (IES)	Jaimovich and Rebelo (2009)
ω	0.54	measures the weight of C_m in the utility function	Calibrated
ψ	0.45	scale parameter	Working time 1/3 of time endowment

Parameters that are chosen to be equal for the two countries to ease comparison.

common to implicitly set $\sigma = 1$ which corresponds to the case of logarithmic utility. Then, it seems natural to set equal the following two parameters: $\omega = 0.54$, which is the utility function parameter that measures the weight of the market consumption, C_m, and the labour disutility scale parameter, $\psi = 0.45$. Table 3 summarizes these latter choices.

The key contribution of the quantitative experiments below is the discussion on the news shocks propagation mechanism. Such a mechanism depends on the parameters that govern *i)* the short-run wealth effect, γ, *ii)* the preference for housing services, η, that governs the substitution between C_m and C_r, and *iii)* the intertemporal labor supply elasticity, θ. These parameters further help to capture the features of the data to achieve the comovement (γ) and persistence (θ) observed in the empirical identification. Overall, these parameters are key to better understand the implications of news shocks reproducing the observed investment process. Table 4 reports the range we consider of values for these key parameters. In particular, the parameter γ helps to account for the individual characteristics of the two economies. As discussed by Jaimovich and Rebelo (2009), and in order to obtain comovement, the short-run wealth effects should be somewhat weaker than those implied by a KPR specification (< 0.6). For that reason, we consider intermediate values of γ for both countries. Precisely, for Spain, we set a weak short-run wealth effect, close to GHH preferences, $\gamma = 0.06$, while for Germany, $\gamma = 0.56$. This reduced-form specification captures the fact that owning a house in Spain has fiscal advantages [cf. Díaz and Franjo (2016)] and provides both collateral and better prospects for financial returns than the stock market [cf. Akin et al. (2014)].

Also, as η governs the elasticity of substitution between market and home production, the news effects become more important in the model under a low elasticity of substitution between market and home production - the elasticity of substitution between C_m and C_r is defined as $\epsilon_r = 1/(1-\eta)$. The reason for the particular choices for the parameter η is based, first, on the fact that it should reflect the beliefs about the complementarity and substitutability between the market activity and

Table 4: Key parameters

Param.	Value		Description
	SPAIN	**GERMANY**	
γ	0.06	0.56	governs the short-run wealth effect on the labor supply
η	-1.31	0.85	$\epsilon_h = 1/(1-\eta)$ elasticity of substitution between C_m and C_r
θ	7.2	1.25	intertemporal labor supply elasticity

Parameters for each country are chosen to minimize the distance between model and data IRFs.

home activity in the two economies. Secondly, it is important to notice that there is a lack of consistent and long time time series on time use in the home production for the two countries in the data set. Finally, given the empirical differences observed in the VAR estimation in labour market features between the two economies, we set for Germany a much responsive labor supply ($\theta < 1.3$) than for Spain, for which we set it not very responsive ($\theta < 7.2$). These assumptions can be interpreted as a reduced-form for differences in labour market frictions.[16]

Notice that despite the reduced form approximation to the financial-fiscal channel and the workings of the labour market, the model we propose considers two sectors, each of them with its relative productivity and factor allocation. The whole production in the economy is driven by the movements in the relative prices of investment, and beyond the response through preferences.

4   Quantitative experiments

Next, we inspect the theoretical impulse response functions (IRFs) of the relative prices of investment in response to a news shock in our benchmark model. We start with the news shocks on the relative prices of residential investment, q_{rt} (residential RPI). In Appendix E, we include the estimations of news shocks on the relative prices of business structures, q_{st}, and the relative prices of equipment investment, q_{et}.

For the purpose of analyzing the news shocks' propagation mechanism, there are various moments of interest: the variable movement on impact, meaning at $t = 1$, then, at the period t between $2 < t < 4$, at the time of the realization of the shock, $t = 4$, and finally, after the realization of the

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[16]These differences became particularly important after 2000, with the so-called Hartz reforms of the labour market in Germany implemented in 2003 and 2005, as discussed for instance by Bauer and King (2018) and Bradley and Kügler (2019).
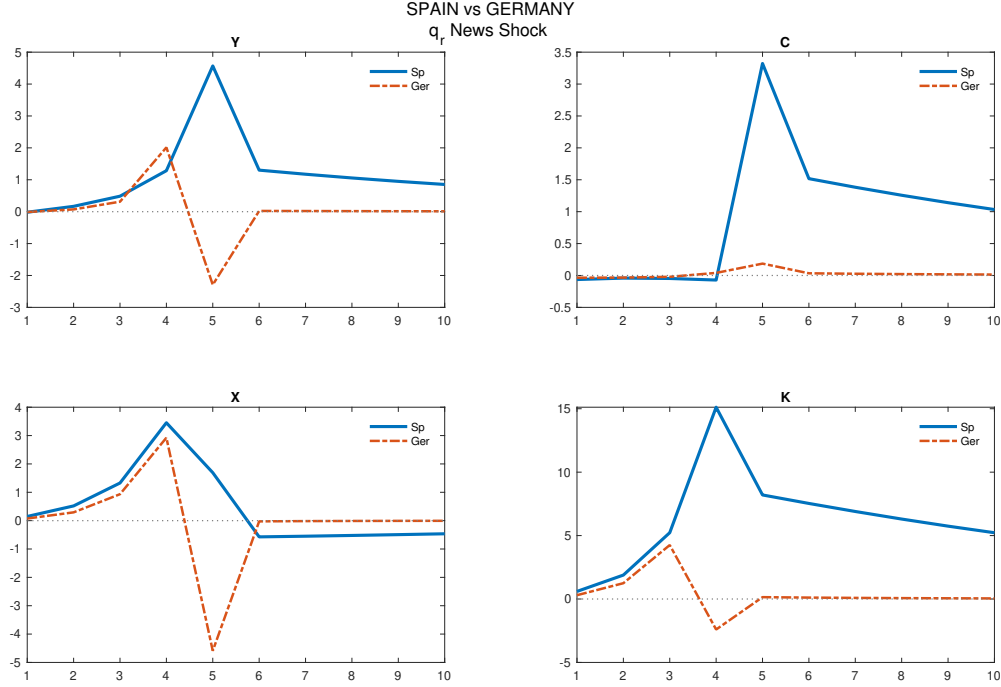
Figure 3: q_r news shock effect on aggregate variables

shock, $t = 4$.

4.1 News Shocks on q_{rt}

4.1.1 Effects on aggregate variables of a q_{rt} news shock effects

Figure 3 shows the IRFs of aggregate model's variables following a 1% positive news shock on the relative prices of residential investment.

On impact, at time t, the Spanish and German output, consumption, investment, and capital accumulation, do not move. For both economies, starting from the second period, the output, investment and capital accumulation start increasing, though the positive shock only occurs in period four. The aggregate consumption does not react for either economy. The Spanish output, consumption and capital accumulation peak only after the realization of the news shock. That means, in the fifth period, when they reach the maximum after which persistently stay above the steady state for many periods. Starting with the sixth period, the Spanish aggregate investment falls slightly under the steady state, where it stays for 15 periods. For Germany, most of the aggregate
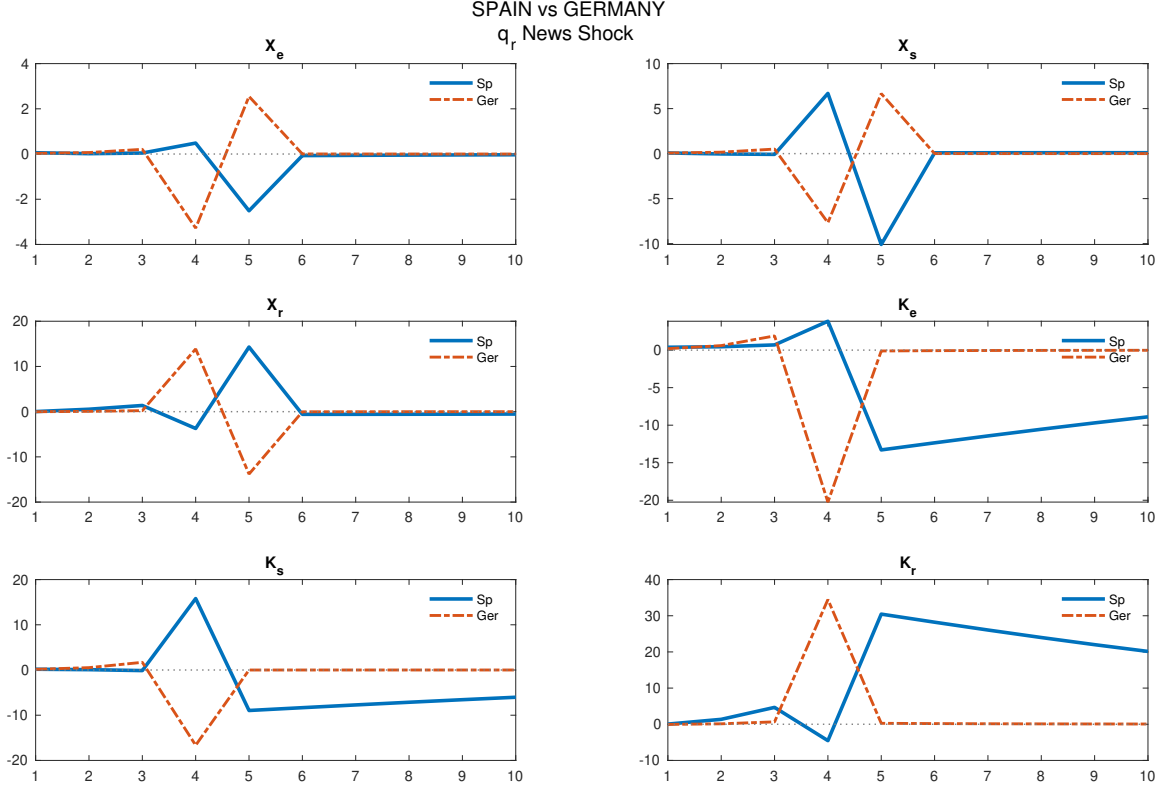
Figure 4: q_{rt} news shock effect on investment categories and capital accumulation

variables increase occurs between period two and four, when the news arrives, and not in period four when the q_{rt} shock materializes. After the fourth period, the German output, investment and capital accumulation are falling, returning to the log run equilibrium already from the sixth period, while the consumption response, even if it is very small, it is positive.

The Spanish IRFs for output, consumption, and capital accumulation are positive and persistently above the steady state, indicating a long and persistent economic growth and capital accumulation already from the second period. For Germany, the initial increase of the variables is followed by a fall and a rapid return to the log run equilibrium after that. At the aggregate level, if in the period before the shock realization the variables are positively correlated, after the shock materializes, the effects are opposite for the two economies, with much stronger fluctuation for Spain, and less for Germany.

4.1.2 Effects on investment categories and capital accumulation of a q_{rt} news shock

Figure 4 shows the IRFs of investment categories, X_e, X_s, X_r, and capital accumulation, K_e, K_s, K_r, following a positive 1% news shock on the relative prices of residential investment. The first observation is that the model is able to mimic the negative correlation in investment between the two countries found in the data especially starting from the 2000s.

For the propagation mechanism, there are three moments of interest: the variable movement before, at the time of the realization, and after the shock. For the Spanish economy, the equipment, X_e, and structures investment, X_s, are increasing on the realization of the shock, after which they both are falling. The initial increase in the structures investment is stronger than the equipment one, but also the fall is deeper, even it is not persistent. The residential investment, X_r, is increasing strongly after the realization of the news shock, even thought in the period before the realization of the shock, there are two opposite but weak movements; one of a mild increase starting from the second period, followed by a very short fall exactly on the realization of the shock.

For the German economy the movements are exactly opposite. Equipment and structures are decreasing on the shock realization, to increase in the following periods. Residential investment is increasing only on the realization of the shock after which there is a fall. For Germany, it is the case that the news shock effect on equipment and structures investment is positive, while it is negative for residential investment.

The capital accumulation,K_e, K_s, K_r, is negatively correlated for the two economies. Again, we analyze the effects looking at the three moments of interest: the variable movement before, at the time of the realization, and after the shock.

For the German economy, capital accumulation is negative at the time of the news shock realization for equipment, K_e, and business structures, K_s, while it is positive for residential capital, K_r. None of the variables movement is persistent. On the contrary, the Spanish variables are showing nice persistent movements; negative for the equipment and business structures, and positive and very persistent for the residential capital accumulation.

5 Extension - a small open economy model

This section describes an extension of the model that incorporates news shocks in a small open economy version of our benchmark economy. We follow Schmitt-Grohé and Uribe (2003) and assume that the interest-rate faced by agents is increasing in their individual debt position, d_t. The small open economy model still has two productive sectors, but only the market sector produces for abroad. As in the closed economy setting, key assumptions for the model are that home production is not a perfect substitute for market goods and services, and that is not tradable in the market.

The driving forces in the business cycle model include country - specific stochastic stationary contemporaneous shocks and news shocks. The news shock is hitting the residential investment ISTC. In particular, as the empirical analysis suggests, the ISTC news shock has different long-run implications, but the contemporaneous effects are essentially zero.

5.1 Country-specific interest rate premium

Households can borrow and lend in the international capital market at the exogenous international real interest rate, r_t. We assume that the domestic interest rate r_t is increasing in the aggregate stock of foreign debt, d_t. More precisely, we assume that r_t evolves according to:

$$r_t = r^* + p(\tilde{d}_t) \tag{5.1}$$

where r^* denotes the world interest rate and $p(\tilde{d}_t)$ is a country-specific interest rate premium. The function $p(\tilde{d}_t)$ is assumed to be strictly increasing. Following Schmitt-Grohé and Uribe (2003) we assume for the risk premium: $p(\tilde{d}_t) = \psi_d \left(e^{(d_t - \bar{d})} - 1 \right)$, where $\psi_d > 0$ is a parameter and $\bar{d}$ is the level of debt in steady state.

5.2 News shocks effects on aggregate variables

In a small open economy households can borrow and lend in international markets. Figure 5 shows that the Spanish economy starts to increase activity after the shock a period earlier with respect to the closed economy. After the news shock hits, in period $t = 2$, and as the Spanish household has the possibility to borrow in the international markets, the GDP, aggregate investment and capital

Figure 5: IRF Aggregate variables
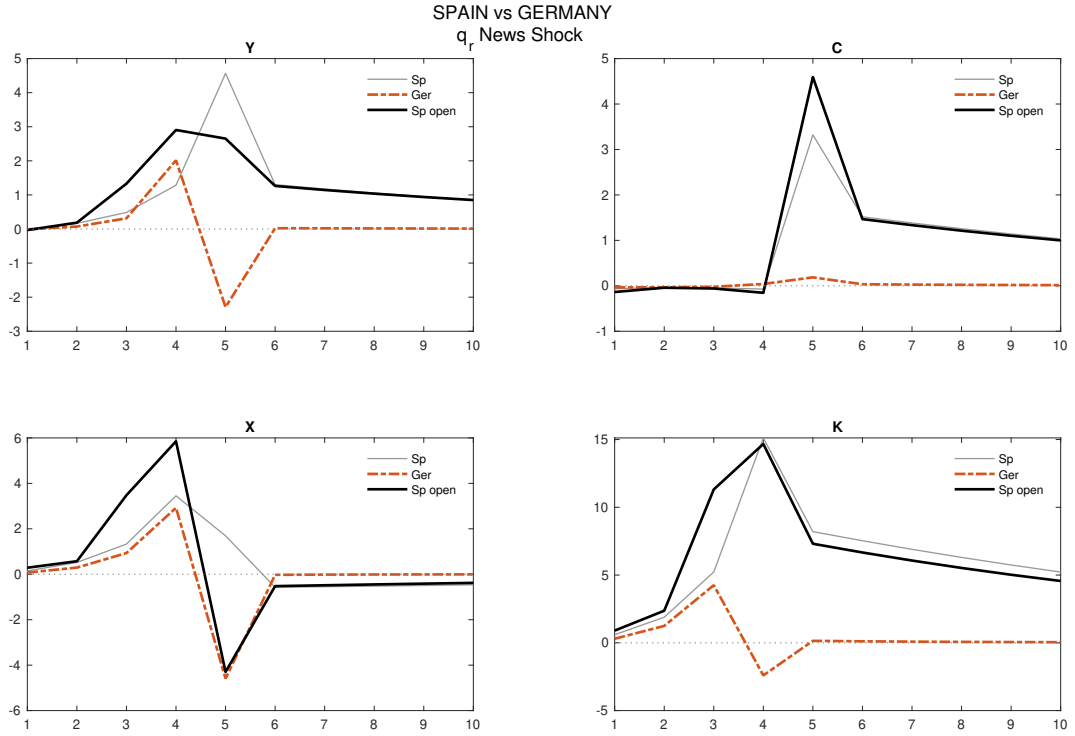
SPAIN vs GERMANY
q_r News Shock

Note: The black line represents the Spanish economy in a small open economy setting; the dotted red line represents the German economy in the benchmark model, while the gray line represents the Spanish economy in the benchmark model.

accumulation starts to increase. Although the GDP increase is milder than in the closed economy setting, the investment and consumption increase is much stronger. As such, the model is able to replicate a well-known Spanish economic characteristic of a much higher volatility of consumption than GDP over the business cycle.

5.3   News shocks effects on Investment categories

Figure 6 represents the impulse response function of investment categories. The residential capital accumulation for the Spanish economy is starting to increase much earlier that in the closed economy setting. Although the increase is lower, the accumulated effect of the news shock is stronger. The message is that in an open economy setting, the responses to news shocks are smoother and more realistic.

Figure 6: IRF Investment categories
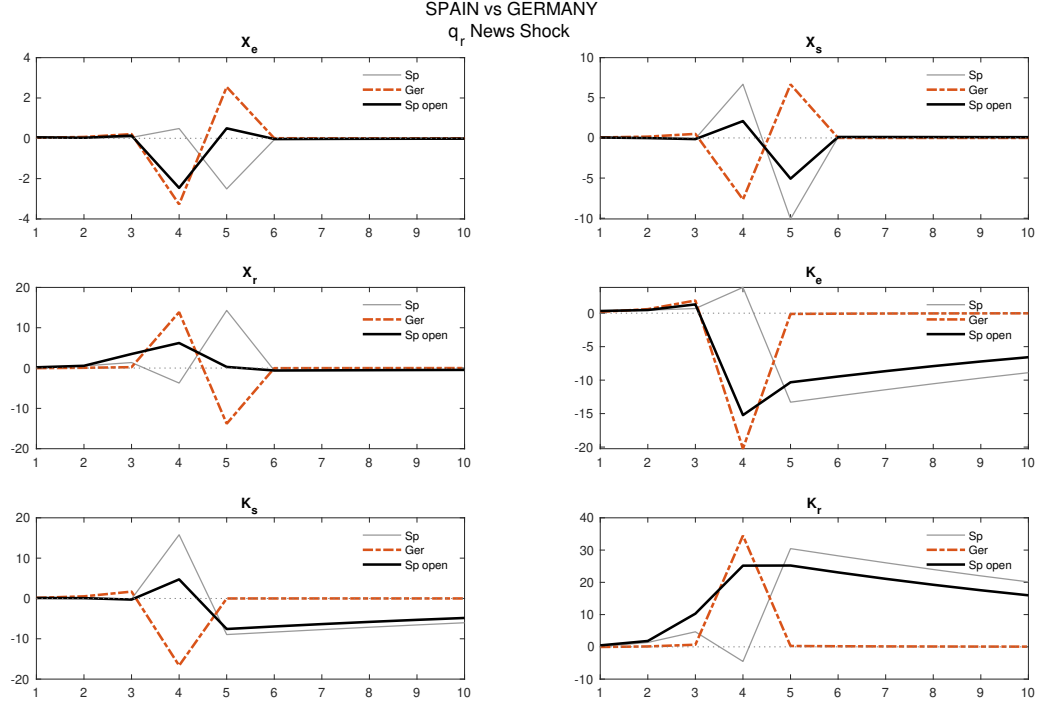
Note: The black line represents the Spanish economy in a small open economy setting; the dotted red line represents the German economy in the benchmark model, while the gray line represents the Spanish economy in the benchmark model.

6 Conclusion

This paper provides evidence that anticipated (news) shocks to the relative price of residential investment are the main force behind business cycle fluctuations in Spain. To obtain these results, we first implement the Barsky and Sims (2011) estimation approach. In so doing, we could identify news shocks in all three spikes observed in the data for the relative price of investment both in Germany and in Spain, but the propagation mechanisms are different for the two economies. The empirical impulse responses produce significant positive business cycle comovement in both countries.

The news shocks that explain in a high measure the variation of output and investment, are robust to different lag choices and to alternative VAR specifications. A significant forecast error variance contribution (80%) of residential investment in the Spanish economy is explained by news shocks to the relative prices of residential investment. For the German economy, the news shocks explain the variance of the aggregate variables to a lesser extent.

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Then, the theoretical model we propose to interpret the empirical results confirms the role of the news shocks to the relative price of residential investment (RPI) as an important driver of the housing boom in Spain. The key contribution of the quantitative experiments with the proposed model is to put together the news shock on the RPI with a reduced form for the wealth effect from house prices and for the frictions in the Spanish labour market. The propagation mechanism of those news socks is consistent with the observation of recent economic growth due to residential investment in Spain. For Germany, the wealth effect induced by the residential ISTC news shock increases investment in equipment and business structures instead. It is worth emphasizing, however, that the propagation mechanism we have described seems to have been exacerbated after the euro. One possible explanation is that German credit flows feed the real state bubble in Spain, as far as German investors realized they could have an expansion without a domestic housing boom. We leave these issues for further research.

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Appendix

A DATA

Data sources are the *EU KLEMS* and the *OECD* databases.[17] We consider the period 1970-2015. Additionally, the disaggregated information on consumption expenditures used in the calibration is from *EUROSTAT* over the period 1995-2015.

A.1 The relative price of investment goods and the stock of capital

The EU KLEMS September 2017 release is based on the NACE 2 industry classification and the new European System of National Accounts (ESA 2010). Compared with the previous one (ESA 1995), ESA 2010 includes more assets in the definition of Gross Fixed Capital Formation (GFCF). The database structure of capital and investment is organized in eleven categories, provides deflators for all categories, and calculates the capital stock using a perpetual inventory method.

The procedure to construct the **Residential Investment**, **Business Structures** and the composite **Equipment** follows Díaz and Franjo (2016):

Residential Investment contains the category *Residential structures*,

Business Structures contains *Total Non-residential investment*,

Equipment contains all other categories corresponding to various types of business equipment, computer software, and research and development as intellectual property, weapons systems, and investment in cultivated assets, precisely: [1.] *Computing equipment* [2.] *Communications equipment* [3.] *Computer software and databases* [4.] *Transport Equipment* [5.] *Other Machinery and Equipment* [6.] *Cultivated assets* [7.] *Research and development* [8.] *Other IPP assets.*

We construct the implicit price deflator of *non durable goods* and *services*, $D_{nd,t}$ using the data from OECD.Stat, IPC series of ECOICOP.[18] To construct the composite *Equipment* (Paasche index), we take the implicit price deflator of each type of investment good, $D_{i,t}^j$ from EU KLEMS (base year 2010). We define the relative price of the investment good i in category e (*equipment*) as

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$q_{it}^e = D_{it}^e/D_{ndt}$. We construct a constant-price measure of equipment investment as $X_{et} = \sum_i q_{i0}^e X_{it}^e$. Thus, the implicit price deflator of equipment is:

$$q_{et} = \frac{\sum_i q_{it}^e X_{it}^e}{X_{et}} \tag{A.1}$$

Next, we calculate the real stock so that

$$K_{et} = \frac{\sum_i q_{it}^e K_{it}^e}{q_{et}}, \tag{A.2}$$

where K_{et} is the real capital stock calculated by EU KLEMS for each type of investment good. EU KLEMS constructs the stocks of structures and housing. We have calculated their relative price using the deflator of non durable goods and services.

Figure 1 in the main text showed the relative prices of investment for each category (in units of non durable consumption goods and services) for Spain and Germany. The inverse of each q_{it} relative price represents the measure of ISTC, Θ_{it}, in residential investment, business structures and equipment. We have normalized the relative prices so that 1970 is the base year for both countries.

The behavior of the relative price of equipment, shown in the lower panel of that Fig. 1 exhibits a downwards trend for both countries. The fall in the relative price in Spain is higher than Germany's in two periods: from 1970 to 1979 and from 1985 to 1991. Those two periods coincide exactly with periods of a housing boom in Spain, as we observe in the upper panel, where the relative price of residential investment is shown. We observe two booms before the 2000s: the relative price index for Spain reached 144.6 in 1979, and 139.80 in 1991. The peak in 2007 reached 178.4, though. The correlation between the two countries price indexes is 0.65 from 1970 to 1998, whereas it is strongly negative, - 0.85, from 1999 to 2015. Finally, the relative price of business structures, shown in the central panel of that Fig. 1 shows a similar pattern in both countries until the 2000s. The coefficient of correlation from 1970 to 1998 is 0.60, while from 1999 to 2015 the correlation is negative, -0.70. In Germany, however, the relative price of structures is much more volatile than the relative price of residential investment: it fluctuates seven times more.

Figure A.1, in its turn, shows the ratio of capital to GDP for each investment category for Spain and Germany. We have normalized the figures to 1970 as the base year for both countries. We do so as a counterfactual exercise to see what would have happened if they had started at the same level.

Figure A.1: **Investment Capital/ GDP - Spain vs Germany**
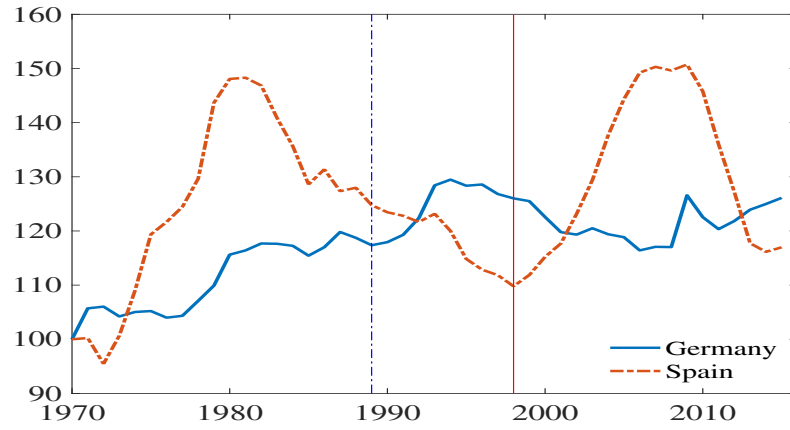
(a) Residential Investment/GDP
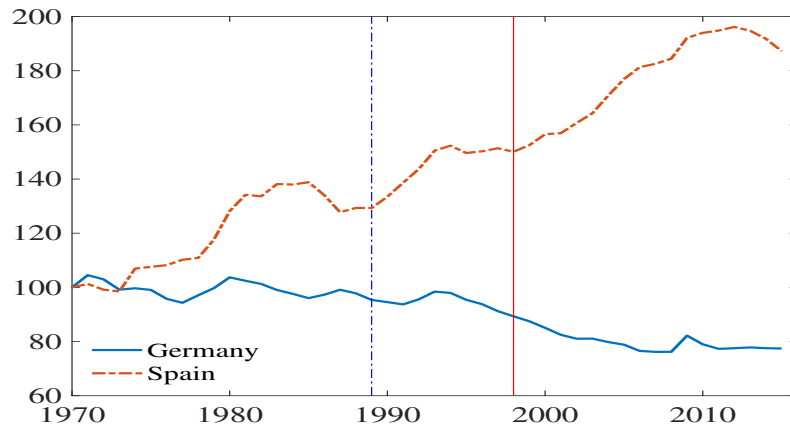
(b) Business Structures/GDP
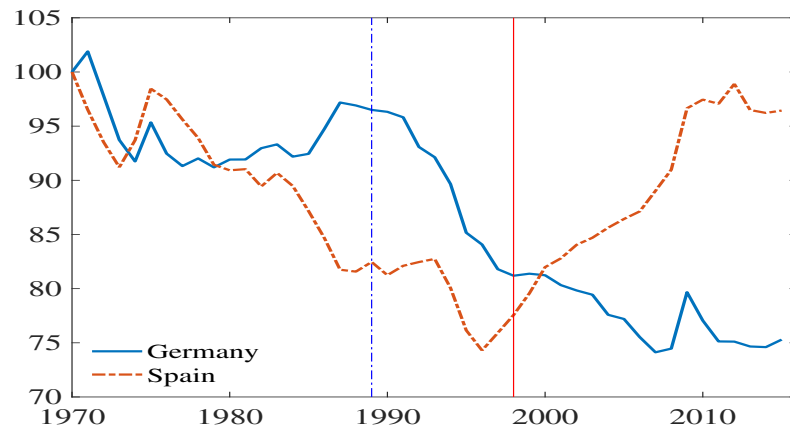
(c) Equipment/GDP

Note: The ratio of capital to GDP for residential investment, structures and equipment, normalized so that 1970 is the base year for both countries. Notice the different Y scales. Vertical lines mark the dates of fall of Berlin Wall (blue), and Spanish Land Law (red).

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As we can see in the lower panel, until 2000 Germany is more intensive in equipment than Spain. Then Spain becomes more intensive in its capital equipment to GDP ratio. In the central panel, the ratio of business structures to GDP in Spain exhibits an upward trend, while for Germany, the trend is slightly downward and quite stable. The upper panel in Figure A.1 shows the ratio of residential capital to GDP. The spikes in the housing stock in Spain correspond to two periods of strong increase in residential capital, but only in the 2000-2009 spike the whole economy was booming. During the first spike from 1973 to 1981 the economy was stagnant. Thus, the housing prices boom in 1991 in Spain came with a balanced housing capital to GDP ratio.

A.2   Output, Consumption, and Housing Services

We consider measured GDP as the sum of market output, Y_m, and home production Y_r, $GDP = Y_m + Y_r$. Market output is consumption and investment, that is, $Y_m = C_m + X_e + X_s$, whereas home production is the sum of housing services and residential investment, $Y_r = C_r + X_r$. Our measure of C_r comprises the services of rental housing, maintenance and repair, as well as the imputed services of owner occupied housing (computed using a rental equivalence approach as in Díaz and Luengo-Prado (2008).) We use EUROSTAT data and the model's Y_r to calculate C_r. For Spain we compute C_r is 21.7% of household consumption expenditure, whereas for Germany is 23.5%. Notice that prior to 1995 EUROSTAT did not report disaggregated data on consumption expenditures.

Figure A.2 shows the implied ratios K_r/Y_r, K_s/Y_m and K_r/Y_m. These ratios are consistent with Fig. 1 in the main text and with Fig. A.1 above, and they are used to calibrate the factor shares in market output, α_e, and α_s, and the factor share in the home production sector, α_r. For Spain, the ratio K_r/Y_r, is falling up to the Great Recession. We interpret this observation as the result of a strong wealth effect in non-market output growing at a higher rate than residential capital. For Germany the path for this series is stable. The K_s/Y_m series show a converging path until the Great Recession and comovement afterwards, while the K_e/Y_m series are diverging exactly after that point. The three ratios support the idea of substitutability between equipment and residential capital for Germany, while for Spain reflects the complementarity of the three types of capital.

Figure A.2: **Investment Capital to Residential and Market output: Spain vs Germany**

(a) Residential Capital/Y_r

(b) Business Structures Capital/Y_m

(c) Equipment Capital/Y_m
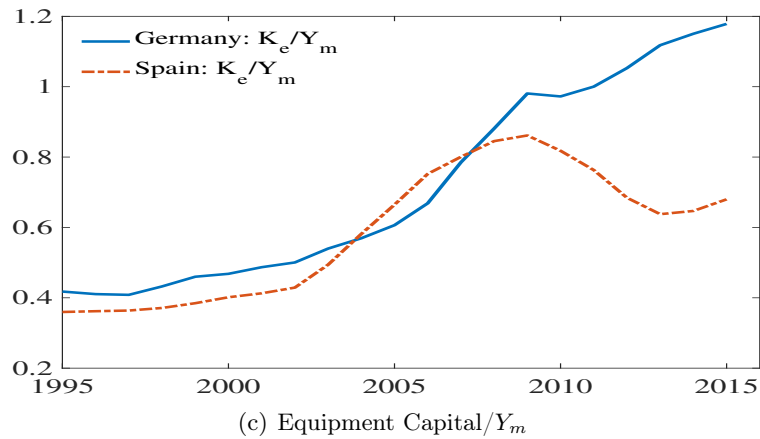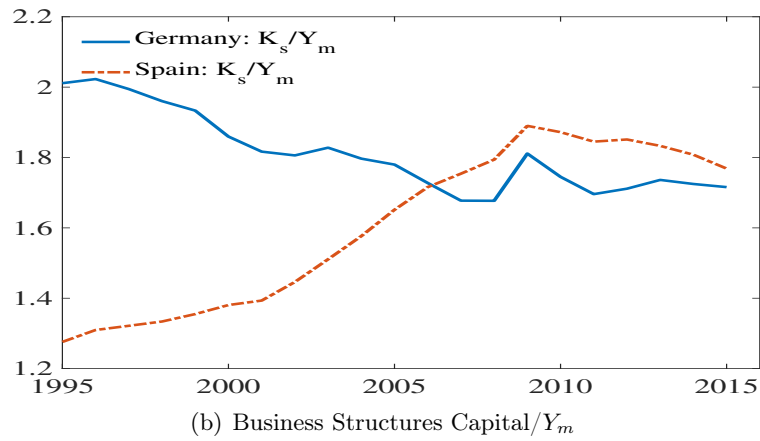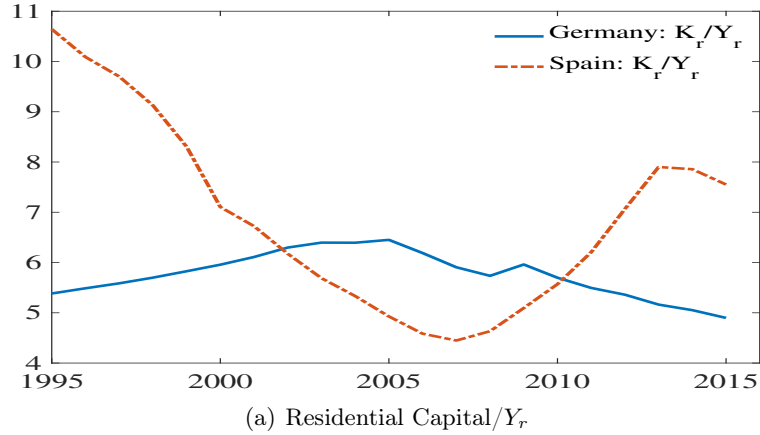
Note: The ratio of capital to Y_r for residential investment and the ratio Y_m structures and equipment used for calibration

Figure A.3: **Neutral progress non-market & market output: Spain vs Germany**

(a) Neutral progress non-market output, A

(b) Neutral progress market output, Z
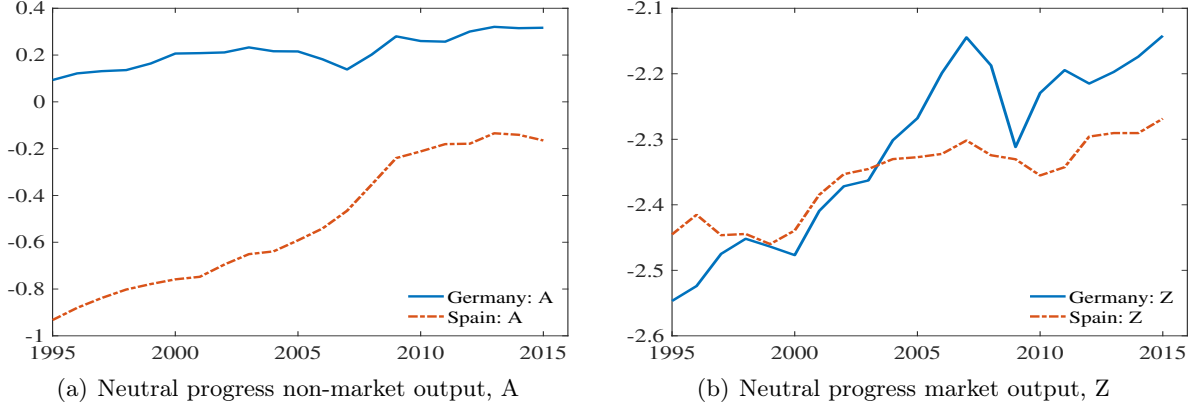
Note: The neutral progress for non-market output, A, and for market output, Z, time series are obtained by using a standard Solow decomposition.

A.3   Productivity measures

From the evolution of the relative prices of investment we estimate their stochastic structure. We estimate the parameters $\bar{q}_e, \bar{q}_s, \bar{q}_r$ and $\rho_{q_e}, \rho_{q_s}, \rho_{q_r}$ from the time series properties of the series from the *EU KLEMS* data base. Again, the inverse of each q_{it} relative price represents the measure of ISTC, Θ_{it}, in residential investment, business structures and equipment.

We also measure neutral progress for non-market output, A_t, and market output, Z_t. These are shown in figure A.3. These series of neutral progress show different pictures for each country. The neutral progress for non-market output has a higher level, but it is flat for Germany, while it is increasing for Spain until the Great Recession. Neutral progress for market output is almost flat for Spain, while for Germany is increasing. From those series we estimated the neutral progress parameters, $\bar{A}$ and $\bar{Z}$, and the autocorrelation parameter, ρ_A and ρ_Z.

Nevertheless, the Spanish economy has experienced important institutional changes during the period 1970-1996. In particular, the labor market suffered various legal changes. In the 80s was introduced a new legislation intended to reduce the flexibility in the workweek and to rise severance payments (see, for instance, Bentolila et al. (2012)). The differences between the two countries, became particularly important after 2000. Germany implemented in 2003 and 2005 the so-called Hartz reforms of the labour market, as discussed for instance by Bauer and King (2018) and Bradley and Kügler (2019).

B VAR IDENTIFICATION

We identify news shocks using Barsky and Sims (2011) methodology. Let $\mathbf{y}_t$ be a $k \times 1$ vector of observables of length T. Let the reduced form moving average representation in the levels of the observables be given as

$$\mathbf{y}_t = \mathbf{B}(\mathbf{L})\mathbf{u}_t \tag{B.1}$$

where $B(L)$ is a $k \times k$ matrix polynomial in the lag operator, L, of moving average coefficients and u_t is the $k \times 1$ vector of reduced-form innovations. We assume there exists a linear mapping between innovations and structural shocks, ε_t, given as:

$$\mathbf{u}_t = \mathbf{A}_0 \varepsilon_t \tag{B.2}$$

This implies the following structural moving average representation:

$$\mathbf{y}_t = \mathbf{C}(\mathbf{L})\varepsilon_t \tag{B.3}$$

Where $\mathbf{C} = \mathbf{B}(\mathbf{L})\mathbf{A}_0$ and $\varepsilon_t = \mathbf{A}_0^{-1}\mathbf{u}_t$. The impact matrix must satisfy $\mathbf{A}_0 \mathbf{A}_0^{'} = \mathbf{\Sigma}$, where $\mathbf{\Sigma}$ is the variance-covariance matrix of reduced-form innovations. There are, however, an infinite number of impact matrices that solve the system. In particular, for some arbitrary orthogonalization, $\tilde{A}$ (we choose the convenient Cholesky decomposition), the entire space of permissible impact matrices can be written as $\tilde{A}D$, where D is a orthonormal matrix ($D' = D^{-1}$ and $DD' = I$, identity matrix).

The h step ahead forecast error is:

$$\mathbf{y}_{t+h} - E_{t-1}\mathbf{y}_{t+h} = \sum_{\tau=0}^{h}\mathbf{B}_\tau\tilde{\mathbf{A}}_0 D\varepsilon_{t+h-\tau} \tag{B.4}$$

where $B\tau$ is the matrix of moving average coefficients at horizon τ. The contribution to the forecasterror variance of variable i attributable to structural shock j at horizon h is then:

$$\Omega_{i,j}(h) = \frac{\mathbf{e}_i'\left(\sum_{\tau=0}^{h}\mathbf{B}_\tau\tilde{\mathbf{A}}_0 D\mathbf{e}_j\mathbf{e}_j'D'\tilde{\mathbf{A}}_0'\mathbf{B}_\tau{}'\right)\mathbf{e}_i}{\mathbf{e}_i'\left(\sum_{\tau=0}^{h}\mathbf{B}_\tau\mathbf{\Sigma}\mathbf{B}_\tau'\right)\mathbf{e}_i} \tag{B.5}$$

$$= \frac{\sum_{\tau=0}^{h}\mathbf{B}_{i,\tau}\tilde{\mathbf{A}}_0\gamma\gamma'\tilde{\mathbf{A}}_0'\mathbf{B}_{i,\tau}'}{\sum_{\tau=0}^{h}\mathbf{B}_{i,\tau}\boldsymbol{\Sigma}\mathbf{B}_{i,\tau}'}$$

The $\mathbf{e}_i$ denote selection vectors with one in the ith place and zeros elsewhere. The selection vectors inside the parentheses in the numerator pick out the jth column of $\mathbf{D}$, which will be denoted by γ. $\tilde{\mathbf{A}}_0\gamma$ is $k \times 1$ is a vector corresponding to the jth column of a possible orthogonalization and has the interpretation as an impulse vector. The selection vectors outside the parentheses in both numerator and denominator pick out the ith row of the matrix of moving average coefficients, which is denoted by $\mathbf{B}_{i,\tau}$.

Let q_t^i occupy the first position in the system, and let the unanticipated shock be indexed by 1 and the news shock by 2. Our identifying assumption implies that these two shocks account for all variation of q_t^i at all horizons. Eqs. (2.1) and (2.2), imply that these two shocks account for all variation in q_t^i

$$\Omega_{1,1}(h) + \Omega_{1,2}(h) = 1 \quad \forall h \tag{B.6}$$

It is general not possible to force this restriction to hold at all horizons. Instead, we propose picking parts of the impact matrix to come as close as possible to making this expression hold over a finite subset of horizons. With the surprise shock identified as the innovation in observed technology, $\Gamma_{1,1}(h)$ will be invariant at all h to alternative identifications of the other $k-1$ structural shocks. As such, choosing elements of A_0 to come as close as possible to making the above expression hold is equivalent to choosing the impact matrix to maximize contributions to $\Gamma_{1,2}(h)$ over h.

Since the contribution to the forecast error variance depends only on a single column of the impact matrix, this suggests choosing the second column of the impact matrix to solve:

$$\gamma* = \arg\max\sum_{\mathbf{h=0}}^{\mathbf{H}}\Omega_{1,2}(h) = \frac{\sum_{\tau=0}^{h}\mathbf{B}_{i,\tau}\tilde{\mathbf{A}}_0\gamma\gamma'\tilde{\mathbf{A}}_0'\mathbf{B}_{i,\tau}'}{\sum_{\tau=0}^{h}\mathbf{B}_{i,\tau}\boldsymbol{\Sigma}\mathbf{B}_{i,\tau}'} \tag{B.7}$$

s.t.

$$\tilde{\mathbf{A}}_0(1,j) = 0 \quad \forall j > 1 \tag{B.8}$$

$$\gamma(1,1) = 0 \tag{B.9}$$

$$\gamma'\gamma = 1 \tag{B.10}$$

So as to ensure that the resulting identification belongs to the space of possible orthogonalization of the reduced form, the problem is expressed in terms of choosing γ conditional on an arbitrary orthogonalization, $\tilde{A}_0$. H represents the finite truncation horizon[19]. The first two constraints impose that the news shock has no contemporaneous effect on the level of q_t^i. The third restriction (that γ have unit length) ensures that γ is a column vector belonging to an orthonormal matrix.

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[19]The finite truncation horizon in this paper is 10 periods

C Empirical evidence of news shocks vs. surprise shocks

This appendix illustrates the empirical results from a VAR identification of an anticipated (news) versus unanticipated (surprise) shock for Spain and Germany. These are from our benchmark VAR.

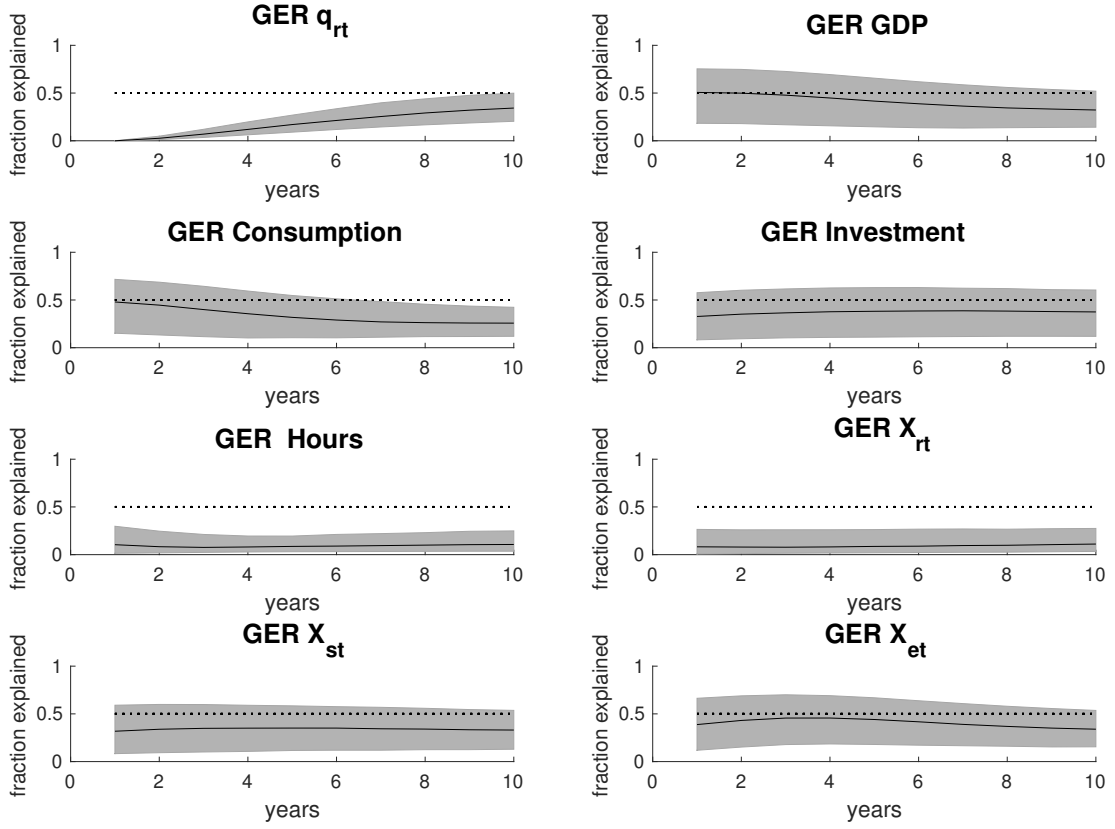## C.1 SPAIN - q_{rt} news shock
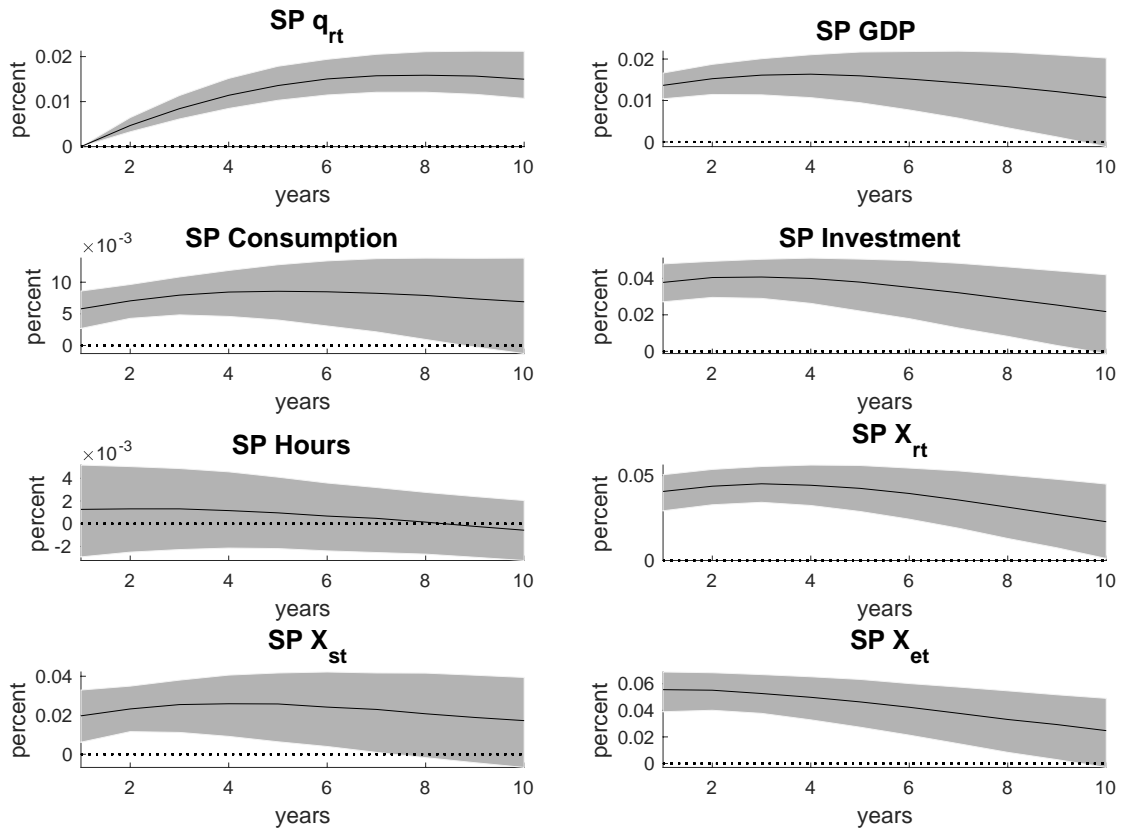
(a) Impulse Response Functions: q_{rt} news shock

Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.
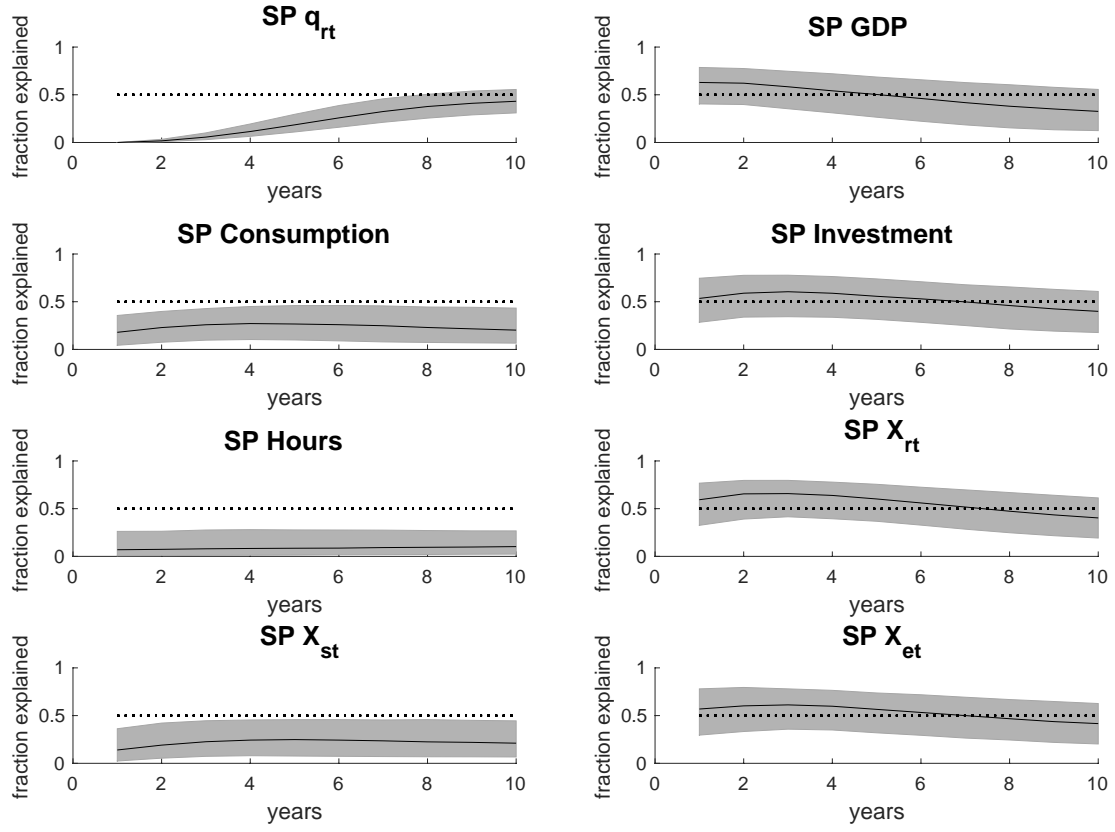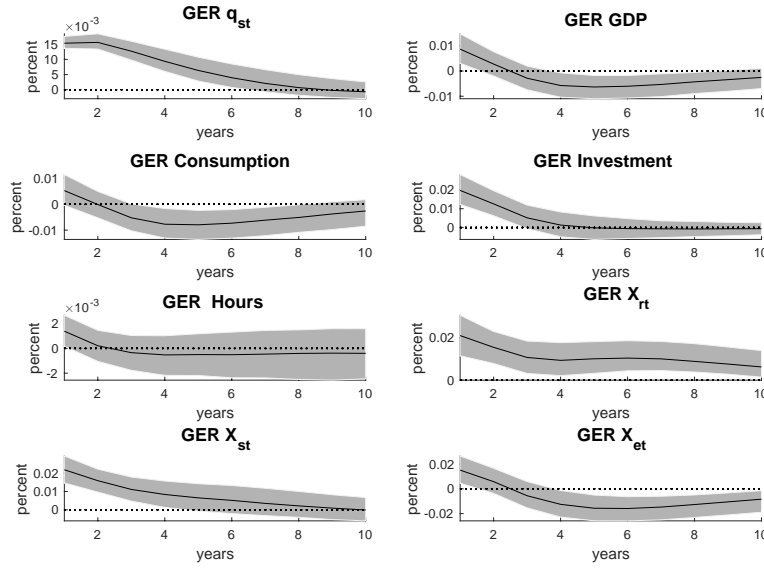
(b) Forecast Error Decomposition: q_{rt} news shock

Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table C.1: SPAIN - Maximum Forecast Error Variance (FEV) - q_t^r news shock

Spain	q_{rt}	GDP_t	C_t	I_t	Hours	X_r	X_s	X_e
Median contribution	0.61	0.59	0.15	0.65	0.05	0.80	0.46	0.43
Year	10	3	5	5	9	4	7	5

C.2   SPAIN - q_{rt} surprise shock
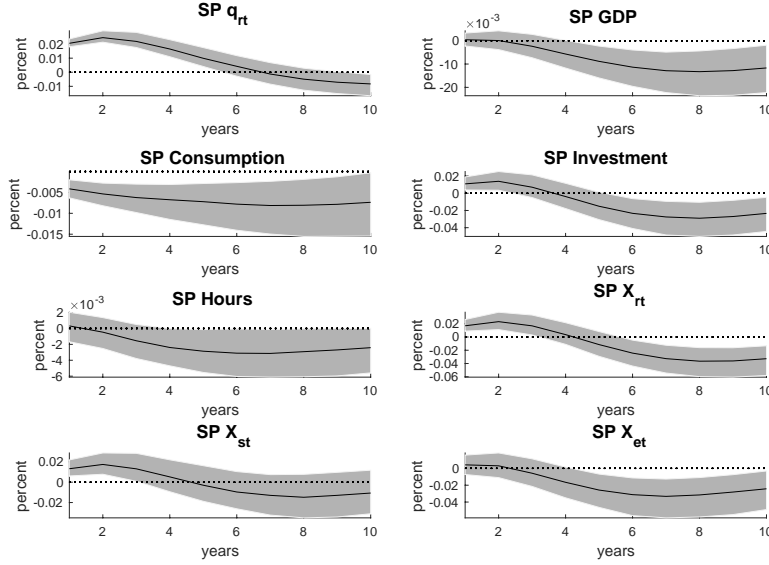
(a) Impulse Response Functions: q_{rt} surprise shock

Notes*:* Median responses to a surprise shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.
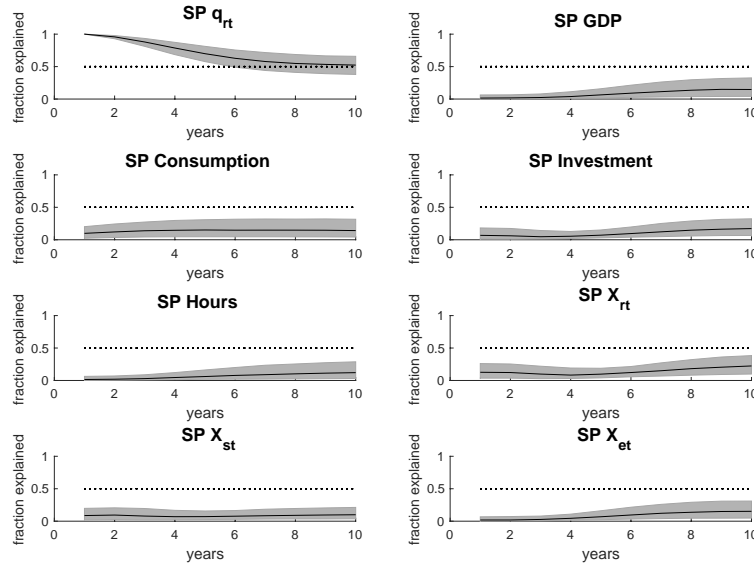
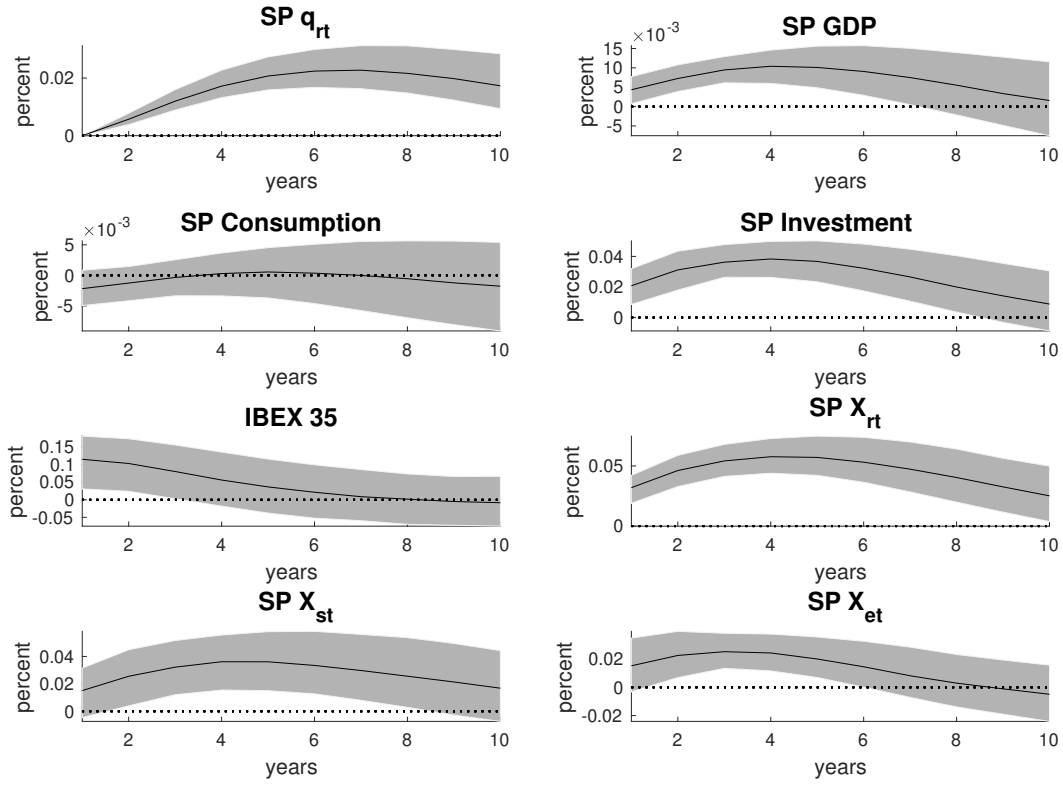(b) Forecast Error Decomposition: q_{rt} surprise shock

Notes*:* Median responses to a surprise shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

C.3 GERMANY - q_{rt} news shock
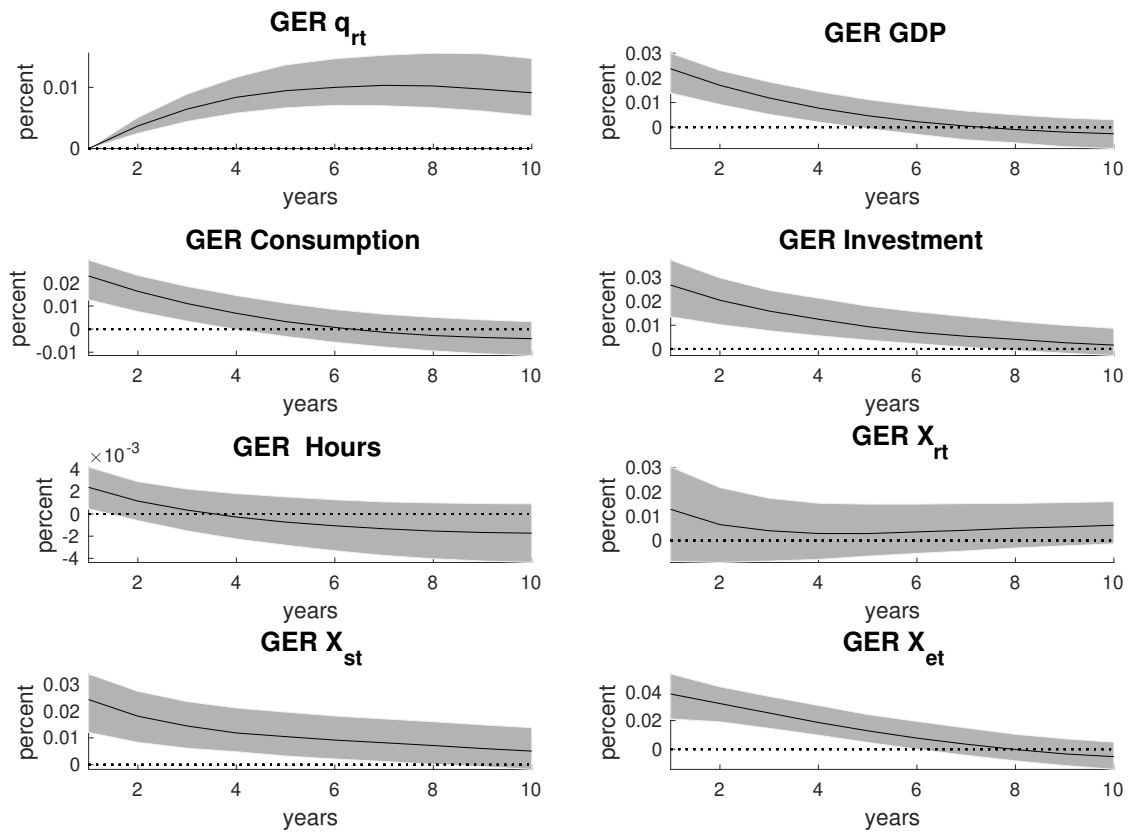
(a) Impulse Response Functions: q_{rt} news shock

Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.

(b) Forecast Error Decomposition: q_{rt} news shock

Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table C.3: GERMANY - Maximum Forecast Error Variance (FEV) - q_t^r news shock

Germany	q_{rt}	GDP_t	C_t	I_t	Hours	X_r	X_s	X_e
Median contribution	0.31	0.51	0.48	0.39	0.11	-	0.35	0.46
Year	10	2	1	9	10	3	4	10

C.4   GERMANY - q_{rt} surprise shock

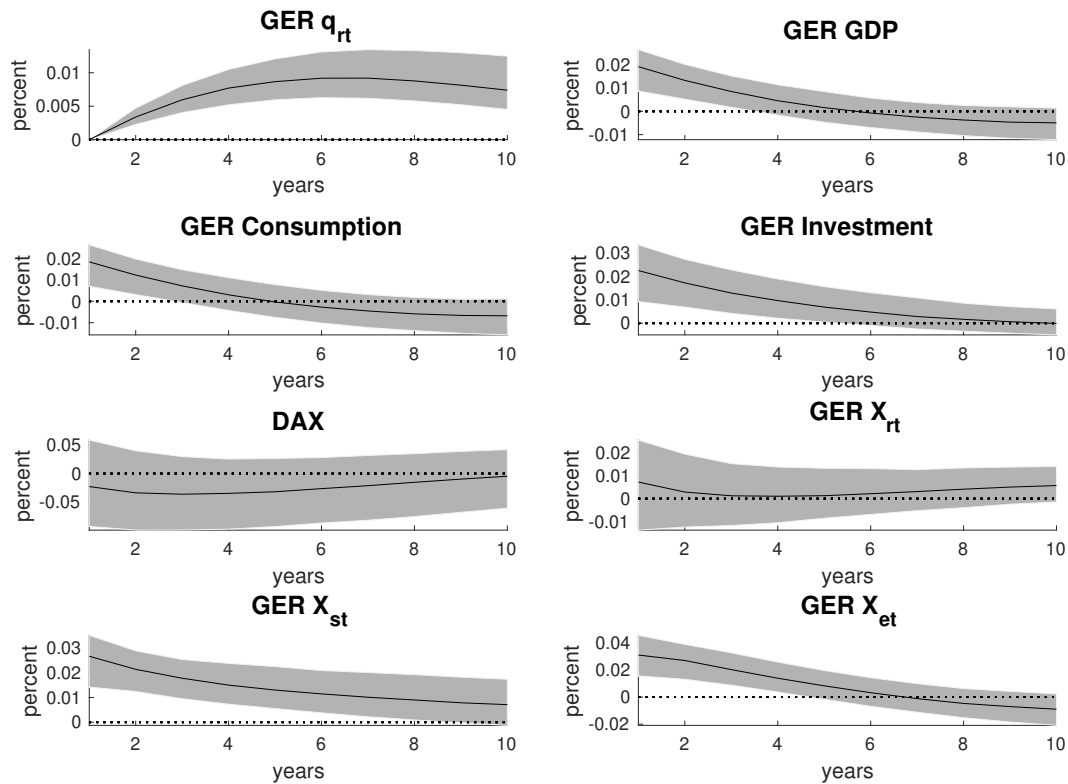(a) Impulse Response Functions: q_{rt} surprise shock

Notes*:* Median responses to a surprise shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.
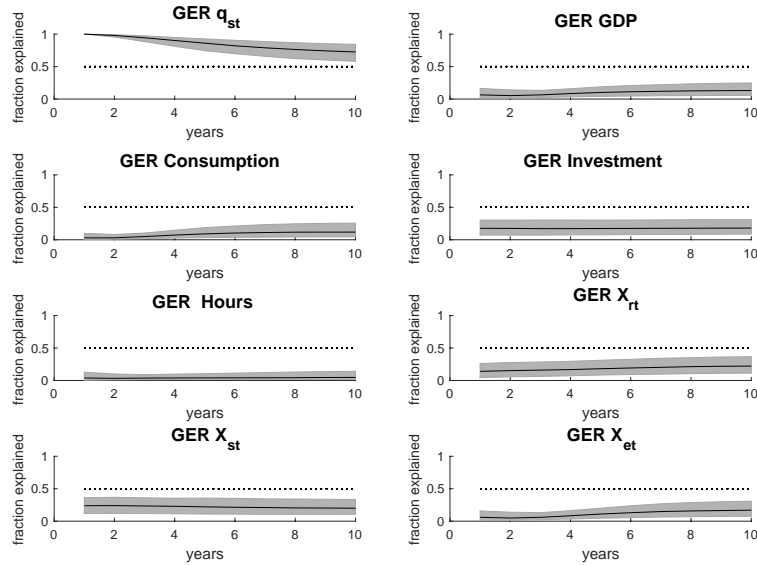
(b) Forecast Error Decomposition: q_{rt} surprise shock

Notes*:* Median responses to a surprise shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Appendix for Online Use

# D   Alternative VAR Identification and Alternative Shocks

D.1   SPAIN - q_{rt} news shock - alternative VAR

Figure D.1: SPAIN - Impulse responses to a 1% innovation in the q_{rt} news shock - alternative VAR
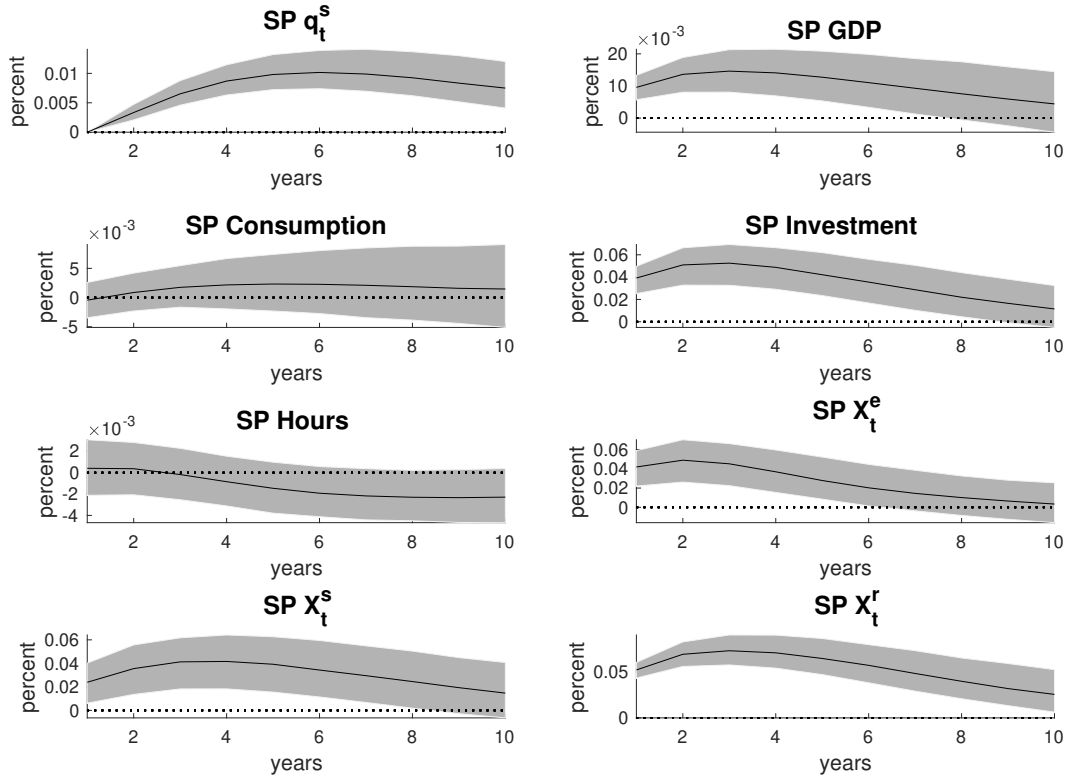

Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.

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Figure D.2: SPAIN - Forecast Error Variance (FEV) - q_{rt} news shock - alternative VAR
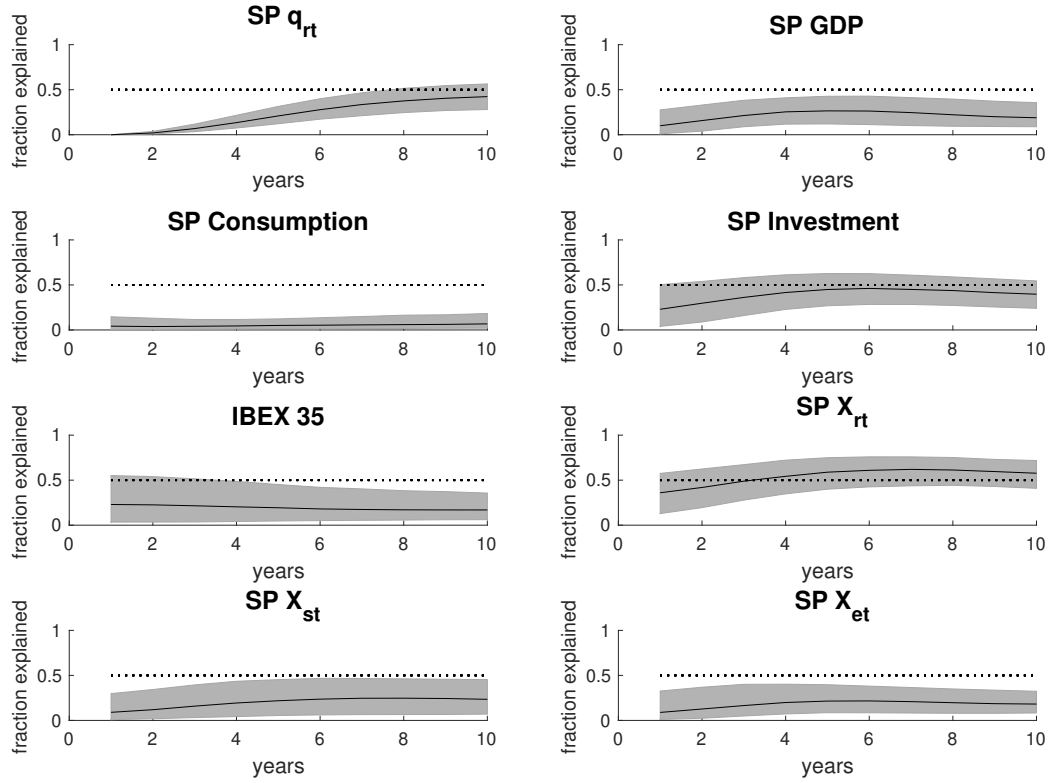
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table D.1: SPAIN - Maximum Forecast Error Variance (FEV) - q_{rt} news shock; alternative VAR

Spain	q_{rt}	GDP_t	C_t	I_t	IBEX 35	X_e	X_s	X_r
Median contribution	0.41	0.27	0.06	0.46	0.21	0.22	0.23	0.62
Year	10	5	10	5	1	5	7	6

D.2 Germany - q_{rt} news shock - alternative VAR

Figure D.3: GERMANY - Impulse responses to a 1% innovation in the q_{rt} news shock; alternative VAR

Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.

Figure D.4: GERMANY - Forecast Error Variance (FEV) - q_{rt} news shock; alternative VAR
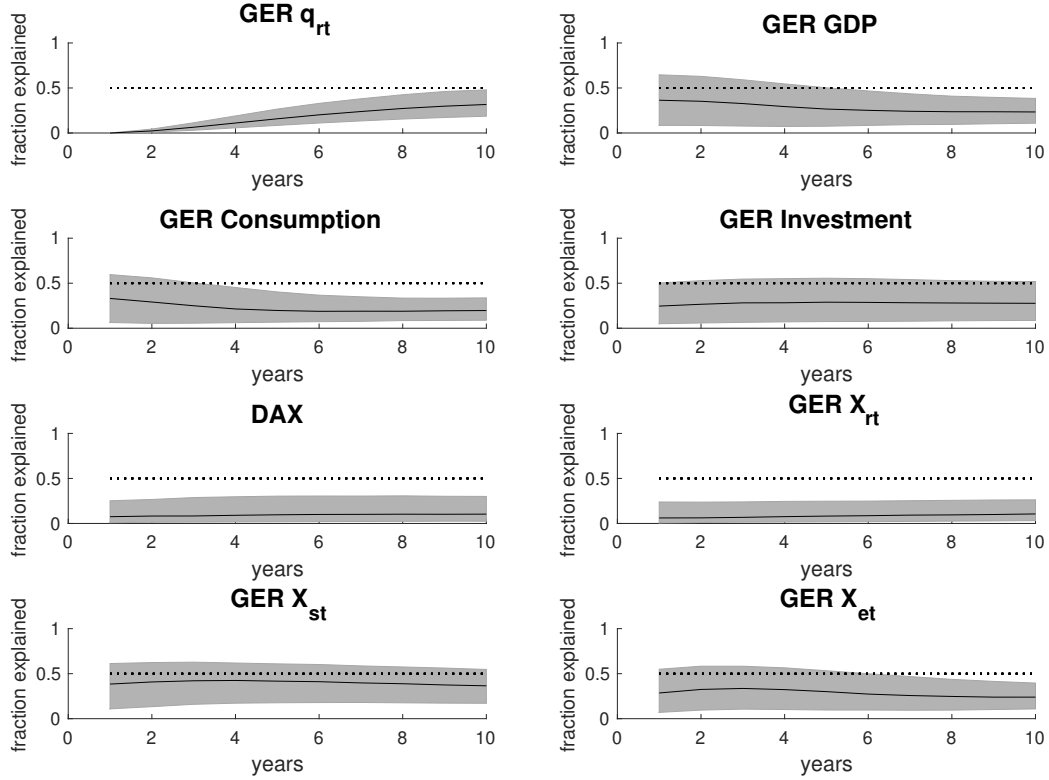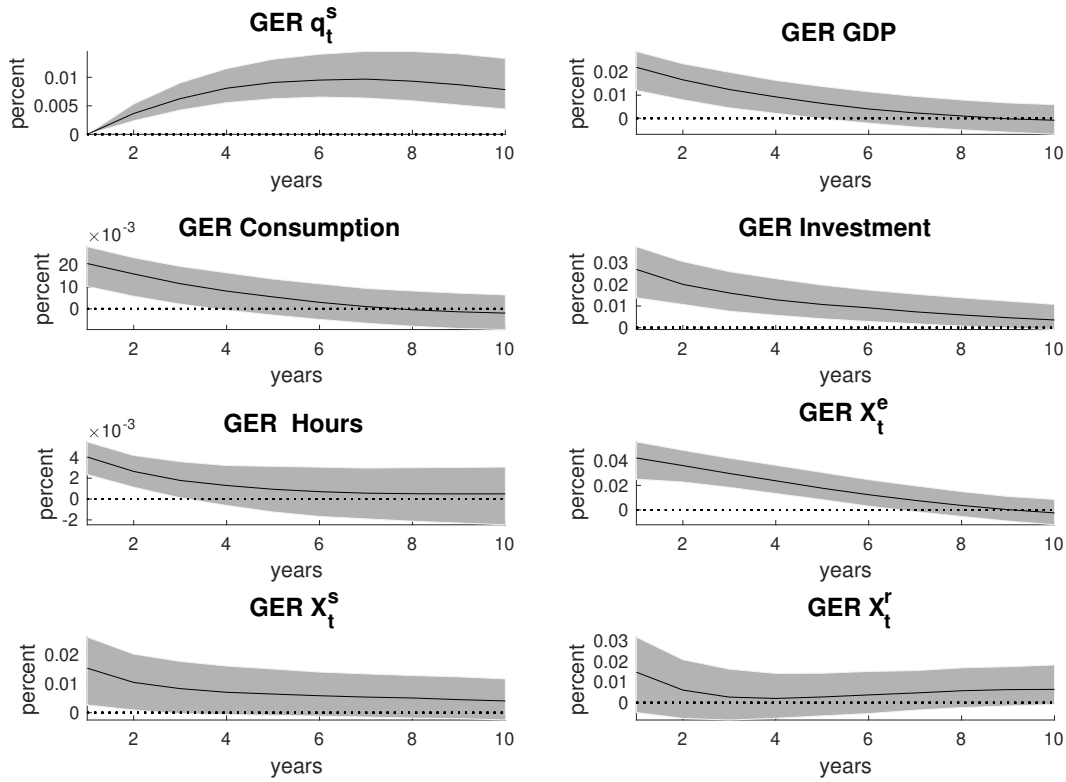

Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table D.2: GERMANY - Maximum Forecast Error Variance (FEV) - q_{rt} news shock; alt. VAR

Germany	q_{rt}	GDP_t	C_t	I_t	DAX	X_e	X_s	X_r
Median contribution	0.32	0.38	0.41	0.20	0.11	0.19	0.41	0.12
Year	10	1	1	6	10	4	5	10

## D.3 Spain - q_{st} news shocks - benchmark var

Figure D.5: SPAIN - Impulse responses to a 1% innovation in the q_{st} news shock; benchmark VAR

Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.

Figure D.6: SPAIN - Forecast Error Variance (FEV) - q_{st} news shock; benchmark VAR
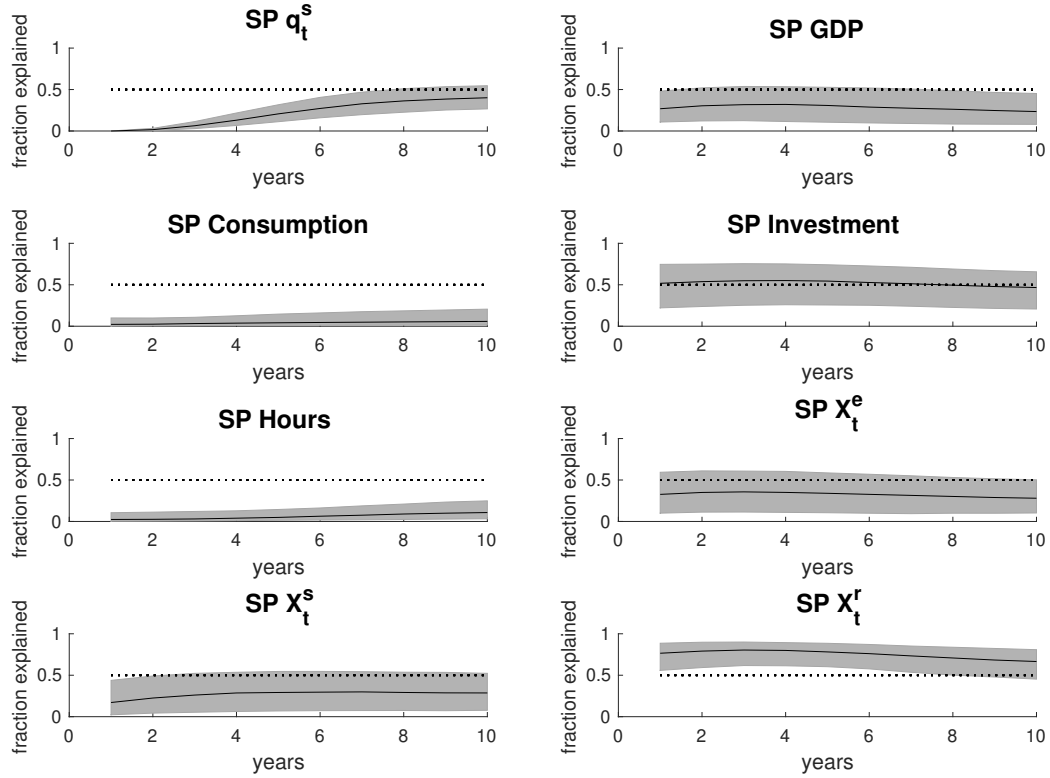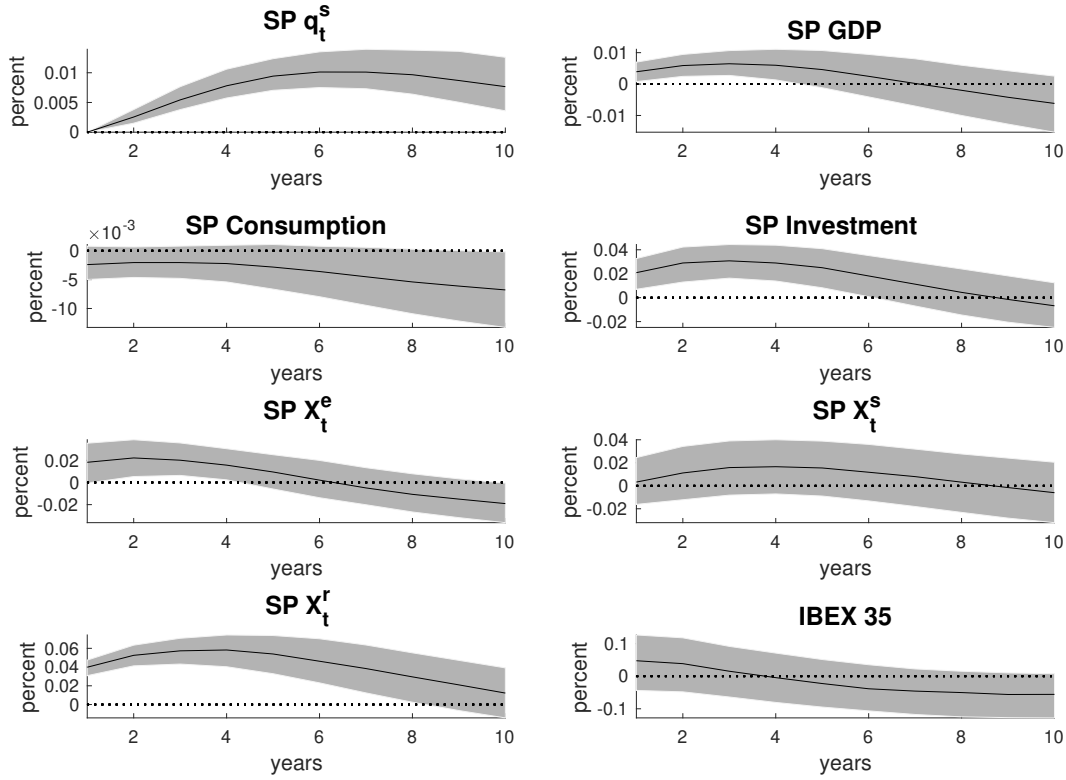

Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table D.3: SPAIN - Maximum Forecast Error Variance (FEV) - q_{st} news shock benchmark VAR

Spain	q_{st}	GDP	Consumption	Investment	Hours	X_e	X_s	X_r
Median contribution	0.40	0.32	0.06	0.55	0.11	0.36	0.30	0.80
Year	10	4	10	4	10	3	7	3

D.4 Germany - q_{st} news shocks - benchmark var

Figure D.7: GERMANY - Impulse responses to a 1% innovation in the ISTC news shock - q_{st} news shock; benchmark VAR

Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.

Figure D.8: GERMANY - Forecast Error Variance (FEV) - q_{st} news shock; benchmark VAR
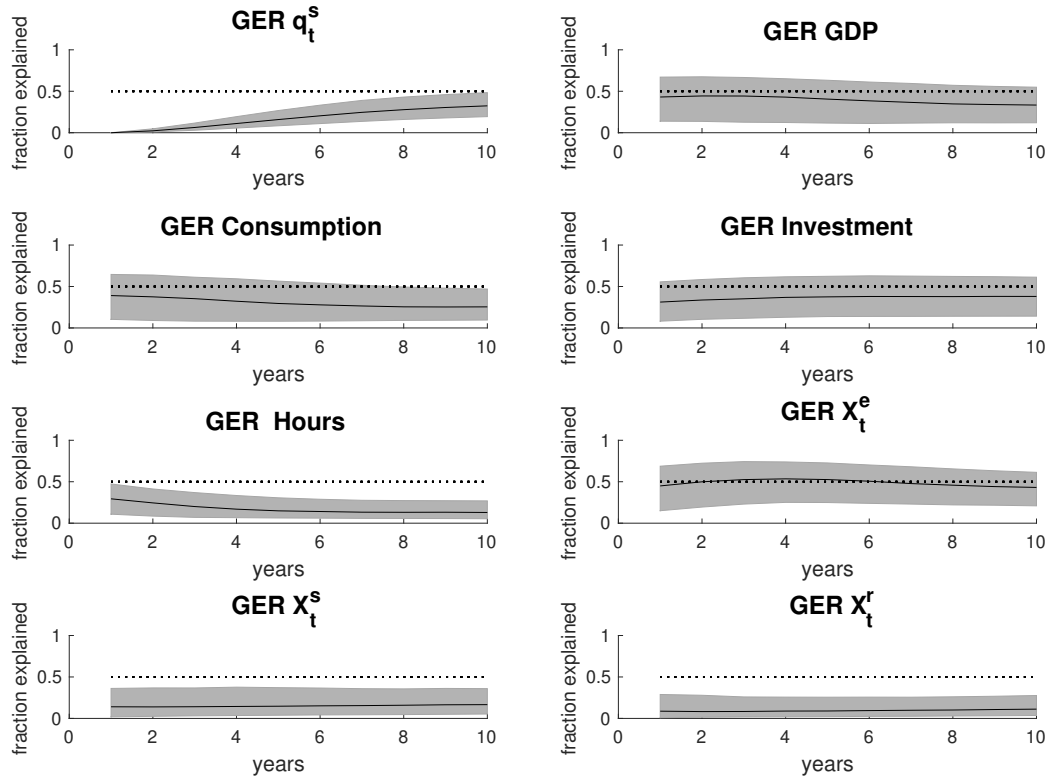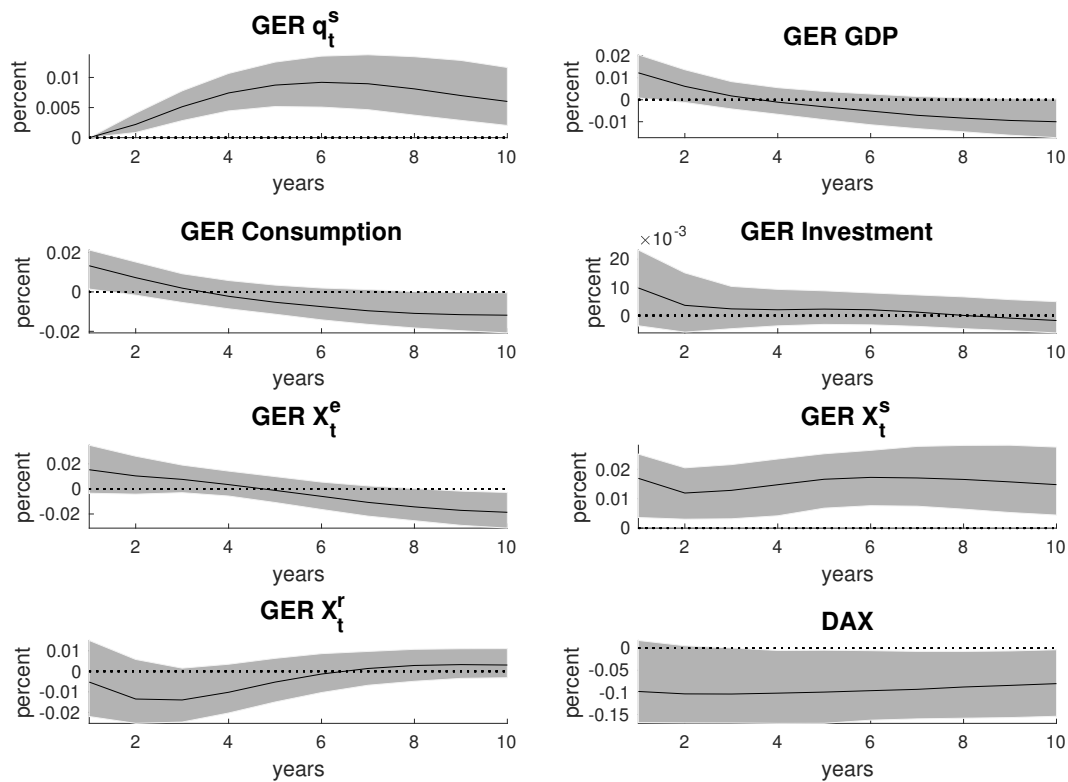

Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table D.4: GERMANY - Maximum Forecast Error Variance (FEV) - q_{st} news shock; benchmark VAR

| Germany	q_{st}	GDP	Consumption	Investment	Hours	X_e	X_s	X_r
Median contribution	0.32	0.44	0.39	0.38	0.29	0.53	0.17	0.11
Year	10	2	1	9	1	4	10	10

D.5 Spain - q_{st} news shock - Alternative VAR

Figure D.9: SPAIN - Impulse responses to a 1% innovation in the q_{st} news shock; alternative VAR

Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.

Figure D.10: SPAIN - Forecast Error Variance (FEV) - q_{st} news shock - alternative VAR
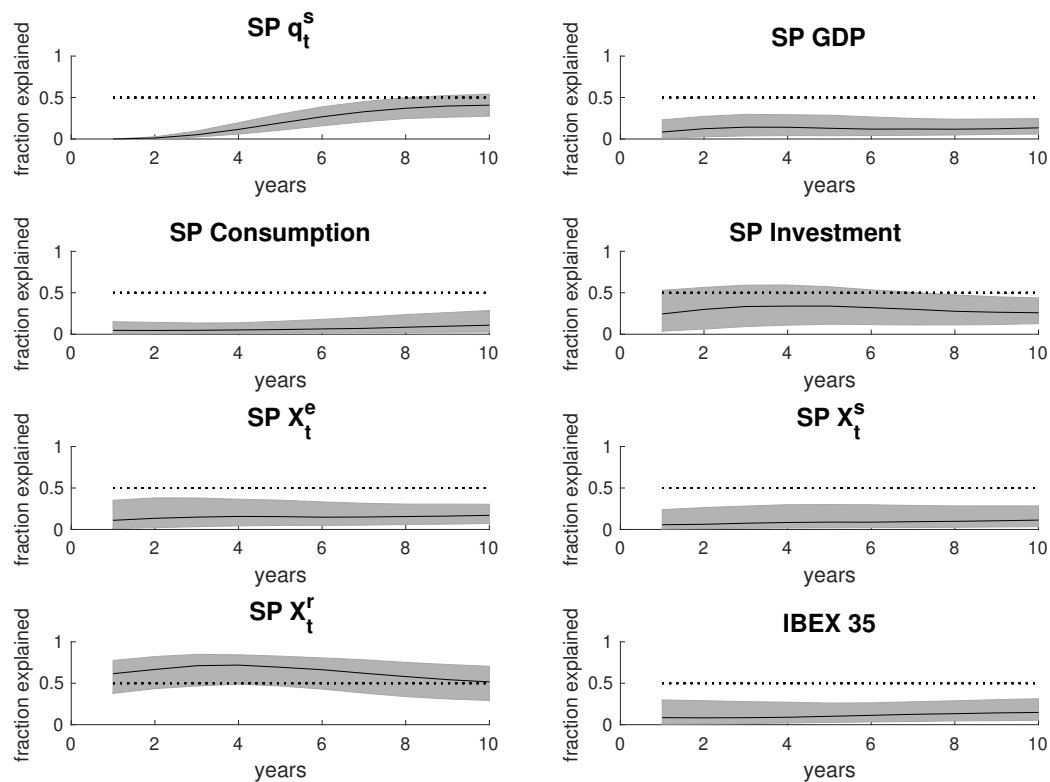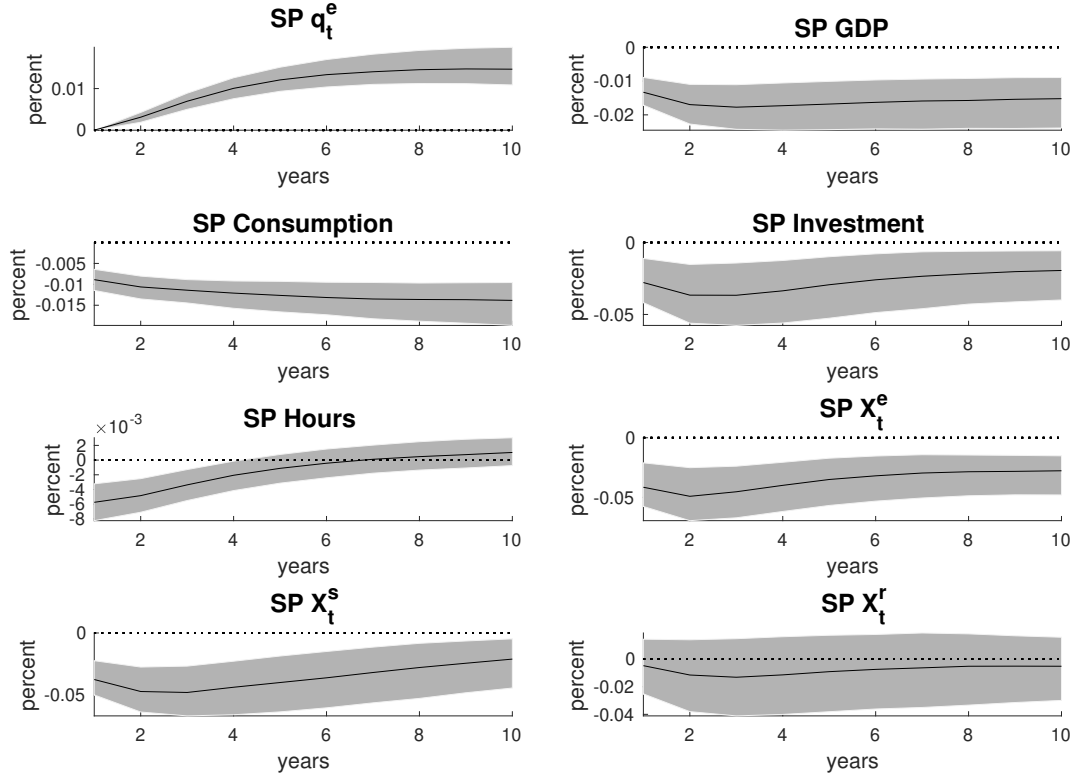

Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table D.5: SPAIN - Maximum Forecast Error Variance (FEV) - q_{st} news shock; alternative VAR

Spain	q_{st}	GDP	Consumption	Investment	X_e	X_s	X_r	IBEX 35
Median contribution	0.41	0.14	0.11	0.34	0.17	0.11	0.72	0.15
Year	10	3	10	5	10	10	4	10

D.6 Germany - q_{st} news shock - Alternative VAR

Figure D.11: GERMANY - Impulse responses to a 1% innovation in the q_{st} news shock - alternative VAR

Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.

Figure D.12: GERMANY - Forecast Error Variance (FEV) - q_{st} news shock; alternative VAR
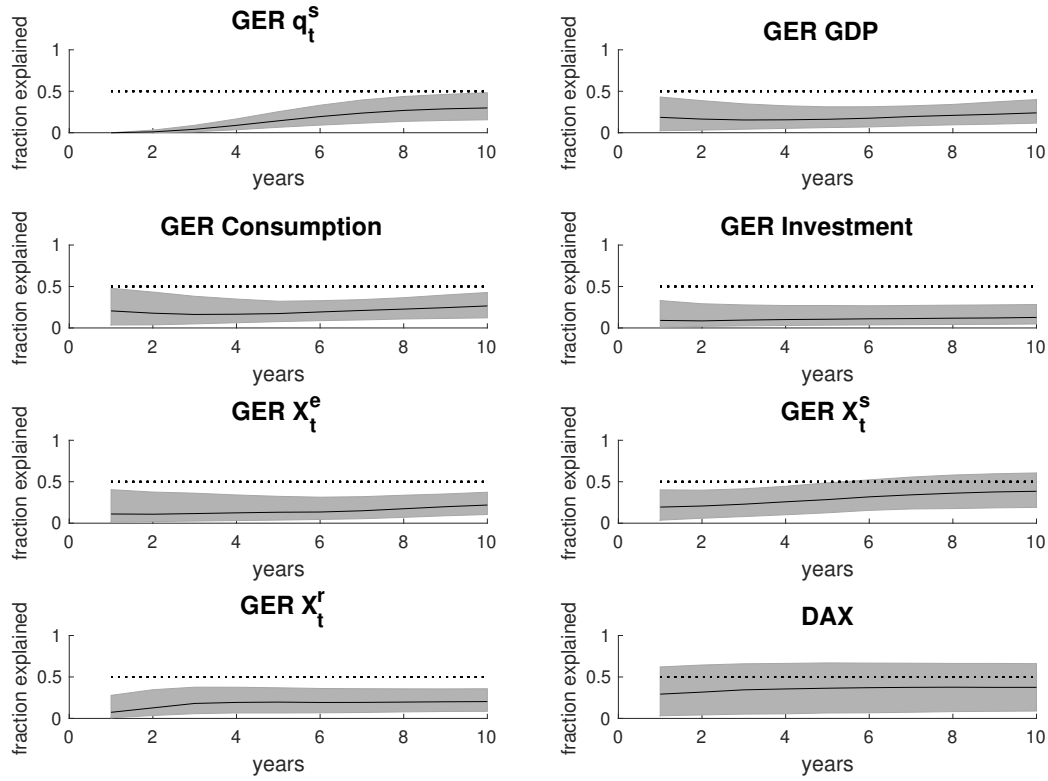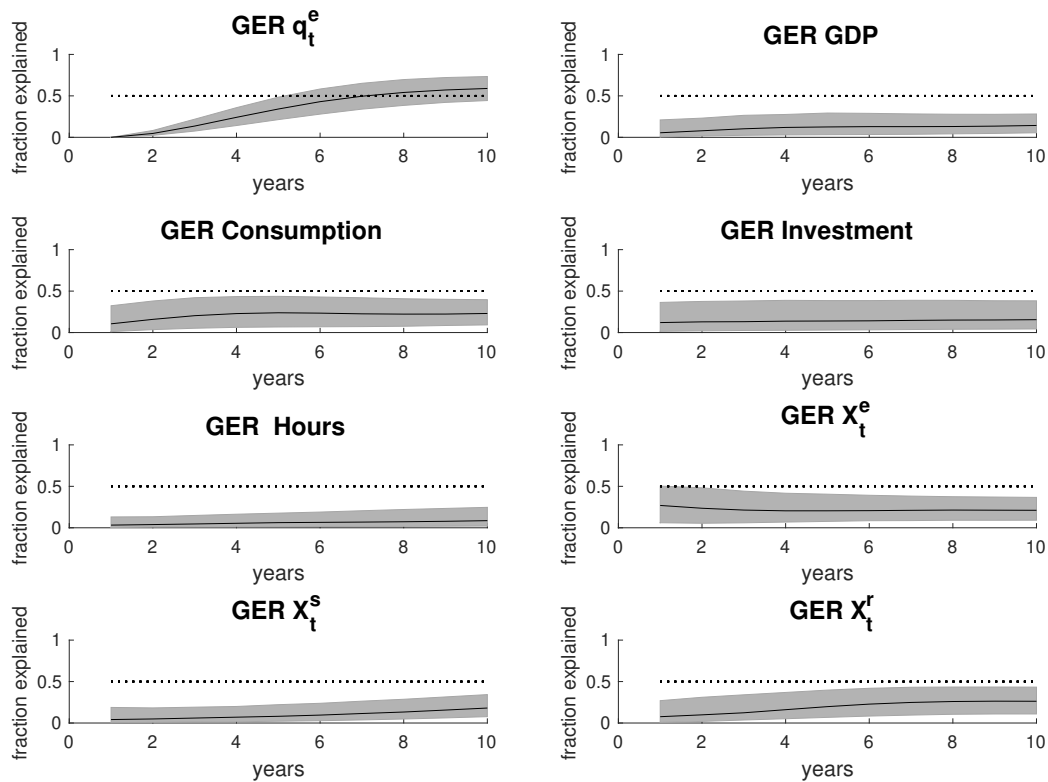

Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table D.6: GERMANY - Maximum Forecast Error Variance (FEV) - q_{st} news shock; alt. VAR

| **Germany**	q_{st}	GDP	Consumption	Investment	X_e	X_s	X_r	DAX
Median contribution	0.30	0.24	0.27	0.13	0.22	0.38	0.20	0.38
Year	10	10	10	10	10	10	10	8

D.7   Spain - q_{et} news shock - benchmark VAR

Figure D.13: SPAIN - Impulse responses to a 1% innovation in the q_{et} news shock; benchmark VAR

Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.

Figure D.14: SPAIN - Forecast Error Variance (FEV) - q_{et} news shock; benchmark VAR
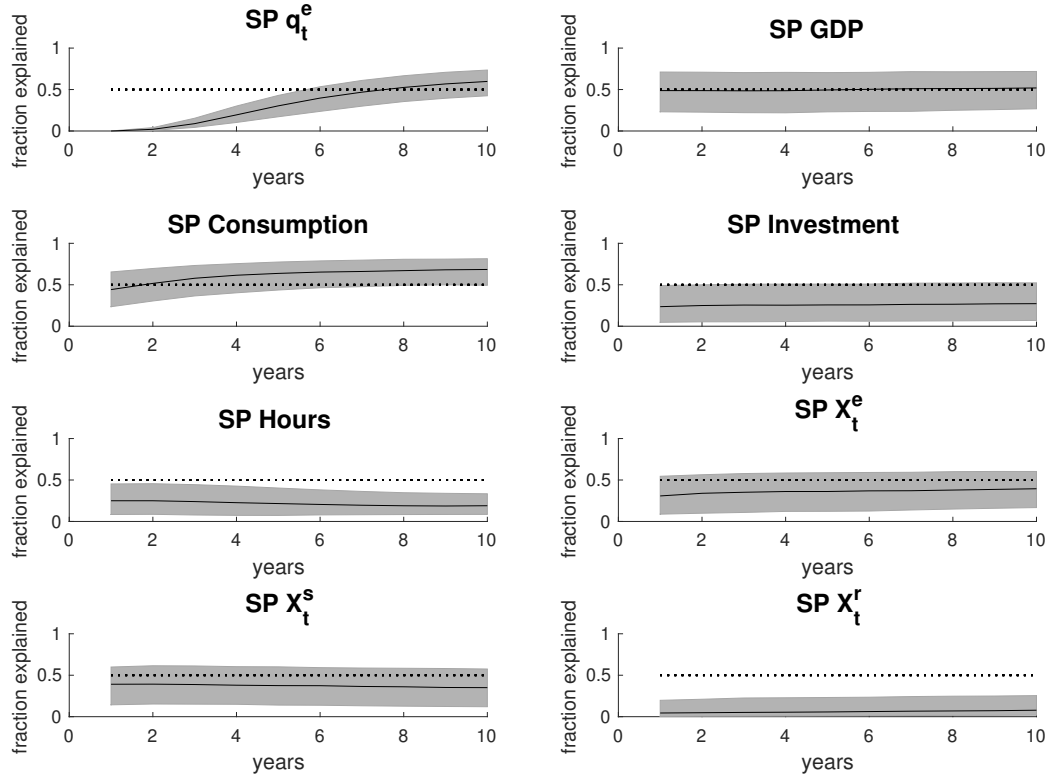
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table D.7: SPAIN - Maximum Forecast Error Variance (FEV) - q_{et} news shocks; benchmark VAR

Spain	q_{et}	GDP	Consumption	Investment	Hours	X_e	X_s	X_r
Median contribution	0.60	0.52	0.68	0.27	0.25	0.39	0.39	0.08
Year	10	10	10	10	1	10	2	10

D.8   Germany - q_{et} news shock - benchmark VAR

Figure D.15: GERMANY - Impulse responses to a 1% innovation in the ISTC news shock - q_{et} news shock; benchmark VAR
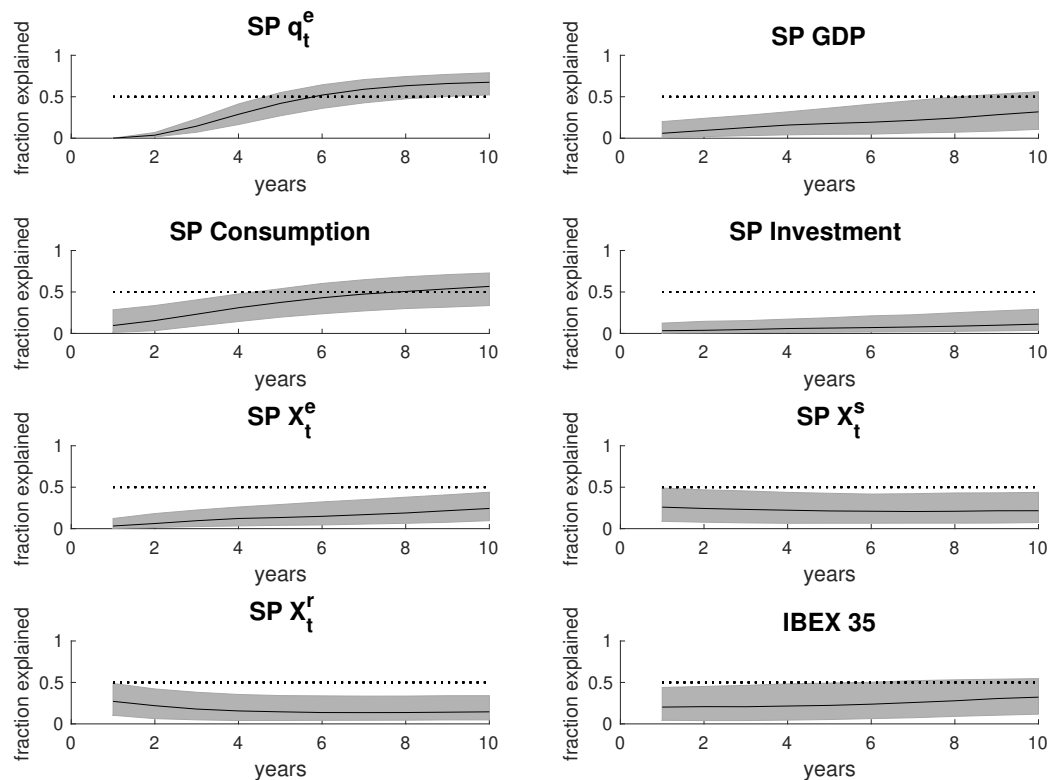

Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.

Figure D.16: GERMANY - Forecast Error Variance (FEV) - q_{et} news shock; benchmark VAR
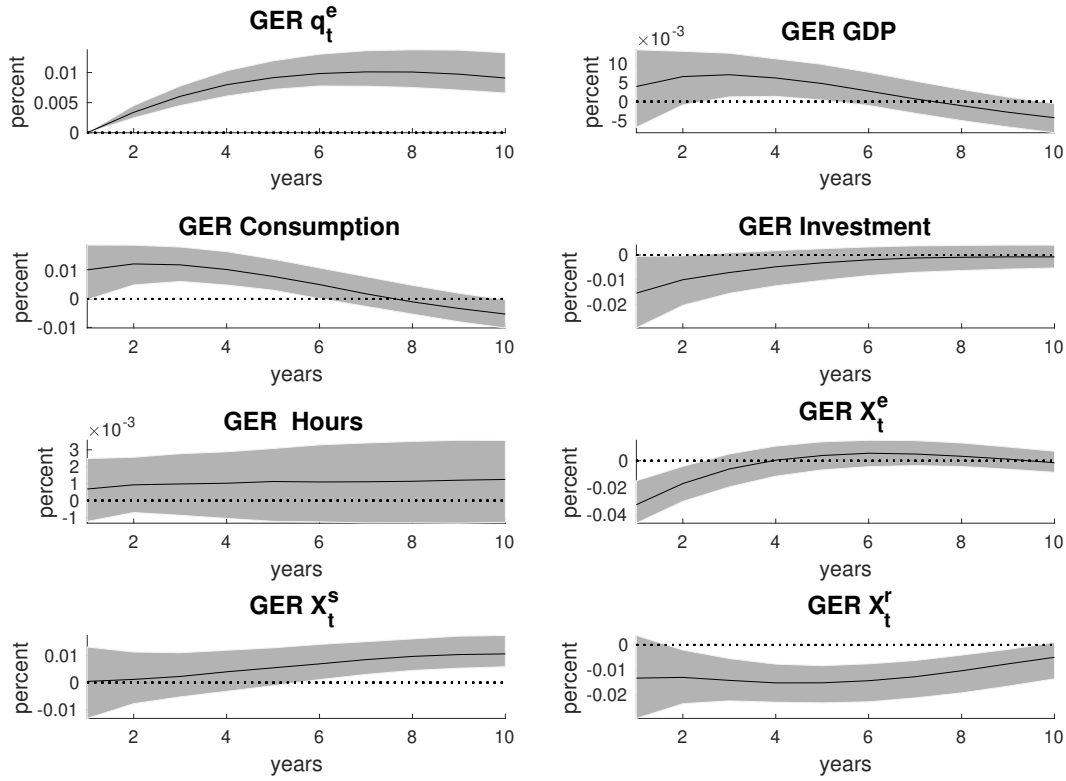
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table D.8: GERMANY - Maximum Forecast Error Variance (FEV) - q_{et} news shock; bench. VAR

| Germany	q_{et}	GDP	Consumption	Investment	Hours	X_e	X_s	X_r
Median contribution	0.59	0.14	0.24	0.16	0.09	0.27	0.18	0.26
Year	10	10	5	10	10	1	10	9

D.9 Spain - q_{et} news shock - alternative VAR

Figure D.17: SPAIN - Impulse responses to a 1% innovation in the q_{et} news shock; alternative VAR
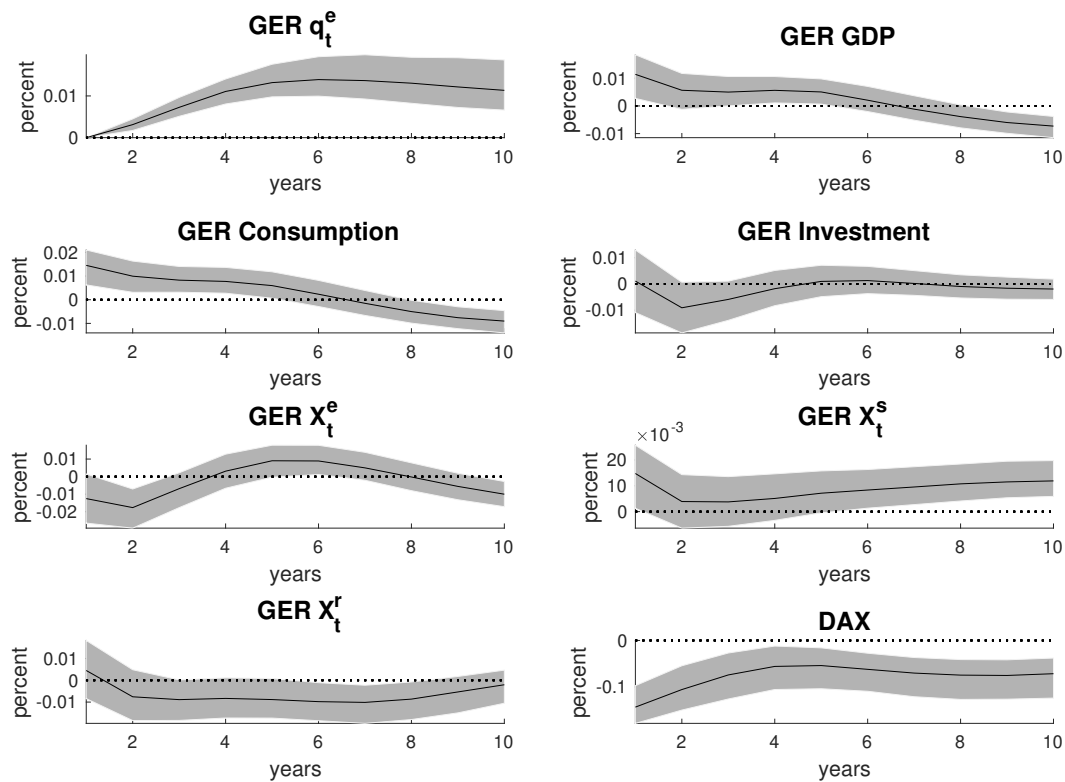

Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.

Figure D.18: SPAIN - Forecast Error Variance (FEV) - q_{et} news shock - alternative VAR
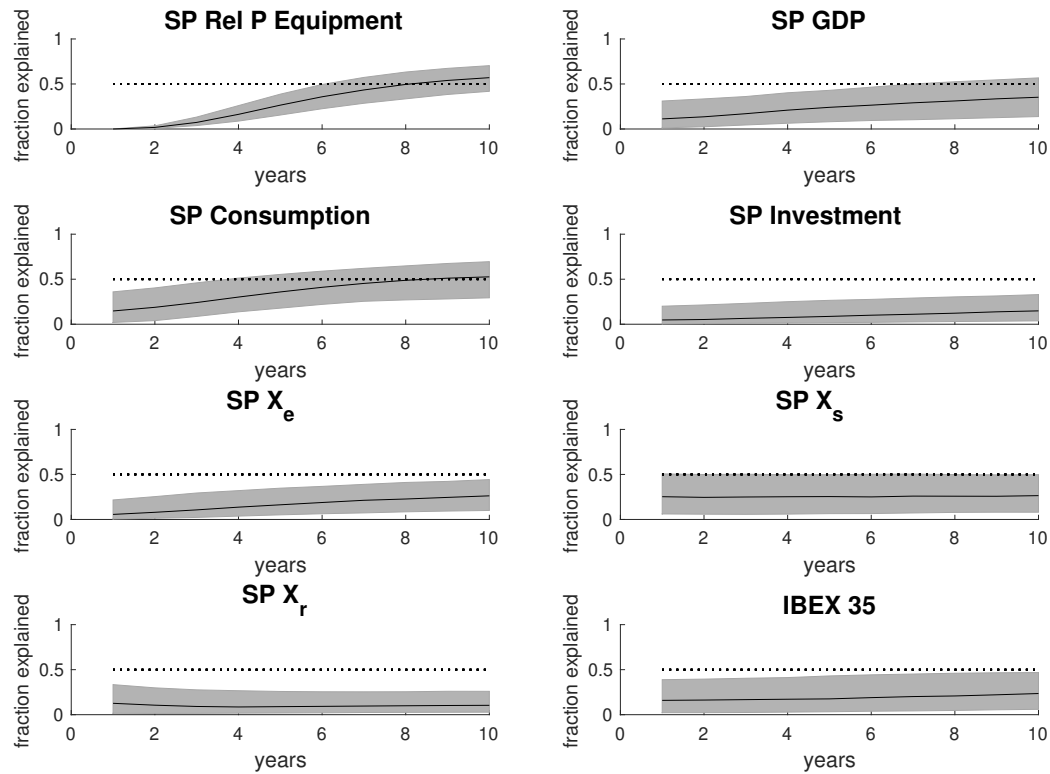
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table D.9: SPAIN - Maximum Forecast Error Variance (FEV) - q_{et} news shock; alternative VAR

| **Spain**	q_{et}	GDP	Consumption	Investment	X_e	X_s	X_r	IBEX 35
Median contribution	0.67	0.32	0.57	0.11	0.24	0.26	0.27	0.32
Year	10	10	10	10	10	1	1	10

D.10 Germany - q_{et} news shock - alternative VAR

Figure D.19: GERMANY - Impulse responses to a 1% innovation in the q_{et} news shock; alternative VAR

Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage deviations.

Figure D.20: GERMANY - Forecast Error Variance (FEV) - q_{et} news shock; alternative VAR
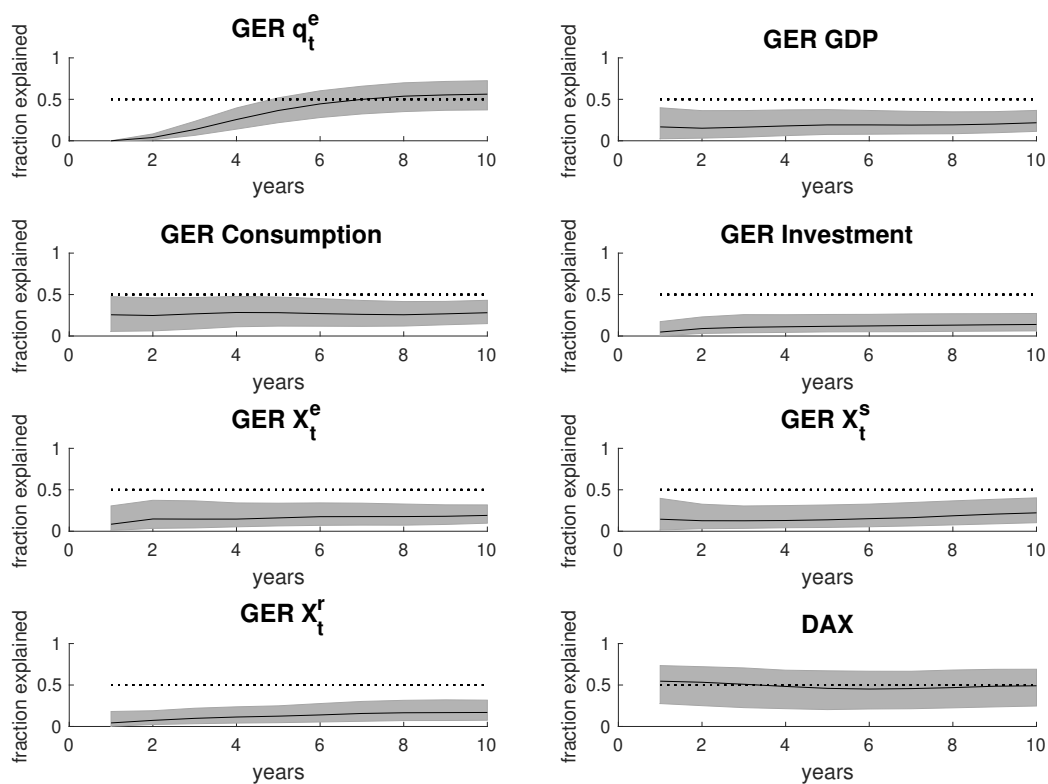
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table D.10: GERMANY - Maximum Forecast Error Variance (FEV) - q_{et} news shock; alternative VAR

Germany	q_{et}	GDP	Consumption	Investment	X_e	X_s	X_r	DAX
Median contribution	0.56	0.22	0.28	0.14	0.19	0.22	0.17	0.55
Year	10	10	4	10	10	10	10	1

Appendix for Online Use

E   Theoretical Model
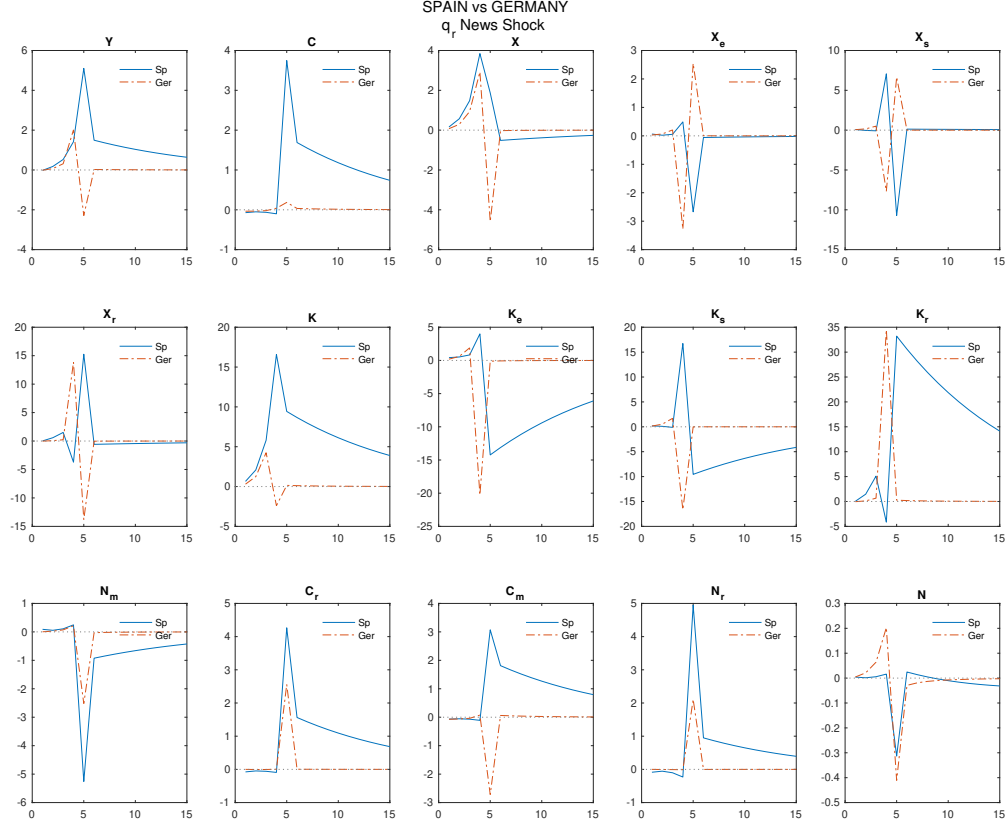
E.1 q_{rt}, News Shock

Figure E.21: q_{rt} news shock effects on all model's variables

Figure E.21 shows the overall IRFs of model's variables following a news shock on the relative prices of residential investment increases of 1%.
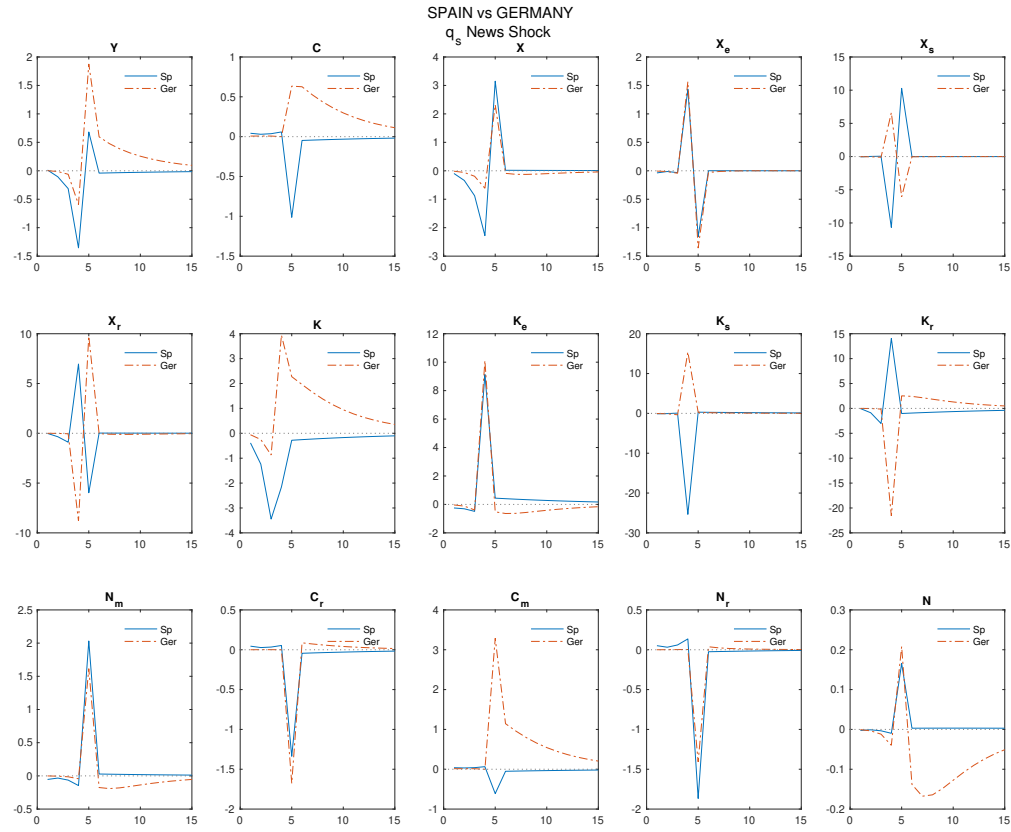
E.2 q_{st}, News Shock - all var

Figure E.22: q_{st} news shock effects on all model's variables

Figure E.22 shows the overall IRFs of model's variables following a news shock on the relative prices of business structures increases of 1%.
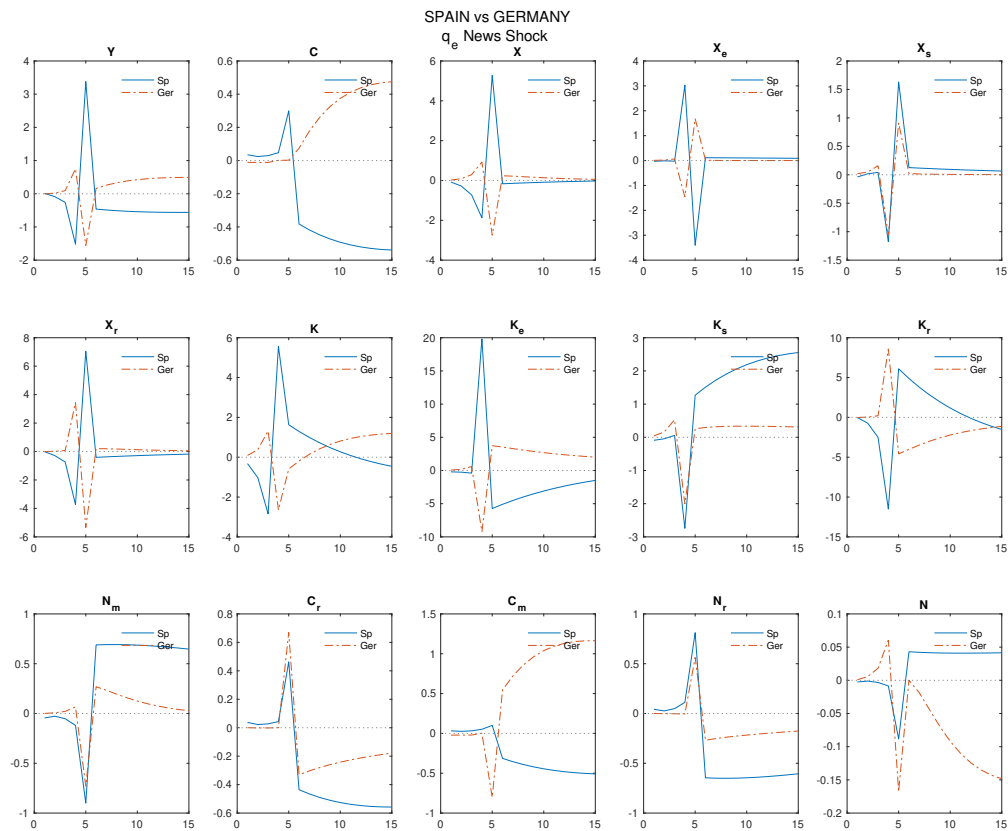
E.3 q_{et}, News Shock - all var

Figure E.23: q_{et} news shock effects on all model's variables

Figure E.23 shows the overall IRFs of model's variables following a news shock on the relative prices of equipment investment decreases of 1%.
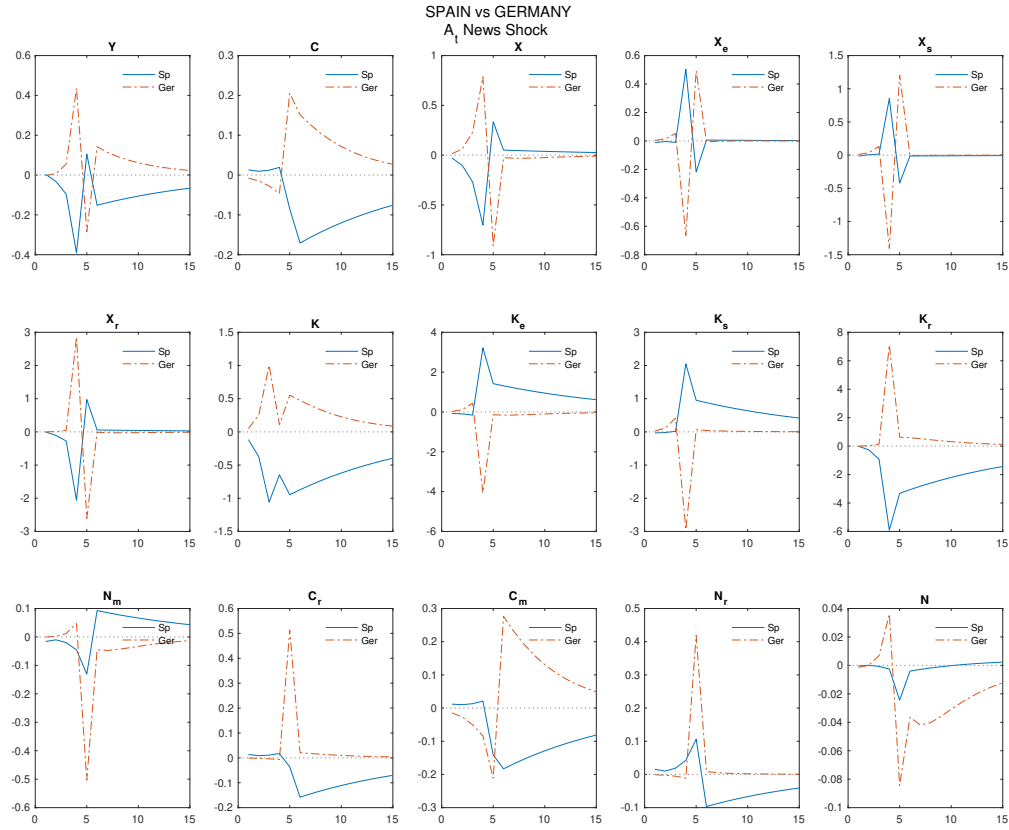
E.4 A_t news shock

Figure E.24: A_t News Shock

Figure E.24 shows the IRFs model variables following a news shock on the home production TFP of a magnitude of 1%

Appendix for Online Use

F Model Details

The model uses the class of preferences proposed by Jaimovich and Rebelo (2009) that have the ability to parameterize the strength of the short-run wealth effect on the labor supply. In so doing, these preferences nest two classes of utility functions: those characterized in King et al. (1988) - (when parameter $\gamma = 1$) - and in Greenwood et al. (1988) ($\gamma = 0$). Parameter θ helps to generate a rise in hours worked in response to positive news. Therefore, we consider:

$$U(C_t, N_t, \chi_t) = \frac{\left(C_t - \psi N_t^\theta \chi_t\right)^{1-\sigma} - 1}{1 - \sigma} \quad \text{where} \quad \chi_t = C_t^\gamma \chi_{t-1}^{1-\gamma}. \tag{F.1}$$

The presence of χ_t makes preferences non-time-separable in consumption and hours worked. We assume $N_t = N_{mt} + N_{rt}$, and we introduce home production as:

$$C_t = (\omega C_{m,t}^\eta + (1 - \omega) C_{r,t}^\eta)^{1/\eta} \tag{F.2}$$

where $C_{m,t}$ is market consumption. Finally, home production is given by:

$$C_{r,t} = A_{r,t} K_{r,t}^{1-\theta_h} N_{r,t}^{\theta_r} \tag{F.3}$$

Consequently, the utility function is:

$$U(C_{m,t}, C_{r,t}, N_{m,t}, N_{r,t}, \chi_t) = \frac{\left(\left(\omega C_{m,t}^\eta + (1 - \omega) C_{r,t}^\eta\right)^{1/\eta} - \psi (N_{m,t} + N_{r,t})^{\theta_n} \chi_t\right)^{1-\sigma} - 1}{1 - \sigma} \tag{F.4}$$

and the household budget constraint is

$$C_{mt} + q_{e,t} K_{e,t+1} + q_{s,t} K_{s,t+1} + q_{r,t} K_{r,t+1}$$
$$= W_t N_{m,t} + r_{e,t} K_{e,t} + r_{s,t} K_{s,t} + q_{e,t}(1 - \delta_e) K_{e,t} + q_{s,t}(1 - \delta_s) K_{s,t} + q_{r,t}(1 - \delta_r) K_{r,t} \tag{F.5}$$

The Planner solves:

$$\max_{C_t, N_t, \chi_t} \sum_{t=0}^{\infty} \beta^t U\Big(U(C_{m,t}, C_{r,t}, N_{m,t}, N_{r,t}, \chi_t) \Big) \tag{F.6}$$

s.t.:

$$C_{mt} + q_{e,t}K_{e,t+1} + q_{s,t}K_{s,t+1} + q_{r,t}K_{r,t+1}$$
$$= W_t N_{m,t} + r_{e,t}K_{e,t} + r_{s,t}K_{s,t} + q_{e,t}(1-\delta_e)K_{e,t} + q_{s,t}(1-\delta_s)K_{s,t} + q_{r,t}(1-\delta_h)K_{r,t}$$

$$\chi_t = C_t^\gamma \chi_{t-1}^{1-\gamma},$$
$$C_t = \Big(\omega C_{m,t}^\eta + (1-\omega)C_{r,t}^\eta \Big)^{1/\eta},$$
$$C_{rt} = A_t K_{r,t}^{1-\theta_r} N_{r,t}^{\theta_r},$$

$$Y_t = Z_t K_{e,t}^{\alpha_e} K_{s,t}^{\alpha_s} N_{m,t}^{1-\alpha_e-\alpha_s},$$
$$Y_t = C_t + q_{e,t}X_{e,t} + q_{s,t}X_{s,t} + q_{r,t}X_{r,t},$$
$$X_t = X_{e,t} + X_{s,t} + X_{r,t},$$

$$K_{e,t+1} = \Theta_{e,t}X_{e,t} + (1-\delta_e)K_{e,t},$$
$$K_{s,t+1} = \Theta_{s,t}X_{s,t} + (1-\delta_s)K_{s,t},$$
$$K_{r,t+1} = \Theta_{r,t}X_{r,t} + (1-\delta_r)K_{r,t},$$

$$q_{e,t} = 1/\Theta_{e,t}$$
$$q_{s,t} = 1/\Theta_{s,t}$$
$$q_{h,t} = 1/\Theta_{h,t}$$

$$\log Z_t = (1-\rho_Z)\log barZ + \rho_Z \log Z_{t-1} + \varepsilon_t^Z,$$
$$\log A_t = (1-\rho_A)\log barA + \rho_A \log A_{t-1} + \varepsilon_t^A,$$
$$\log q_{e,t} = (1-\rho_{q_e})\log barq_e + \rho_{q_e} \log q_{e,t-1} + \varepsilon_t^{q_e},$$
$$\log q_{s,t} = (1-\rho_{q_s})\log \bar{q}_s + \rho_{q_s} \log q_{s,t-1} + \varepsilon_t^{q_s},$$
$$\log q_{r,t} = (1-\rho_{q_r})\log \bar{q}_r + \rho_{q_r} \log q_{r,t-1} + \varepsilon_t^{q_r} + \varepsilon_{t-1}^{news},$$

F.1 The Household's Maximization Problem

$$\max_{C_t, N_t, K_{r,t+1}, K_{e,t+1}, K_{s,t+1}, \chi_t} \mathcal{L} : \sum_{t=0}^{\infty} \beta^t \left\{ \left[\frac{\left((\omega C_{m,t}^{\eta} + (1-\omega)C_{h,t}^{\eta})^{1/\eta} - \psi(N_{m,t} + N_{r,t})^{\theta_n} X_t \right)^{1-\sigma} - 1}{1-\sigma} \right] \right.$$

$$- \lambda_t \left(C_{m,t} + q_{e,t}K_{e,t+1} + q_{s,t}K_{s,t+1} + q_{r,t}K_{r,t+1} \right.$$

$$\left. - w_t N_{m,t} - (r_{e,t} + q_{e,t}(1-\delta_e))K_{e,t} - (r_{s,t} + q_{s,t}(1-\delta_s))K_{s,t} - q_{r,t}(1-\delta_r)K_{r,t} \right)$$

$$\left. - \mu_t \left(\chi_t - (\omega C_{m,t}^{\eta} + (1-\omega)C_{r,t}^{\eta})^{\frac{\gamma}{\eta}} \chi_{t-1}^{1-\gamma} \right) - \xi_t \left(C_{rt} - A_t K_{r,t}^{1-\theta_r} N_{r,t}^{\theta_r} \right) \right\} \quad \text{(F.7)}$$

FOCs

$$\frac{\partial \mathcal{L}}{\partial C_{m,t}} : \left((\omega C_{m,t}^{\eta} + (1-\omega)C_{r,t}^{\eta})^{1/\eta} - \psi(N_{m,t} + N_{r,t})^{\theta_n} \chi_t \right)^{-\sigma} \omega C_{m,t}^{\eta-1} (\omega C_{m,t}^{\eta} + (1-\omega)C_{r,t}^{\eta})^{1/\eta-1}$$

$$+ \mu_t \left(\gamma \omega C_{m,t}^{\eta-1} (\omega C_{m,t}^{\eta} + (1-\omega)C_{r,t}^{\eta})^{\gamma/\eta-1} \chi_{t-1}^{1-\gamma} \right) = \lambda_t \quad \text{(F.8)}$$

$$\frac{\partial \mathcal{L}}{\partial C_{r,t}} : \left((\omega C_{m,t}^{\eta} + (1-\omega)C_{r,t}^{\eta})^{1/\eta} - \psi(N_{m,t} + N_{r,t})^{\theta_n} \chi_t \right)^{-\sigma} (1-\omega)C_{r,t}^{\eta-1} (\omega C_{m,t}^{\eta} + (1-\omega)C_{r,t}^{\eta})^{1/\eta-1}$$

$$+ \mu_t \left(\gamma(1-\omega)C_{r,t}^{\eta-1} (\omega C_{m,t}^{\eta} + (1-\omega)C_{r,t}^{\eta})^{\gamma/\eta-1} \chi_{t-1}^{1-\gamma} \right) = \xi_t \quad \text{(F.9)}$$

$$\frac{\partial \mathcal{L}}{\partial N_{m,t}} : \left((\omega C_{m,t}^{\eta} + (1-\omega)C_{r,t}^{\eta})^{1/\eta} - \psi(N_{m,t} + N_{r,t})^{\theta_n} \chi_t \right)^{-\sigma} \psi \theta_n (N_{m,t} + N_{r,t})^{\theta_n-1} \chi_t = \lambda_t w_t$$

$$\text{(F.10)}$$

$$\frac{\partial \mathcal{L}}{\partial N_{r,t}} : \left((\omega C_{m,t}^{\eta} + (1-\omega)C_{r,t}^{\eta})^{1/\eta} - \psi(N_{m,t} + N_{r,t})^{\theta_n} \chi_t \right)^{-\sigma} \psi \theta_n (N_{m,t} + N_{r,t})^{\theta_n-1} \chi_t$$

$$= \xi_t (\theta_r A_t K_{r,t}^{1-\theta_r} N_{r,t}^{\theta_r-1}) \quad \text{(F.11)}$$

$$\frac{\partial \mathcal{L}}{\partial \chi_t} : \left((\omega C_{m,t}^\eta + (1-\omega)C_{r,t}^\eta)^{1/\eta} - \psi(N_{m,t} + N_{r,t})^{\theta_n}\chi_t \right)^{-\sigma} \psi(N_{m,t} + N_{r,t})^{\theta_n} + \mu_t =$$
$$E_t \left[\mu_{t+1}\beta\left((1-\gamma)(\omega C_{m,t+1}^\eta + (1-\omega)C_{r,t+1}^\eta)^{\gamma/\eta}\chi_t^{-\gamma} \right) \right] \quad \text{(F.12)}$$

$$\frac{\partial \mathcal{L}}{\partial \lambda_t} : C_{m,t} + q_{e,t}K_{e,t+1} + q_{s,t}K_{s,t+1} + q_{r,t}K_{r,t+1}$$
$$= w_t N_{m,t} + r_{e,t}K_{e,t} + r_{s,t}K_{s,t} + q_{e,t}(1-\delta_e)K_{e,t} + q_{s,t}(1-\delta_s)K_{s,t} + q_{r,t}(1-\delta_r)K_{r,t} \quad \text{(F.13)}$$

$$\frac{\partial \mathcal{L}}{\partial \mu_t} : \chi_t = (\omega C_{m,t}^\eta + (1-\omega)C_{r,t}^\eta)^{\frac{\gamma}{\eta}}\chi_{t-1}^{1-\gamma} \quad \text{(F.14)}$$

$$\frac{\partial \mathcal{L}}{\partial \xi_t} : C_{rt} = A_t K_{r,t}^{1-\theta_h}N_{r,t}^{\theta_r} \quad \text{(F.15)}$$

$$\frac{\partial \mathcal{L}}{\partial K_{e,t+1}} : \lambda_t = \beta E_t \left[\lambda_{t+1}\frac{r_{e,t+1} + q_{e,t+1}(1-\delta_e)}{q_{e,t}} \right] \quad \text{(F.16)}$$

$$\frac{\partial \mathcal{L}}{\partial K_{s,t+1}} : \lambda_t = \beta E_t \left[\lambda_{t+1}\frac{r_{s,t+1} + q_{s,t+1}(1-\delta_s)}{q_{s,t}} \right] \quad \text{(F.17)}$$

$$\frac{\partial \mathcal{L}}{\partial K_{r,t+1}} : \lambda_t = \beta E_t \left[\lambda_{t+1}\frac{q_{r,t+1}(1-\delta_r)}{q_{r,t}} + \xi_{t+1}\frac{(1-\theta_r)A_{t+1}K_{r,t+1}^{-\theta_r}N_{r,t+1}^{\theta_r}}{q_{r,t}} \right] \quad \text{(F.18)}$$

$$\log Z_t = (1 - \rho_Z) \log \bar{Z} + \rho_Z \log Z_{t-1} + \varepsilon_t^Z \tag{F.19}$$

$$\log A_t = (1 - \rho_A) \log \bar{A} + \rho_A \log A_{t-1} + \varepsilon_t^A \tag{F.20}$$

$$\log q_{e,t} = \rho_{q_e} \log q_{e,t-1} + \varepsilon_t^{q_e} \tag{F.21}$$

$$\log q_{s,t} = \rho_{q_s} \log q_{s,t-1} + \varepsilon_t^{q_s} \tag{F.22}$$

$$\log q_{r,t} = \rho_{q_r} \log q_{r,t-1} + \varepsilon_t^{q_r} + \varepsilon_{t-4}^{news} \tag{F.23}$$

F.2 The Firms problem:

Firm producing final good

$$\max_{K_{e,t}, K_{s,t}, N_t} \Pi_t = Z_t K_{e,t}^{\alpha_e} K_{s,t}^{\alpha_s} N_t^{1-\alpha_e-\alpha_s} - r_{e,t} K_{e,t} - r_{s,t} K_{s,t} - w_t N_{m,t}. \tag{F.24}$$

FOCs

$$\frac{\partial \Pi_t}{\partial K_{e,t}} : \alpha_e Z_t K_{e,t}^{\alpha_e-1} K_{s,t}^{\alpha_s} N_{m,t}^{1-\alpha_e-\alpha_s} = r_{e,t} \tag{F.25}$$

$$\frac{\partial \Pi_t}{\partial K_{s,t}} : \alpha_s Z_t K_{e,t}^{\alpha_e} K_{s,t}^{\alpha_s-1} N_{m,t}^{1-\alpha_e-\alpha_s} = r_{s,t} \tag{F.26}$$

$$\frac{\partial \Pi_t}{\partial N_t} : (1 - \alpha_e - \alpha_s) Z_t K_{e,t}^{\alpha_e-1} K_{s,t}^{\alpha_s} N_{m,t}^{-\alpha_e-\alpha_s} = w_t \tag{F.27}$$