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NEWS-DRIVEN HOUSING BOOMS: SPAIN VS. GERMANY.

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News-driven housing booms: Spain vs. Germany*

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Abstract

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. We confront the identified shock with other shocks to provide evidence that our structural interpretation is valid. Then, 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 a reduced-form friction in labor 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 highlight the propagation mechanism of anticipated shocks to future investment, which is consistent with the housing booms in Spain and their absence in Germany. Such a mechanism complements a view relying on a combination of monetary, financial or housing supply and demand, surprise shocks.

JEL classification: C32, D84, E22, E32
Keywords: investment-specific technical change; news shocks; housing booms; wealth effects

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1 Introduction

Spain is one of the many European countries that experienced a housing boom in the early 2000s. The economic expansion in Spain was particularly characterized by sustained growth of residential investment, as Aspachs-Bracons and Rabanal (2010) and Díaz and Franjo (2016) discuss. In contrast, Germany, a peer Euro Zone economy, had a different economic performance, and during the years of the 2000s expansion did not experience a housing boom. 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 homeownership rates in Spain are much higher than in Germany.[1] One reason 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 factors.[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] Several authors have pointed out as well to the specific role of preferences and to institutional features.[4] Thus, fundamental empirical evidence illustrates key differences in the pattern of residential investment in Spain vs. Germany.

Notwithstanding, there are patterns in common to be highlighted at the aggregate level. We find compelling the fact that fluctuations in the relative price of residential investment and business structures were synchronized in Spain and Germany during 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. The evidence we discuss suggests movements in the relative prices of the different types of investment that are related within and between countries. However, we do not find evidence supporting that a traditional surprise shock drives these data. The question we ask then is whether there are anticipated shocks to future investment decisions underlying those comovements. To answer

[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.

[3] The importance of the tourism sector in Spain has been recently highlighted by Almunia et al. (2021) 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.

[4] See again Akin et al. (2014) on the perverse connection between real estate appraisal firms and banks in Spain during the housing boom. Also, there is evidence that culture matters for the rent versus buy decision and for homeownership behavior (cf. Huber and Schmidt (2021) and the references therein).

this question, we extract news about future investment decisions in Spain and Germany from the observed movements in the relative prices of investment (RPIs). Notice that the RPIs are generally taken as measures of Investment-Specific Technical Change (ISTC). Thus, we follow Fisher (2006) and Canova et al. (2007) by assuming that investment-specific shocks are the sole driver of long-run movements in the RPIs. 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 anticipated ISTC (news) shock. The identified news shock is the one that has no effect on current ISTC, but 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.[5]

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 Rios-Rull (2020), and combines a housing wealth effect driven by the expectation of rising prices of residential investment, with a reduced-form for frictions in labor reallocation. Thus, an 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 labor are reallocated to equipment investment. This propagation mechanism is consistent with the housing booms in Spain and their absence in Germany, and complements a view based on the monetary or financial transmission mechanisms as in Gómez-Gónzalez and Rees (2018) or in't Veld et al. (2015), while retaining the findings in Boscá et al. (2020), according to which the housing demand and supply shocks had the more prominent role during the boom and the bust. Clearly though, the favorable credit conditions during the expansion, as well as the subsequent debt imbalances observed in the euro area during the Great Recession, must underlie part of the amplification of the cyclical asymmetries we illustrate here. We leave for further research to make explicit those amplification mechanisms.

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

[5] Considering alternative measures of house prices does not change the shock of interest identified. We opt for the unified framework in the *EU KLEMS* 2017 release (see Appendix A) to make the data more comparable. Moreover, we will show that residential RPI seems to lead movements in other house price indexes.

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. 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.

A key issue is whether the structural interpretation of the identified shocks is valid. To clarify this issue, first we examine the correspondence between the identified shock series and technological changes in the housing sector. Such an inspection suggests that a positive residential RPI (a negative residential ISTC) news shock is essentially an adverse shock to the housing technology: a finding for which a narrative interpretation can be given. Secondly, we explore how our identified shock series correlates with different shocks such as TFP surprise and news shocks, monetary policy shocks, and credit supply shocks. The finding is that the aggregate variables in the VAR respond to those alternative shocks either lagging the response to the residential RPI news shock or moderately in the opposite direction that might be expected associated to a boom. One limitation in alleviating the concern on the structural interpretation of our identified shock is the focus on real variables and the use of consistent data from *EU KLEMS*, whose frequency is annual (see Appendix A).

In light of this additional evidence, and in order to better 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 effects of the news shocks 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 on those parameters that control the labor supply elasticity. The model generates two important forms of comovement in response to news shock. The first 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).[6] 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 U.S. 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)], finds TFP news shocks to be negligible sources of fluctuations instead. Recently, Angeletos et al. (2020) 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 general equilibrium.[7] 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 subsidies to the housing sector (see, among others, Akin et al. (2014) for the banking channel, and Díaz-Giménez and Puch (1998) on 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 study their relative importance. Ben Zeev and Khan (2015) provide strong support for ISTC news shocks in driving the U.S. business cycle: the news shocks account for 70% of variation in output,

[6]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.

[7]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.

hours, and consumption, and 60% of variation in investment. Therefore, and although we focus on residential RPI news shocks, these authors find a similar variance decomposition for aggregate variables in the U.S. as the one we present for the Spanish economy. In any case, the debate on how to isolate ISTC and TFP news shocks is present in existing literature [cf. Barsky et al. (2015), Ben Zeev and Pappa (2017) and Watanabe (2020)], but the evidence mainly relies on U.S. data.

Finally, our paper is related to the recent literature on housing wealth effects. In particular, Huo and Rios-Rull (2020) build a model in which both wealth shocks and financial shocks to households generate recessions, like those in southern Europe. In our setting, the home production sector specification is key for the propagation mechanism in the model to be in conformity with the evidence we find. More generally, Berger et al. (2018) and Kaplan et al. (2019) identify housing booms driven by shifts in beliefs on housing prices and rents from micro data (PSID). Also, Aruoba et al. (2019) investigate the effect of declining house prices on household consumption behavior.

Our results provide evidence that news shocks to the relative price of residential investment constitute a significant force behind the Spanish business cycle. Such an evidence supports, for instance, the findings in Boscá et al. (2020) that among eighteen surprise shocks in their DSGE model for Spain, the housing demand and supply shocks have the more prominent role during the boom and the bust. Also, and even though the news shocks affect in a lesser extent 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 structural factors closely related to the propagation of wealth effects and frictions to labor reallocation may prevail in the presence of news-driven housing booms, and when confronted to monetary and financial factors. Our paper suggests those anticipated shocks to the relative price of residential investment 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, well before the arrival of the euro.

The paper is organized as follows. Section 2 reviews the empirical evidence, the news shocks identification and the transmission of identified shocks. Section 3 outlines the baseline theoretical model and its calibration, while Section 4 reports quantitative results of the theoretical model. The propagation mechanism of the model provides a rationale for the estimated impact of news shocks on key aggregates. Section 5 presents a small open economy's extension and 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}, against alternatives. To proceed, we estimate a vector autoregression (VAR) model on Spanish and German annual data for the period 1970 - 2015. The use of quarterly data is precluded due to the lack of investment data. First we examine the evidence on comovements for the relative prices of investment.

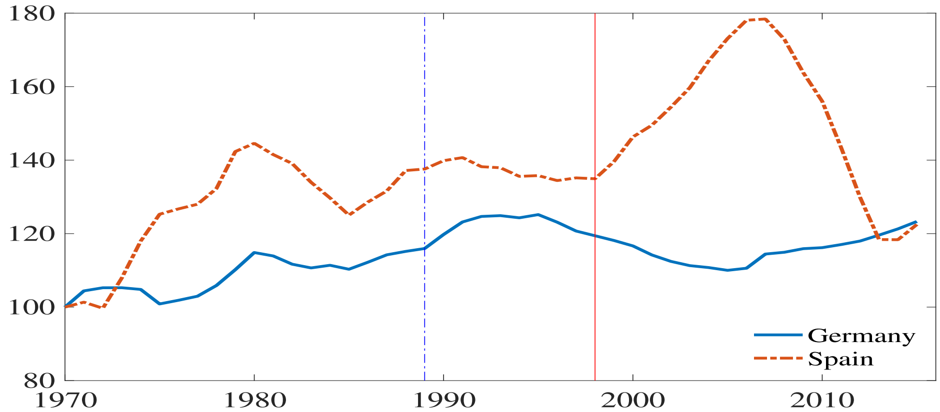
2.1 Evidence on the relative prices of investment (RPIs)

Figure 1 shows the RPIs for residential, business structures and equipment, 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 a gap that widens until 2012, but fully disappears by the end of our sample.[8] The idea here is that the adoption of the euro generated expectations that should be reflected in shifts in the demand for investment.

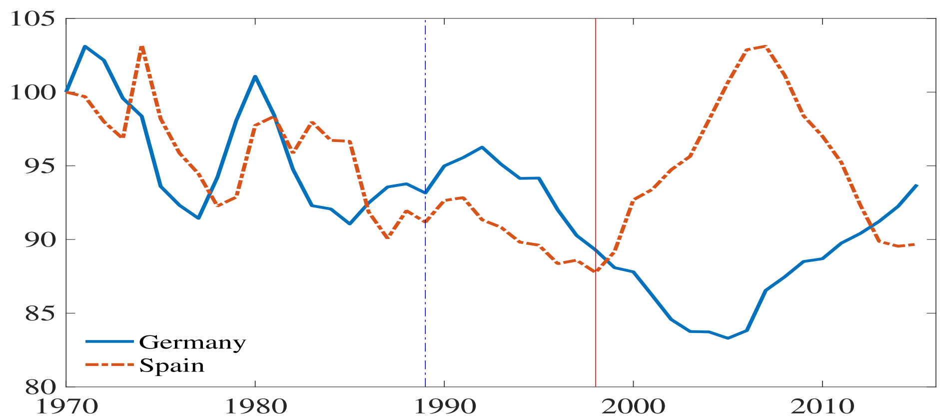
An issue is whether the amplification in residential investment prices in Spain (and some other European countries) may have specifically contributed to the lack of response observed in Germany during the 2000s. In this respect, we further inspect the patterns of investment and capital to GDP ratios in Appendix A. The finding is the residential investment to output ratio comes in two spikes for Spain, but only in the 1998-2009 spike the whole economy was booming (Fig. A.1). Those quantity spikes are asynchronous to the one observed in the German economy after the reunification. In particular, there is clearly a lack of response in residential investment in Germany during the years of the housing boom in Spain. Correspondingly, we see swings in housing capital to output

[8] 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.

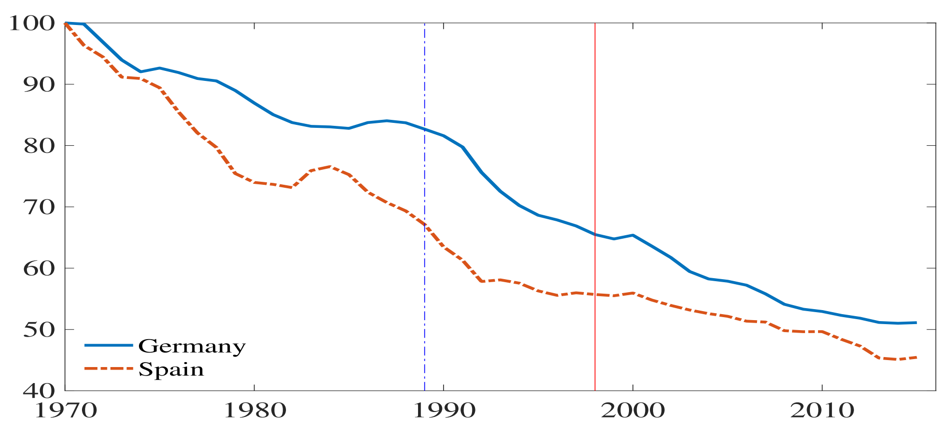
Figure 1: **Relative Prices of Investment - Spain vs Germany**



(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).

ratios in Spain mostly driven by aggregate output fluctuations, whereas in Germany the housing capital to output ratio has remained relatively stable over the sample (Fig. A.2).

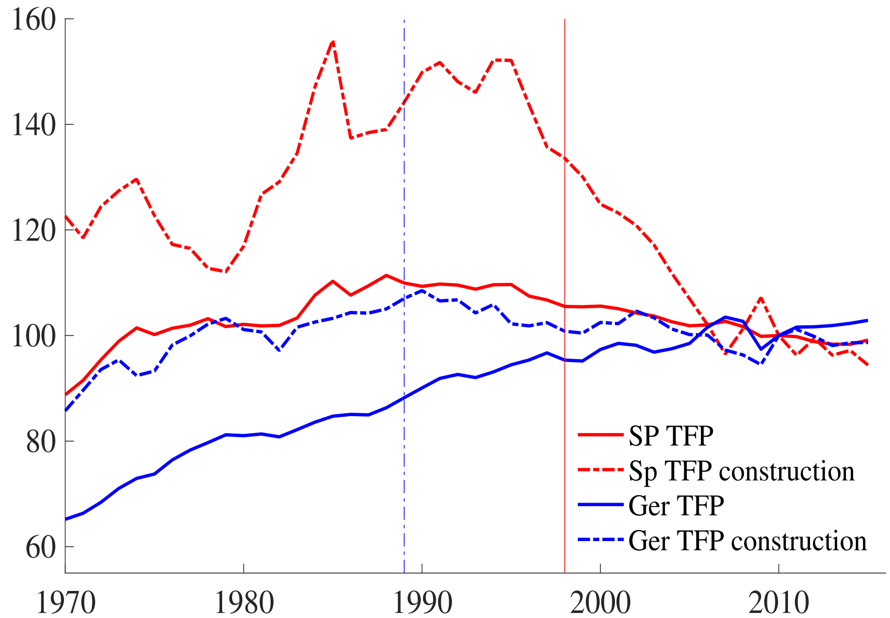
Notice that RPIs are generally taken as measures of Investment-Specific Technical Change (ISTC). One concern is that rising residential RPIs are to be interpreted as adverse technology shocks. To explore such a correspondence, we inspect the time series for Total Factor Productivity (TFP) and for TFP of the construction sector. Figure 2 depicts the corresponding data from EU KLEMS (normalized to 100 in 2010, the base year). It is apparent that TFP in the construction sector (labelled TFPc) has been well above aggregate TFP before the financial crisis, both for Germany and Spain. The gap between sectoral and overall TFP was substantially higher in the case of the Spanish economy, though. The sharp decline in productivity in the construction sector, whose origins date back to 1996 (the year the government promoting the Land Law of 1998 was inaugurated), coincides with a rising residential RPI since then. This can be rationalized by the upsurge of cheap, massive housing as a side effect of the Land Law. Notice also that TFPc in Germany exhibits a (moderate) turning point in 1990 just after the reunification, which brought as well a construction boom and actually, the main observed rise in residential RPI. We interpret these observations as an evidence in favor of the empirical strategy below. Interestingly, all these TFP measures seem to have somewhat converged with the arrival of the Great Recession (and before 2010 normalization).

Overall, by looking to the RPIs of residential and business structures, and despite the fact that they are going through quite different paths, we strikingly observe a common state at the end of the period together with some relevant comovements. We consider this evidence suggests movements in the relative prices of the different types of investment (RPIs) that are related within and between countries. The question we want to ask is whether the underlying comovements are due to surprise or to anticipated shocks to future investment decisions. Prior to this we need to resort to the methodology to identify the news shocks.

2.2 Identification Strategy

We follow Barsky and Sims (2011) approach. Thus, 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

Figure 2: **TFP and TFP for the construction sector - Spain vs Germany**



Note Total Factor Productivity (TFP) measures obtained from EU Klems and normalized to 2010. Vertical lines mark the dates of fall of Berlin Wall (blue), and Spanish Land Law (red).

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:

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

where ε_t is the traditional surprise 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, whereas the news shock, ν_t^n, has no immediate impact on 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. As in Barsky and Sims (2011) approach the responses to the identified shock over a long horizon (ten years, so as the forty quarters in their case) are evaluated whether they are different from zero (see the details in Appendix B). As our VAR is in logs and not in first differences, as discussed next, it is difficult to specify a correspondence between RPIs and ISTC only in the long-run.

2.3 Empirical evidence on news shocks

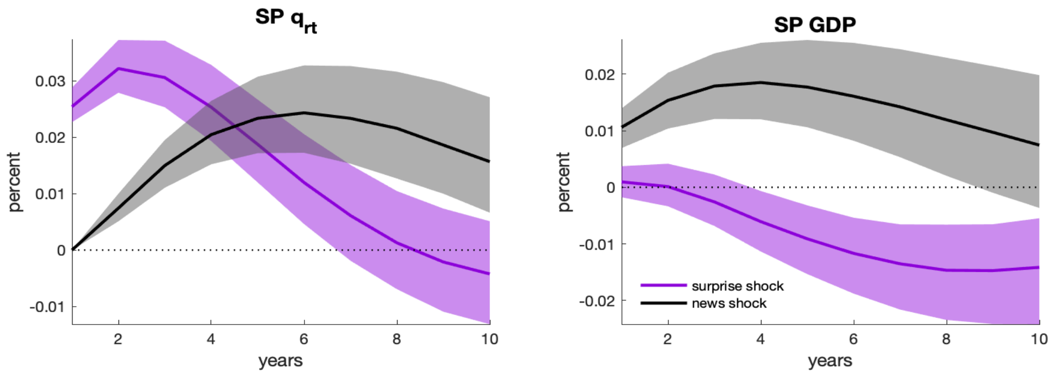
In this section we present the main results of the VAR model for Spain and Germany. The benchmark VAR includes the logs of eight variables: one at a time of the three RPIs, q_{it}; total output, GDP_t; consumption, C_t; aggregate investment, X_t; hours worked, H_t; residential investment, X_{rt}; business structures investment, X_{st}; and equipment investment, X_{et}. A detailed explanation of the data is given in Appendix A. Here we present only the effects on GDP of the q_{rt} news (i.e. the one which portends future increase in residential RPI) and surprise shocks. The details for the full VAR are reported in Appendix C, whereas the estimations of the news shocks on business structures and equipment RPIs are shown in Appendix E.[9] We estimate a Bayesian VAR system in levels.[10] The Akaike criteria, the Hannan-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.

We distinguish between a surprise shock, according to which the forcing variable jumps in $t = 1$, and an anticipated (news) shock that, as indicated, does not react in $t = 1$, but it is increasing

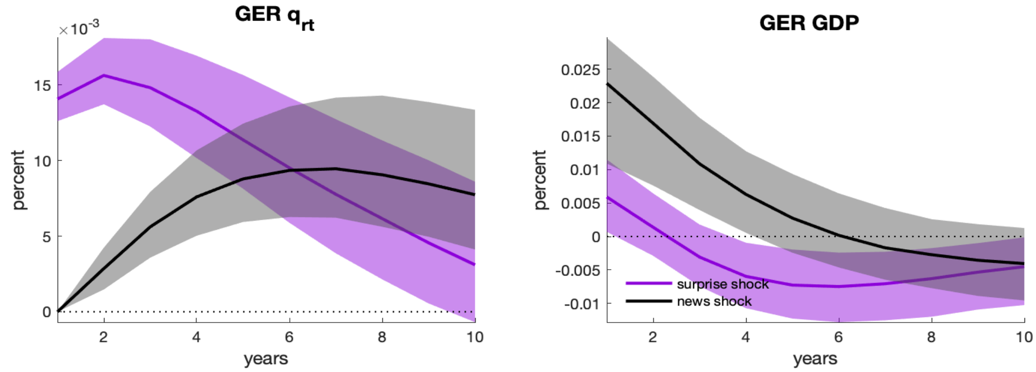
[9] Appendix E reports also results for estimated news shocks on an alternative VAR including the logs of eight other variables: RPI, q_{it}, GDP, GDP_t, consumption, C_t, aggregate investment, X_t, equipment investment, X_{et}, business structures investment, X_{st}, residential investment, X_{rt}, and IBEX 35 for Spain, or DAX for Germany. We further explore our benchmark VAR with alternative housing price measures. All these results are collected for online use.

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

Figure 3: **Surprise vs News shocks - Spain vs Germany**



(a) Spain



(b) Germany

Note: Impulse response functions for a surprise (purple) and news (grey) shock to the relative prices of residential investment for Spain (top panel) and Germany (bottom panel), and their effect on GDP.

afterwards and instantly reflected into forward-looking variables. Figure 3 shows the effects on GDP of a surprise and a news shock in the relative price of residential investment. The two shocks are characterized as such: unanticipated (purple) and anticipated (grey) in the left panel of the figure. They clearly exhibit different effects over GDP for Spain, whereas for Germany the two shocks effects are similar. Precisely, for Spain, while the news shock is producing a persistent expansion, the surprise shock has no effect in the short run and produces a recession in the long run. As such, we do not find evidence supporting that a traditional surprise shock drives the data. This is the finding provided all the relevant information for surprises on housing supply or demand is contained into residential RPI. We consider this evidence a feature of the data that should be incorporated for a proper accounting of the boom and bust dynamics.

From this key evidence we next discuss the overall effects of RPI news and surprise shocks.

Figures C.1 and C.2 in Appendix C report the impulse response functions, (IRF), and the forecast error variance, (FEV), for the two types of shocks and the two countries. As in Figure 3 above, the solid lines correspond to the posterior median estimates, and the bands display the 16%-84% posterior intervals. These bands are constructed by drawing from the posterior distribution of the parameters of the estimated model. We extract the shocks that maximize the fraction of the FEV due to q_{it}, $i = r, s, e$; over the forecast horizon of 10 periods (years), weighting 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 reliable estimates at the long end of the forecasting horizon.

2.4 Impulse Response Functions and Forecast Error Variance: discussion

Next, we further discuss the results for both news and surprise shocks along the different investment categories. In particular, we consider that a positive realization of the news shock means an expected future increase in residential RPI, and therefore, based on its ISTC counterpart, it anticipates a lower quality of housing capital in the medium-to long-run along the boom. Therefore, we further explore the correspondence between our identified news shocks and TFP news shocks. This exploration is also justified by the high share of forecast error variance associated to the residential RPI news shock (or alternatively, its ISTC counterpart) as we will see.

2.4.1 Aggregate effects of q_{rt} news shocks

Following a positive realization of the news shock (see Figures C.1 in Appendix C), residential investment prices do not change on impact by construction, but they grow gradually and peak after six years. The Spanish output, investment and consumption jump on impact, with highly statistically significant responses. Output, investment and consumption reach their peak after three periods. Hours worked response is insignificant. Output and aggregate investment responses, 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

[11] When using the Barsky and Sims' method to identify future q_{it} news shocks, we find that the results are not sensitive to the choice of forecast horizons. We have considered truncation horizons from 10 to 15 years (periods) and the results are very similar.

worked response is statistically significant just for the first period. It is evident that a positive news shock on 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 C.2 in Appendix C depict the contribution to the Forecast Error Variance (FEV) at horizons up to 10 years. For the Spanish economy, the news shock explains 61% of the variation of residential RPI, 59% of output, and 65% of aggregate investment, in three to five years.[12] The hump-shaped pattern of the news shock variance decomposition of output, aggregate investment, and consumption, suggests that the news effect is accumulating over 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, 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.

2.4.2 The alternative of TFP news shocks

One concern is whether the high share of forecast error variance associated to the residential RPI news shock is actually capturing TFP news shocks. To deal with this concern, we replace the residential RPI variable for TFP in our VAR. Then we identify TFP news shocks as we do for residential RPI news shocks. Figure C.3 in Appendix C depicts the impulse response functions to a (positive) TFP surprise and news shock for Spain and Germany. All aggregate variables in the empirical model respond to the identified TFP news shock in Spain in the form of a moderate recession today. In contrast, residential RPI news shock anticipated a boom in Spain, whose intensity and persistence operates through residential investment. Figure C.4, in its turn, depicts the forecast error variance decomposition, and suggests the TFP news shock accounts for a large part of the fluctuations associated to the implied recession in Spain. In contrast, an expansion after a TFP news shock cannot be rejected for Germany, whereas our identified residential RPI news shock produces a positive response on impact, which is more important for equipment and business structures than for residential investment: a key result.

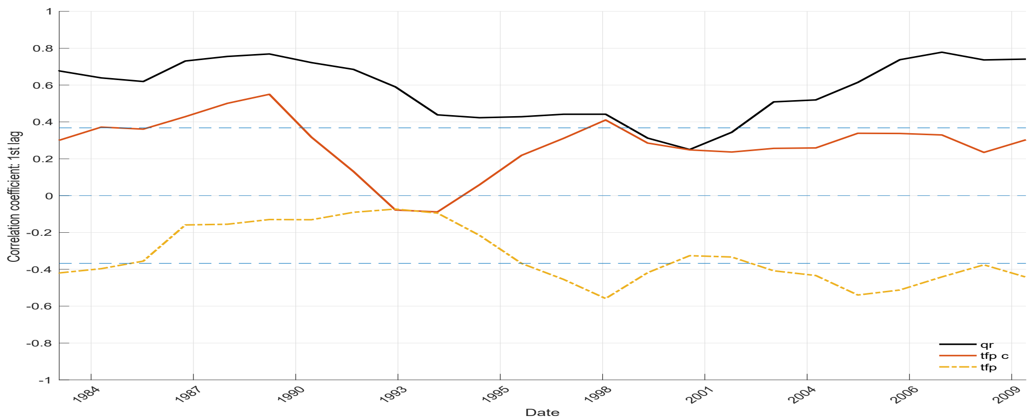
[12] Table C.1 in Appendix C shows the median impact percentile and the forecast horizon period in which that is achieved for Spain and for Germany.

Our interpretation is twofold. First, the observed response in investment, which governs the response in GDP, can be rationalized by the sectoral composition in the Spanish economy. Expansionary sectors during booms have been those with lower productivity (construction and its inputs in a broad sense, and tourism sectors). Rather, high productivity sectors in Spain do not particularly move investment and output. Secondly, TFP news shocks might not be precisely identified for Spain. The reason is TFP is measured with noise. This is particularly so based on annual data. In addition, it exhibits a downward trend since the early 90s (see Fig. 2), with too little fluctuations. All this brings additional variability to the VAR. Consequently, the expected finding of an expansionary effect of TFP news shocks could be more robust when identified based on quarterly data in alternative specifications. Note, finally, the relatively small quantitative importance of identified TFP news shocks compared to residential RPI news shocks.

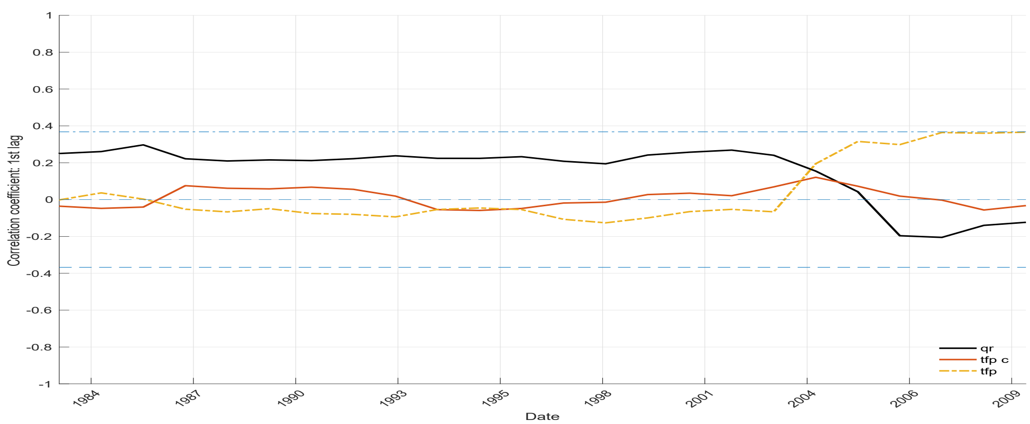
Alternatively, the TFP surprise brings a moderate expansion in both countries. Such an expansion seems more persistent for Spain, but it misses the (residential) investment boom effect we highlight in this paper. A construction sector TFP news shock produces similar results to those obtained from the aggregate TFP news shock: again, a recession in Spain, whereas in Germany a mild recession. These results are available upon request. Rather, we further explore the correlation between actual GDP and simulated GDP from the input of these alternative shocks, namely *i)* the residential RPI news shock, *ii)* the TFP news shock and *iii)* the TFP in the construction sector (TFPc) news shock.[13] Clearly (Fig. 4, top panel), the highest correlation between actual GDP and simulated GDP is obtained with the input of the residential RPI news shock. The correlation in this case is particularly high and always increasing during the years of the housing boom in Spain: 2001-2007. The input of the construction sector TFP news shock (TFPc) provides a related result but, the correlation is neither particularly high nor increasing during the years of the housing boom. Finally, the input of the TFP news shock to simulate model GDP is at odds with actual GDP, and significantly so during the housing boom. The same exercise for the German economy (Fig. 4, bottom panel) results in a moderate but stable response under the input of the residential RPI news shocks. Interestingly, the input of the TFP news shocks seems to take the role for the residential RPI news shock during the 2000s. In any case, all these correlations are not significant, although they are very stable provided the aforementioned switch of roles.

[13] We consider 95% confidence intervals for the computed correlation over a rolling window. We analyze both the contemporaneous correlation and the correlation at one lag (which seems more adequate in our context). The second alternative for Spain and Germany is depicted. The use of contemporaneous correlations does not alter these findings.

Figure 4: **Correlation between actual and simulated GDP at one lag from the input of different identified news shocks - Spain vs Germany**



(a) Spain



(b) Germany

Note: Rolling window correlation. The figures include 95% confidence bands.

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

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 (see again Figures C.1 in Appendix C). 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 residential RPI news shock effects on the different investment categories for Spain suggests that residential investment variance explained 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 response is not statistically significant. However, business structures and equipment IRFs are statistically significant, and both jump on impact and decay shortly after. In particular, the investment in business structures IRF shows the highest degree of persistence to a news shock.

We consider these illustrations, all along Section 2.4, provide substantial evidence in favor of the structural interpretation of the identified shock in this paper that we discuss next.

2.5 Benchmark VAR results interpretation

The key finding at this point 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 mirror the findings in Beaudry and Portier (2006) who find comovement following from, in their case, a TFP news shock in the U.S. According to these authors, an initial comovement of output, investment and consumption is consistent with the news-driven business cycle hypothesis. Here, we do not enter in the debate on the role of TFP news shocks as drivers of the U.S. business cycles. Rather, we provide evidence that a residential RPI news shock for the Spanish economy may take the place several authors have identified for a TFP news shock in the U.S. economy.

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 moderate reaction for Germany. There is an important difference in 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, increases strongly residential investment, and therefore, it is consistent with the fact that the Spanish economy has been booming due to the housing sector. A news shock on residential RPI in Spain 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 suggests a substitution effect out of residential investment and in favour of business structures, and especially, equipment investments. Therefore, our identified residential RPI news shock is also significant for Germany and seems to drive investment substitution. Whether this mechanism operates through an Euro Area channel is left for further research.

2.6 Alternative VAR specifications

In Appendix E (online use), IRFs and FEVs of the news shock identified on business structures RPI, q_{st}, and equipment RPI, q_{et}, are included. These provide details on the results discussed above. Also, the main findings hold across different VAR specifications. An alternative VAR we select is one where we include a forward-looking variable: IBEX 35 for Spain and DAX for Germany (see E.1 to E.4 for the residential RPI, q_{rt}, news in the alternative VAR, and then E.5 to E.20 for q_{st} and q_{et} news in both the benchmark and alternative VAR). The inclusion of stock price indexes does not affect the identification of the news shocks. In addition, we show results when using house price indexes (HPIs) rather than RPIs.[14] We find that the residential RPI captures well the dynamics of the house prices measured by those HPIs (see Figs. E.21 and E.22) we consider. Further, we explore the case of the news in an HPI while keeping the residential RPI in the VAR, as well as the reciprocal case. We find the identified residential RPI news shock explains more of the HPI news shock than the other way around. Our interpretation is the identified news in residential RPI leads the alternative HPI in its dynamic response (see Figs. E.23 to E.26)

A concern on the structural interpretation of the identified shock refers to the potential role of monetary and credit supply shocks. The latter have played an important role in a non-negligible part of the sample period we consider. With respect to the former, we choose to focus on the sovereign debt risk premium, because it is the one more related with the boom-bust dynamics.[15] We do not find statistical evidence of cross-correlation between the residential RPI news shock and the residuals of univariate regressions of this monetary policy variable (see Fig. D.1(a) in Appendix D). We retain this simple illustration because of the annual frequency of our data and the short sample period (1993-2015) for which we have homogeneous interest rates denominated in Euro.

[14] For this HPI we consider the measure of house prices reported by the BIS (see Appendix A). Notice we use annualized relative prices constructed from the residential property prices series.

[15] We consider the Spanish 10-year Government bond yields and we fit an AR(2) process to this interest rate series. These interest rates data are downloaded from the ECB (https://sdw.ecb.europa.eu/).

Next, we discuss the potential correlation of our identified news shock and credit supply shocks. We start with the measure of credit supply shocks of Gilchrist and Zakrajsek (2012) (GZ) for the U.S. We identify a "GZ credit spread news shock" in the VAR. The idea is this shock may matter by its global nature. We find, however, that the GZ credit spread news shock has a higher effect over consumption and equipment investment than on overall investment, residential investment or the relative price of residential investment. Figure D.1(b) in Appendix D shows that the cross correlation between the residential RPI news shock and the GZ credit spread news shock is moderate and mostly occurs contemporaneously for Spain, whereas for Germany the cross-correlation is non-significant (Fig. D.1(f)).[16] We also specify a VAR with the two variables: residential RPI and GZ spread. We find that if the news is in GZ the effect on residential RPI is absent and the response in consumption is bigger than in investment. The opposite occurs if the news is in the residential RPI, so the credit spread responds.

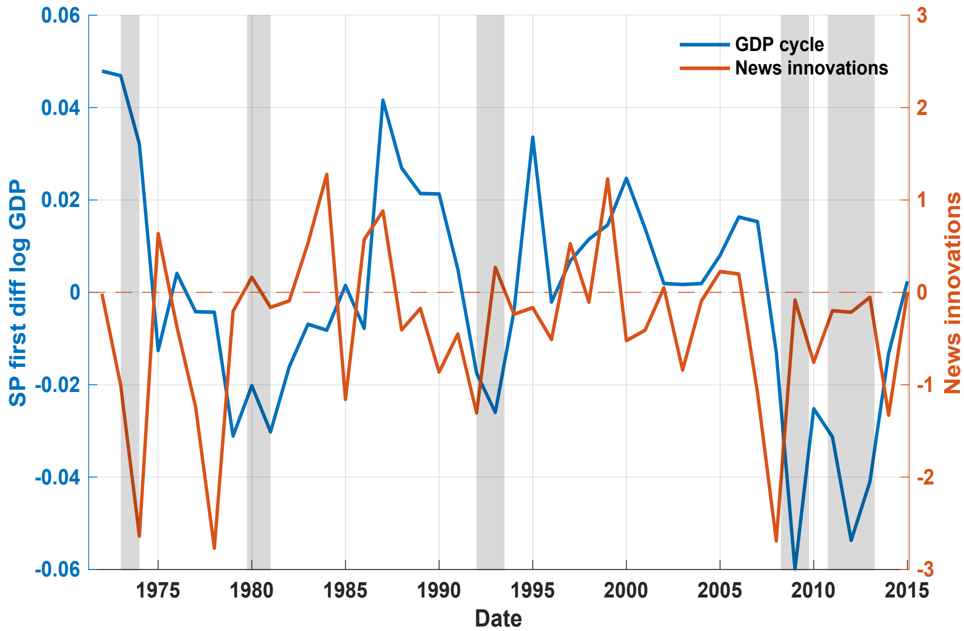
The GZ credit supply series dates back to 1973, which is good to implement our annual frequency SVAR. However, it may have only an indirect effect in the Euro Area. Thus, we consider comparable measures of local credit shocks. First, we use the series constructed by the Banque de France for the countries in the Euro Area [cf. Gilchrist and Mojon (2018), as equivalent to GZ]. There seems to be a moderate anticipation structure in this case (see D.1(c) in Appendix D). We interpret this finding as an indicator that the Great Recession dynamics drives the cross-correlation we compute, as this captures credit risk. Secondly, we consider a shadow interest rate series as in Boscá et al (2020). We compute the cross-correlation between the news shock and the residual of the AR(1) model of this shadow rate. The finding is again that the cross-correlation is moderate and its maximum occurs contemporaneously, as in the case of the global (U.S) credit shock (see D.1(d) in Appendix D).

The drawback with those two series is they are short and therefore, not for use in the SVAR. An alternative we consider, in order to use data back to 1970, is the credit to the non-financial sector constructed by the Bank for International Settlements (BIS) for Spain (see Appendix A). Again, we find a correlation structure with our identified news shock (see Fig. D.1(e) in Appendix D) similar to the mildly significant one obtained with the global-U.S. credit risk shock (again, Fig. D.1(b)).

After looking at how the identified residential RPI shock series correlates with different shocks

[16] A correlation of 0.35, with confidence bands at $\pm$ 0.3: the wide confidence bands suggest a limited statistical fit of this series with the Spanish data. The "GZ credit spread" is the difference in yields between various private debt instruments and government securities of comparable maturity. Such a spread has been considered to have predictive power for economic activity over the 1973–2015 period.

Figure 5: Spain: q_r news shock against 1st diff log GDP



Note: The shaded areas correspond with recession dates for Spain; The units of the left vertical axes is the log difference of GDP per capita whereas the right axes is the change in the news at t.

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

and technological changes in the construction sector, we conclude that our structural interpretation is consistent with the data. The results confirm a residential RPI news-driven source for a large part of aggregate fluctuations in Spain. Moreover, we provide evidence that such an anticipated shock led the response in credit supply. Clearly though, the credit channel has to have played an important role in the amplification of the propagation mechanism for the fundamental shocks we have identified for the Spanish economy (and Germany, differently) before and after the Euro.

To close the discussion on the empirical approach in this paper, Figure 5 depicts the change at time t in our identified news shock, together with the first difference of the log of Spanish GDP (note the VAR is in logs). The change in the residential RPI news shock comoves with the rate of growth of GDP and generally leads the cycle in one year: the correlation at one lead is 0.5 (see Table 1). The contemporaneous correlation for Spain between the change in the news shock and the growth rate is 0.02, though, whereas the correlation at one lag is -0.18, and -0.16 at two lags. 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 year in advance (which is our model period). Excluding the post-2007 period, so as to deal with both the credit supply driven issue and the zero-lower bound: a factor potentially inducing structural changes, produces similar results. In fact, the restricted sample highlights the exuberance of the boom period, with more response in consumption, which is particularly driven by the alternative credit shock. Moreover, the residential RPI news shock identified in the restricted sample is now slightly more contemporaneously correlated with the GZ credit supply shock than in the case of the full sample. Figure D.2 reports this finding, and can be compared with Fig. D.1(b). Our interpretation is that the dynamics of the residential RPI shock and the credit supply shock were particularly close during the boom period, something that can be due in part to the annual frequency of our data. Overall, we retain the key evidence we are highlighting, which is the leading indicator role of the news in housing prices, and that credit responds to the news shock.

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 labor market hours. The home production sector provides home goods to consumers with home labor 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), and therefore the relative prices of investment (RPIs). In particular, as the empirical analysis suggests, the ISTC news shock has different long-run implications, but the contemporaneous effects are essentially zero. Thus, 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.

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 labor, and makes investment and physical capital decisions. Preferences are defined as follows:

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

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:

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

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 labor 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 labor 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 labor 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

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

where key parameters for the propagation mechanism are going to be γ, η and θ, already described. We further comment on them below. However, it is also key the specification of the technology.

3.2 Technology

The production of final output, Y_t, requires market labor, 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_{st}, 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:

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

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 of 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 RPI 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 relative prices in the *EU KLEMS* database 2017 release.[17] The goal of the quantitative experiments is to provide an interpretation of the responses we estimated in the 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, Y_r.[18] 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 not essential for the argument. We fix the intertemporal elasticity of substitution (IES) to be the same in

[17] 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.

[18] We follow, for instance, Díaz and Luengo-Prado (2008), in that total GDP is market output, Y_m, that is, the sum of market consumption, C_m, and all forms of investment ($= X_e + X_s + X_r$).

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).

both economies. In the literature, it is fairly common to implicitly set $\sigma = 1$ which corresponds to the case of logarithmic utility. It seems also 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 labor disutility scale parameter, $\psi = 0.45$. Table 3 summarizes these latter choices.

The 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, and *iii)* the intertemporal labor supply elasticity, $\theta > 1$. 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 for the observed investment processes. Table 4 reports the range we consider for these parameters. In particular, the parameter γ helps to account for the idiosyncratic characteristics of the two economies. As discussed

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.

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). Thus, we consider intermediate values of γ. 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, through γ we introduce a reduced form causal link between household credit and housing demand [cf. Iacoviello and Minetti (2008)].[19]

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	$\epsilon_r = 1/(1-\eta)$ 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.

Parameter 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 home activity in the two economies. Secondly, it is important to notice that there is a lack of long and consistent series on time use in the home production for the two countries.

Finally, parameter θ governs the intertemporal labor supply (Frisch) elasticity, defined as $\epsilon_n =$

[19] On U.S. data, Görtz et al. (2020) recently find that positive news on future TFP drive a decline in credit spreads and an improvement in credit supply indicators, which is consistent with the financial friction parameter γ captures.

$1/(\theta - 1)$. In our context, this elasticity accounts for the prevalence of price adjustment over quantity adjustment during the boom and the bust in Spain and the difficulties this implies. Given the empirical differences observed in the VAR estimation in the labor market features of the two economies, we set for Germany a more responsive labor supply ($\theta < 1.3$) than for Spain, for which we set it not very responsive ($\theta < 7.5$). These assumptions stress a reduced-form for differences in labor market frictions.[20] It is not expected that changes in this parameter bring qualitative differences at business cycle frequencies without further frictions in the labor market of the model.

Notice that despite the reduced form approximation to the financial-fiscal channel and to the workings of the labor 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 well beyond the response through preferences.

4 Quantitative experiments

Next, we inspect the theoretical impulse response functions (IRFs) 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 F (online use), we include, on the one hand, the propagation of the news shocks on the relative prices of business structures, q_{st}, and the relative prices of equipment investment, q_{et}, and on the other hand, that of the news shocks on neutral progress and TFP.

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

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

Figure 6 shows the IRFs of aggregate model variables following a 1% positive news shock on the relative price 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

[20] These differences became particularly important after 2000, with the so-called Hartz reforms of the labor market in Germany implemented in 2003 and 2005, as discussed for instance by Bauer and King (2018) and Bradley and Kügler (2019). In Spain, however, the dual labor market brings about most of the cyclical adjustment on temporary workers, which represent an important but small fraction of the labor force.

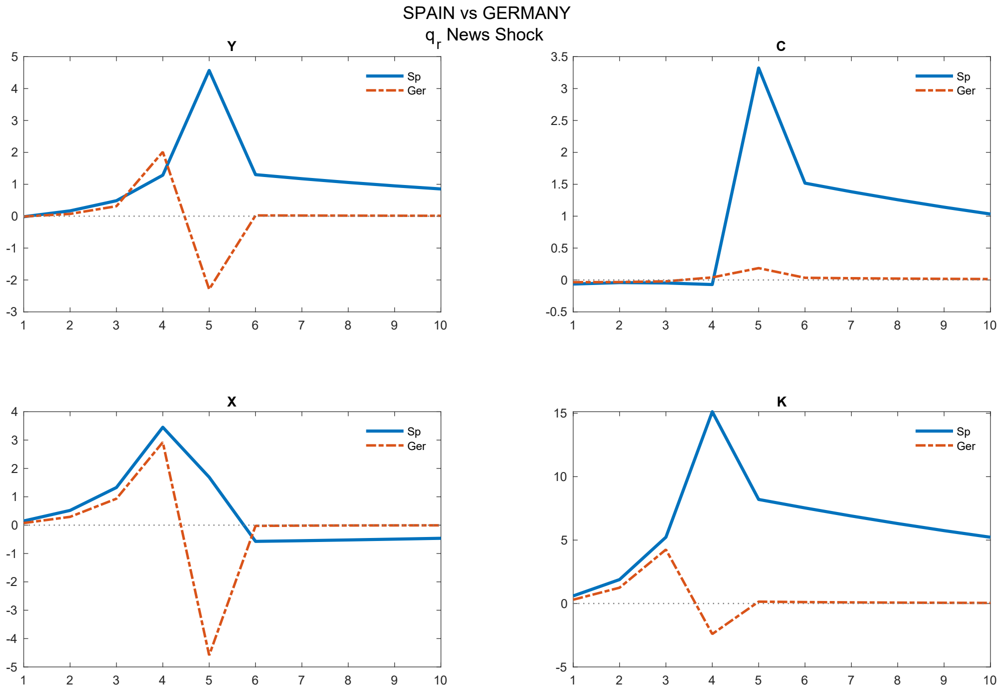
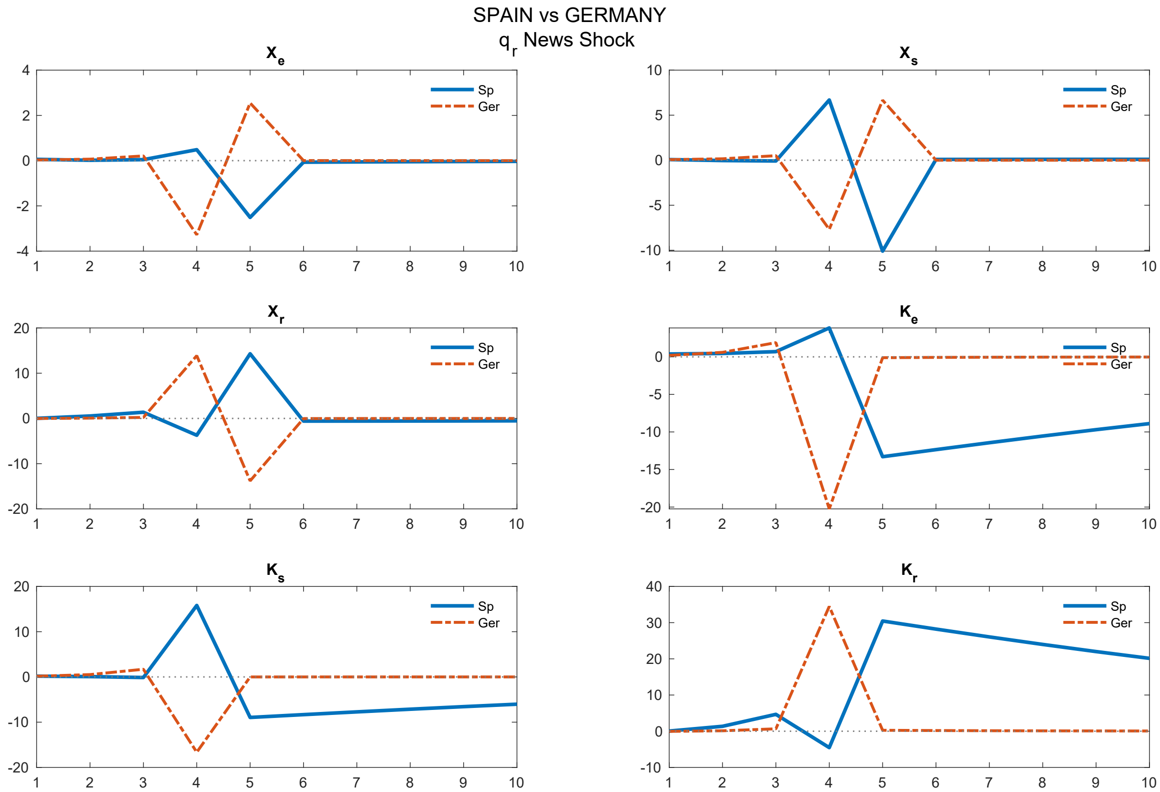


Figure 6: q_r news shock effect on aggregate variables

the second period, the output, investment and capital accumulation start increasing. However, the positive shock only occurs in period four. 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 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, before the realization of the shock, the variables are positively correlated, whereas after the shock



*

Figure 7: q_{rt} news shock effect on investment categories and capital accumulation

the effects are the opposite for the two economies, with much stronger fluctuation for Spain, and less for Germany.

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

Figure 7 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, particularly the one starting from the 2000s.

Again, for the propagation mechanism, there are three dates of interest: before, at the time of the realization, and after the shock. For the Spanish economy, 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 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 though 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 on the realization of the shock. For the German economy the movements are exactly the 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 dates 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. Finally, Figure F.1 in online Appendix F illustrates on the amplification in the (negative) response of market hours worked compared to the (positive) response of residential hours worked for Spain. This, on net, makes total hours worked to adjust less in Spain in the short-run compared to Germany.

4.3 Discussion

First, there is the effect of other RPI shocks. We also explore the responses to our identified shocks to the relative prices of equipment and business structures investment. In this respect, what we have seen in the data is that a (positive) news shock to business structures RPI produces a weak expansion (as expected) both in Spain and Germany, whereas that to equipment RPI produces a recession in Spain and a non-significant response in Germany (as expected –the international trade channel). Our quantitative experiments, in its turn (see Figures F.2 and F.3 in online Appendix F), produce moderate effects and investment substitution in Germany, whereas in Spain these other shocks bring about residential investment either on impact (if q_{et}) or anticipated (if q_{st}). Interestingly, in the model, the news shock to residential sector propagates very much as the equipment RPI news shock.

Also, there is the issue of the response to TFP news shocks. In the DSGE model we consider, the final goods, Z, shock is a combination of neutral progress and ISTC on structures and equipment. The ISTC of residential investment is not part of the Z shock. Thus, we identify the TFP news shock as a Z news shock. Remember we explored in the data the transmission of an identified TFP news shock, and we found it brings a moderate recession in Spain and a mild expansion in Germany. In the quantitative experiments we see (Figures F.5 and F.6, online Appendix F) that a TFP news shock is either not significant or produces a soft recession in Spain, whereas in Germany, on net, it brings a somewhat similar response as in the residential RPI news shock (it brings equipment and structures investment) but with a different timing of effects (first down then up).

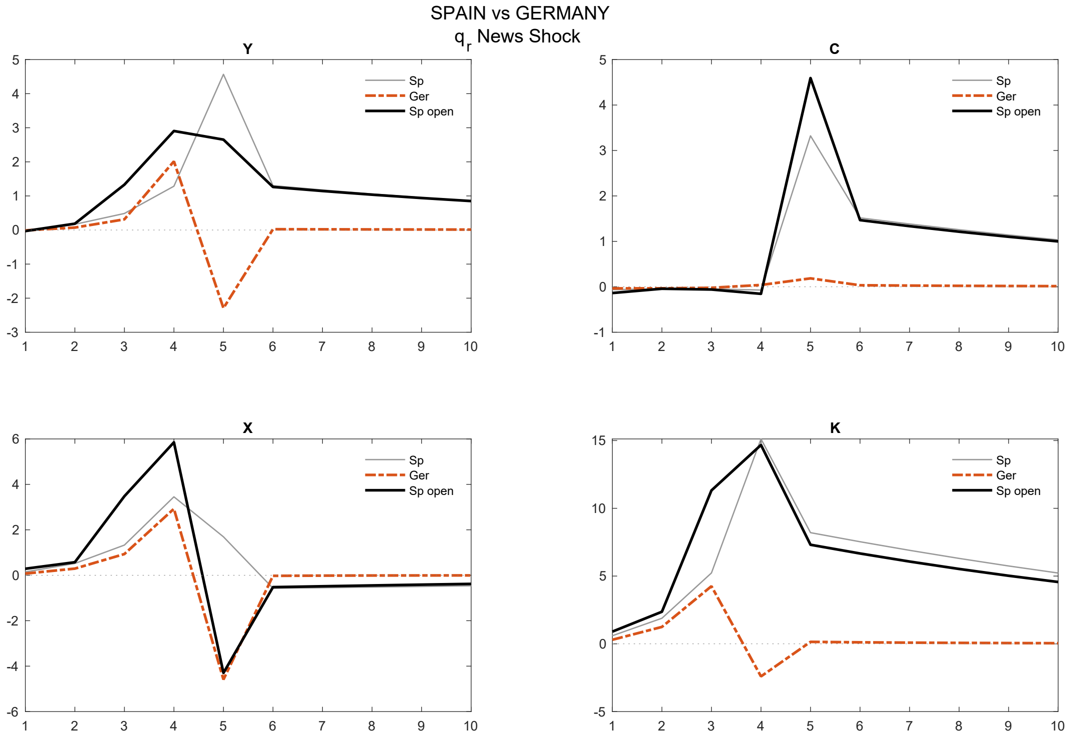
Finally, we find relevant to consider some sensitivity analysis on the parameter governing substitution in the labor input to produce market and housing goods: the parameter θ. Figs. F.7 and F.8 report these changes in θ. The finding is it governs the size of the boom in Spain, as compared with the size of the expansion in Germany. In Spain, this operates through the positive and persistent response in residential and business structures investment. In Germany, through the substitution of residential investment for equipment and business structures investment. So the key is the combination of the amplification channel with the substitution (or not) between the different forms of investment. In our setting we cannot stress on qualitative differences between the Spanish and the German labor markets, at least at business cycle frequencies. In the VAR, responses were amplified, but also more persistent, for Spain.

All in all, this discussion complements the key illustrations of the propagation of the residential RPI news shocks in the simple DSGE model we propose. The goal is to suggest directions in the modelling approach for a fully specified non-aggregate model of the business cycle for Spain, and once the structural interpretation of the identified shock in this paper is considered.

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.

Figure 8: IRF Aggregate variables



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.

The driving forces in the business cycle model include country - specific stochastic stationary contemporaneous shocks and news shocks. The news shock is hitting 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: $p(\tilde{d}_t) = \psi_d \, (e^{(d_t - \bar{d})} - 1)$, 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 8 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 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.

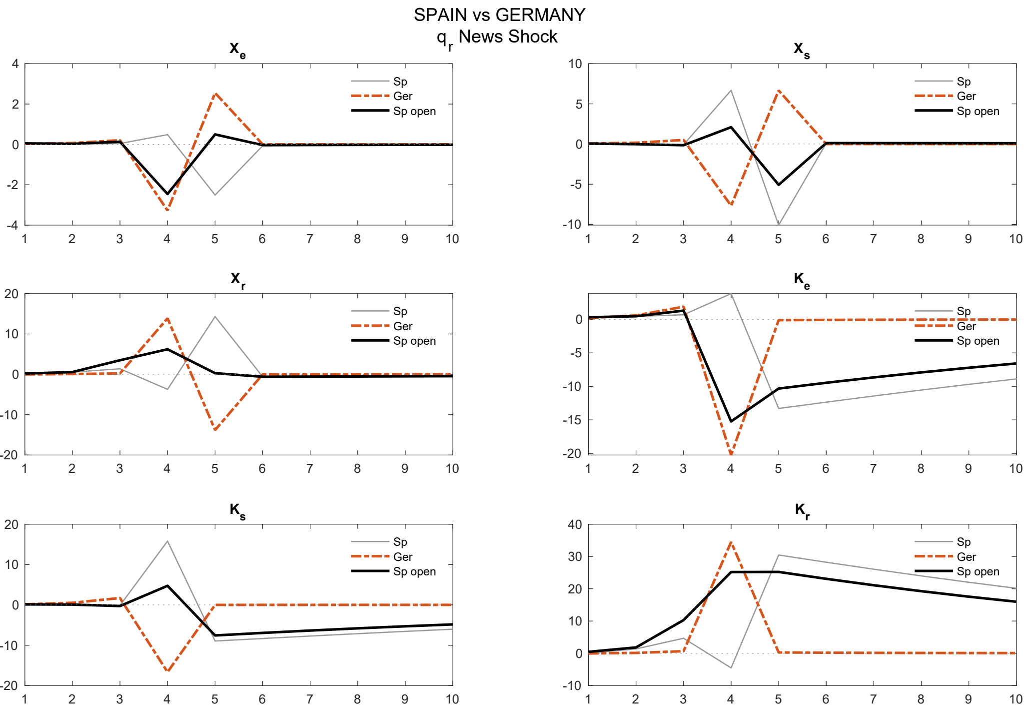
5.3 News shocks effects on Investment categories

Figure 9 shows the impulse response function of investment categories. 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. This suggests that in an open economy setting, responses to news shocks are smoother and more realistic.

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 implement the Barsky and Sims (2011) estimation approach. In so doing, we 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. When confronting the identified shock with other shocks we find that our structural interpretation is valid.

Figure 9: 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.

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 and (59%) of GDP in the Spanish economy is explained by news shocks to the relative prices of residential investment (residential RPI). For the German economy, the news shocks explain the variance of the aggregate variables to a lesser extent. Notwithstanding, a key contribution is that the residential RPI news shock brings about a housing boom in Spain, whereas in Germany it fuels the substitution of residential for equipment investment. Whether this mechanism operates through the Euro Area imbalances is left for further research. Also, there is the issue of RPI endogeneity that worths the examination of more disaggregated data.

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 (ISTC) with a reduced form for the wealth effect from house prices and for the frictions in the Spanish labor market. The propagation mechanism of residential RPI news socks is consistent with the observation of recent boom and bust dynamics 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 also leave for further research the incorporation of these important issues into the models.

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Appendix

A DATA

Data sources are the *EU KLEMS* and *OECD* databases.[21] The sample period is 1970-2015. Additionally, the disaggregated information on consumption expenditures used in the calibration is from *EUROSTAT* over the period 1995-2015. Other data used will be referred when corresponds.

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 Residential, Business Structures and the composite Equipment Investments 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.[22] To construct the composite *Equipment* (Paasche index), we take the implicit price deflator of each type of investment good, $D^j_{i,t}$ from EU KLEMS (base year 2010). We define the relative price of the investment good i in category e (*equipment)* as

[21] The EU KLEMS project is funded by the European Commission, Research Directorate General as part of the 6th Framework Programme, Priority 8, "Policy Support and Anticipating Scientific and Technological Needs"; Examples of research based on this database: O'Mahony and Timmer (2008); van Ark et al. (2008); Inklaar et al. (2009) For the OECD data see https://data.oecd.org

[22] http://stats.oecd.org/index.aspx

$q_{it}^e = D_{it}^e / D_{ndt}$. 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

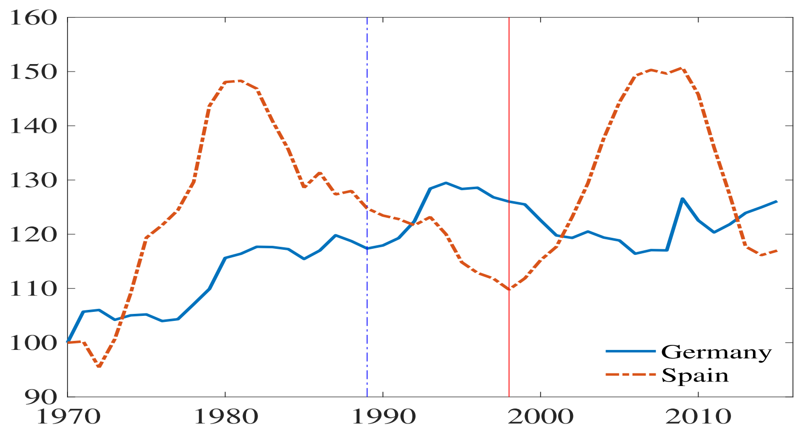
$$K_{et} = \frac{\sum_i q_{it}^e K_{it}^e}{q_{et}}, \tag{A.2}$$

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.

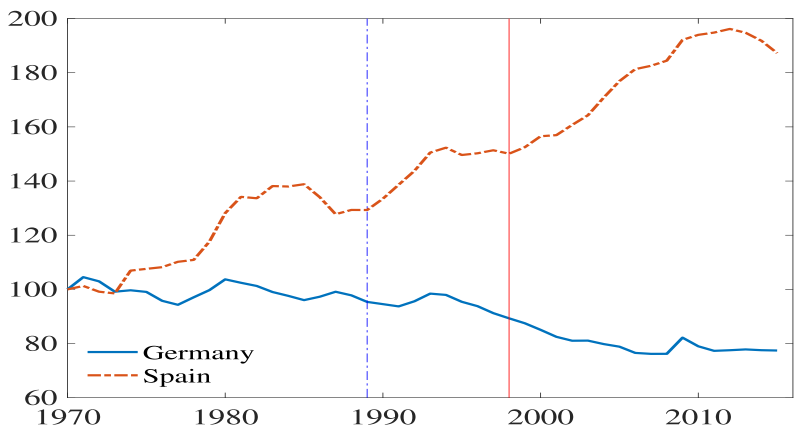
Figure 1 in the main text showed the relative prices of investment for each category (in units of non durable consumption goods and services) for Spain and Germany. The inverse of each q_{it} relative price represents the measure of ISTC, Θ_{it}, in residential investment, business structures and equipment. 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. Indeed, we observe two house price booms before the 2000s: the residential investment 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. Using house price indexes instead does not alter the broad picture. For instance, we have also used a house price index constructed from the residential property prices series collected by the BIS (see BIS SPP:Q:ES/DE:R:628), and conveniently annualized and relative to the price of non-durables and services. 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.

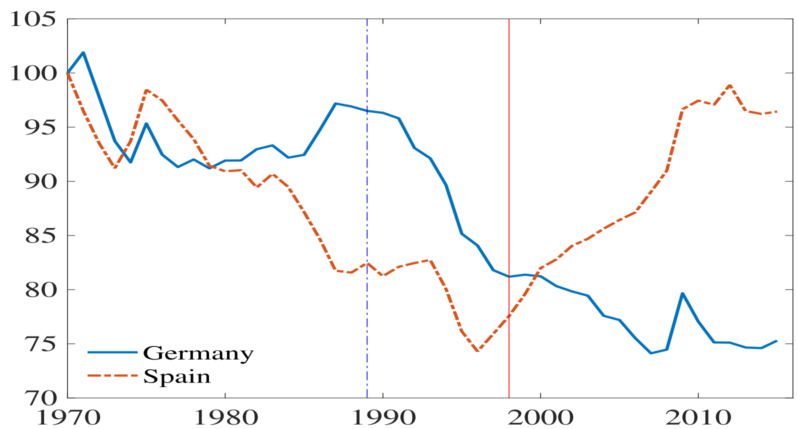
Figure A.1: **Investment Capital/ GDP - Spain vs Germany**



(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).

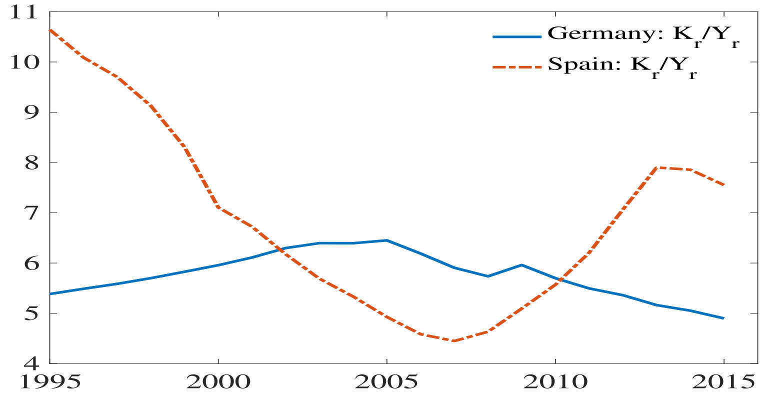
Figure A.1, in its turn, shows the ratio of capital to GDP for each investment category for Spain and Germany. We have normalized the figures to 1970 as the base year for both countries. We do so as a counterfactual exercise should they had started at the same level. As we can see in the lower panel, 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 investment to GDP, but only in the 1998-2009 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 investment to GDP ratio.

A.2 Output, Consumption, and Housing Services

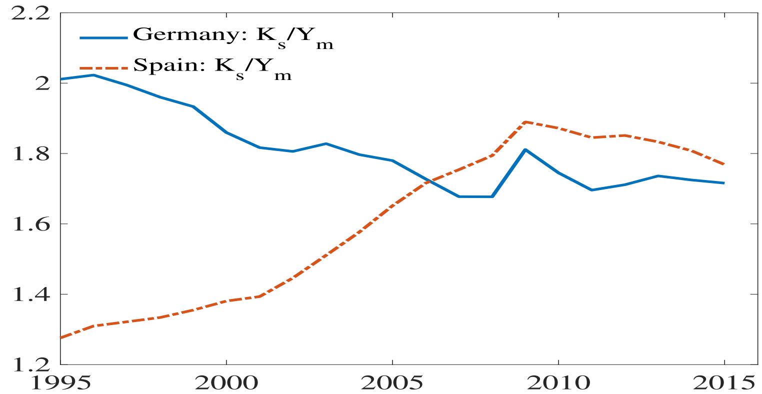
We consider measured GDP as the sum of market consumption, C_m, and all forms of investment ($= X_e + X_s + X_r$). Our measure of C_r comprises the services of rental housing, maintenance and repair, as well as the imputed services of owner occupied housing (computed using a rental equivalence approach 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.

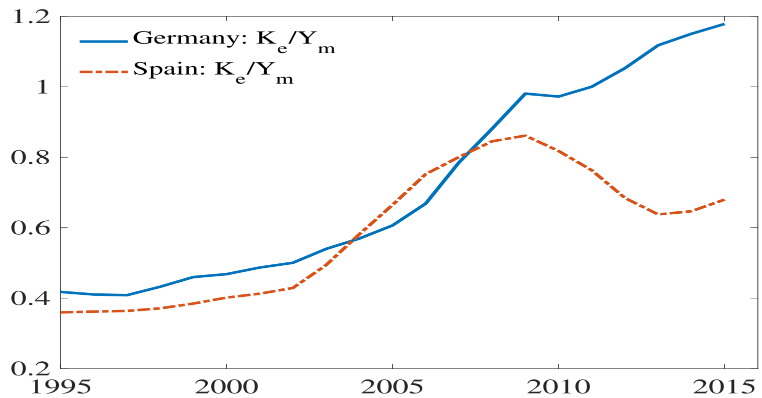
Figure A.2: **Investment Capital to Residential and Market output: Spain vs Germany**



(a) Residential Capital/Y_r



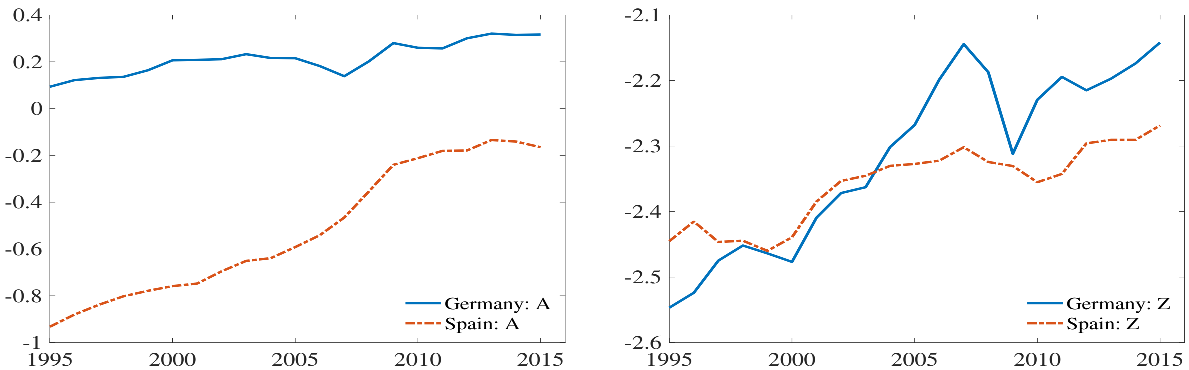
(b) Business Structures Capital/Y_m



(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, and they are consistent with the TFP measures in EU KLEMS we also use. 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.

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 labor 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 $\mathbf{y}_t = \mathbf{B}(\mathbf{L})\mathbf{u}_t$, 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 $\mathbf{u}_t = \mathbf{A}_0\varepsilon_t$. This implies the following structural moving average representation: $\mathbf{y}_t = \mathbf{C}(\mathbf{L})\,\varepsilon_t$, 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:

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

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:

$$\Omega_{i,j}(h) = \frac{\mathbf{e}_i' \left(\sum_{\tau=0}^{h} \mathbf{B}_\tau \tilde{\mathbf{A}}_0 \mathbf{D} \mathbf{e}_j \mathbf{e}_j' \mathbf{D}' \tilde{\mathbf{A}}_0' \mathbf{B}_\tau{}' \right) \mathbf{e}_i}{\mathbf{e}_i' \left(\sum_{\tau=0}^{h} \mathbf{B}_\tau \mathbf{\Sigma} \mathbf{B}_\tau' \right) \mathbf{e}_i} \tag{B.2}$$

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

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) in the main text imply that these two shocks account for all variation in q_t^i. That is $\Omega_{1,1}(h) + \Omega_{1,2}(h) = 1 \quad \forall h$.

It is in 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:

$$\gamma * = \arg\max \sum_{\mathbf{h=0}}^{\mathbf{H}} \Omega_{1,2}(h) = \frac{\sum_{\tau=0}^{h} \mathbf{B}_{i,\tau} \tilde{\mathbf{A}}_0 \gamma \gamma' \tilde{\mathbf{A}}_0' \mathbf{B}_{i,\tau}'}{\sum_{\tau=0}^{h} \mathbf{B}_{i,\tau} \mathbf{\Sigma} \mathbf{B}_{i,\tau}'} \tag{B.3}$$

s.t.

$$\tilde{\mathbf{A}}_0(1,j) = 0 \quad \forall j > 1 \tag{B.4}$$

$$\gamma(1,1) = 0 \tag{B.5}$$

$$\gamma'\gamma = 1 \tag{B.6}$$

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.[23] 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.

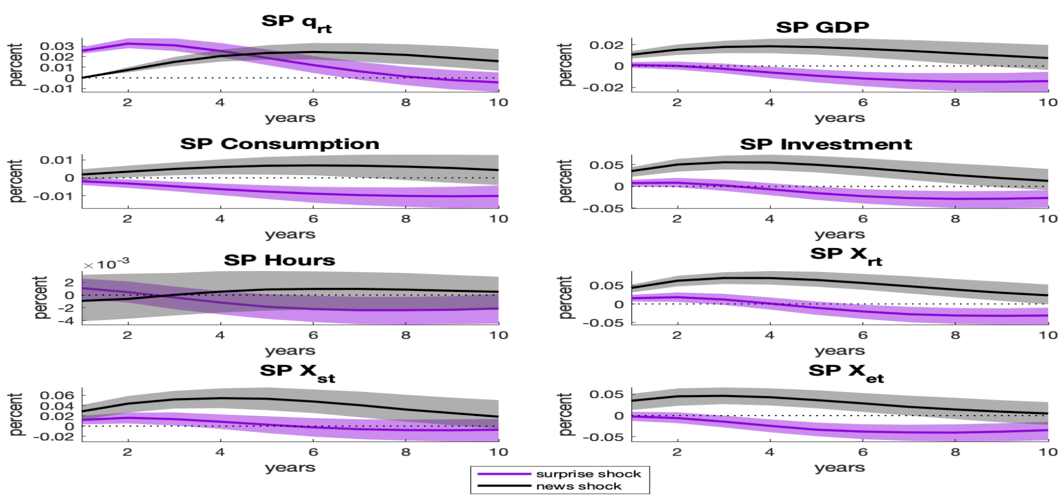
[23] The finite truncation horizon in this paper is 10 periods, that is, 10 years in our empirical setting. Notice that Fisher (2006) builds upon Greenwood et al. (1997). The stochastic growth setting favors the VAR to be written in first-differences so that the writing of long-run constraints is natural. In our case, however, we do not have stochastic growth. Thus, the VAR is in logs, and then it is difficult to specify a correspondence between RPI and ISTC only in the long-run. Therefore, as in Barsky and Sims (2011) the responses over a long horizon are evaluated whether they are different from zero. See Figure E.23 in Appendix E for the effect of different truncation horizons.

C Empirical evidence of news shocks

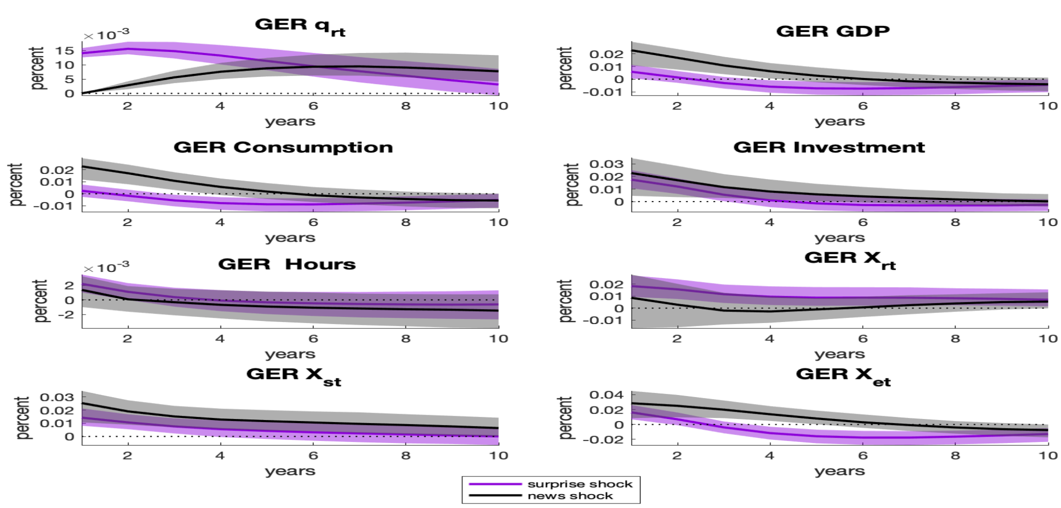
C.1 Surprise vs News shocks - residential RPI - Spain and Germany

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

Figure C.1: **IRFs - Residential RPI Surprise vs News shocks - Spain and Germany**



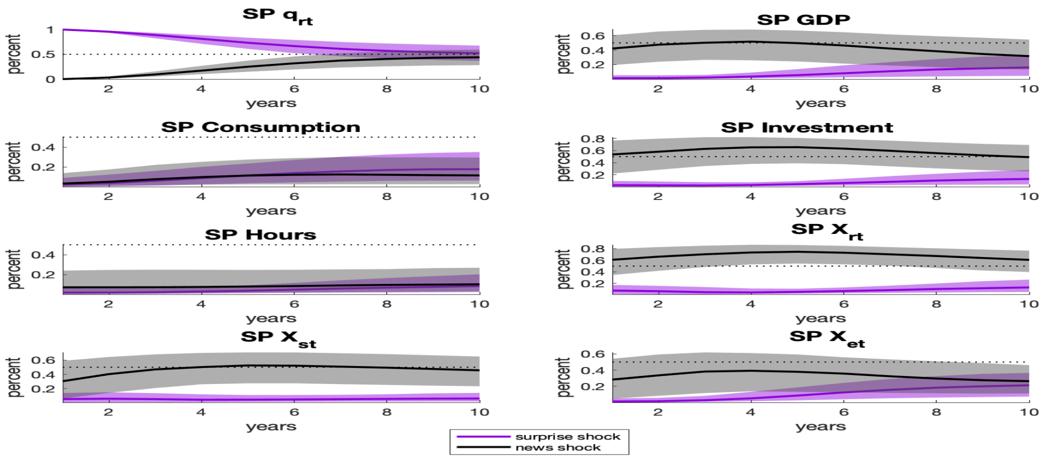
(a) IRFs Spain



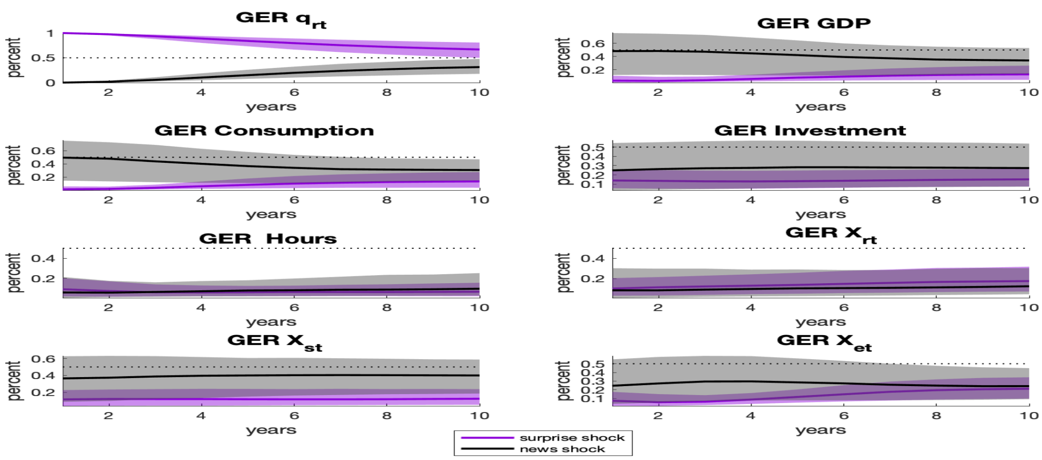
(b) IRFs Germany

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

Figure C.2: **FEVs - Residential RPI Surprise vs News shocks - Spain and Germany**



(a) FEV decomposition Spain



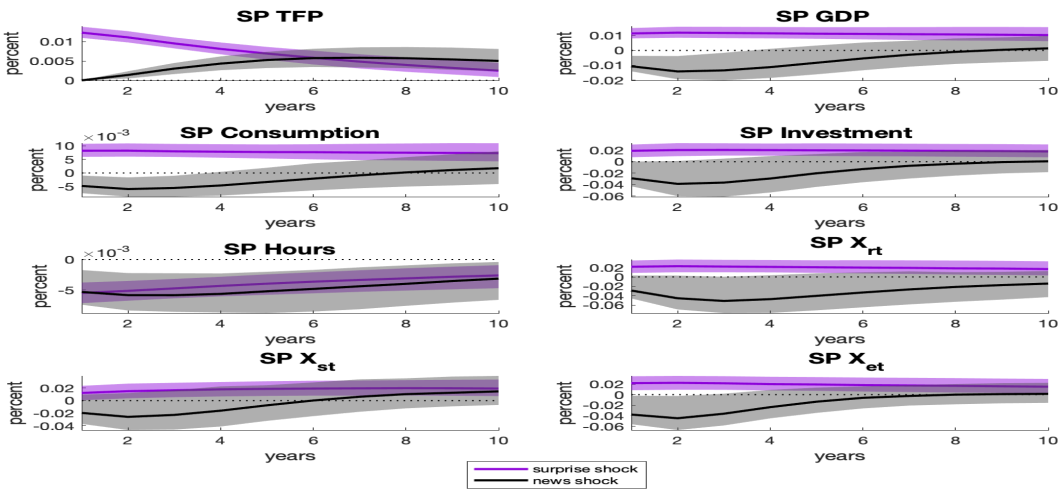
(b) FEV decomposition Germany

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

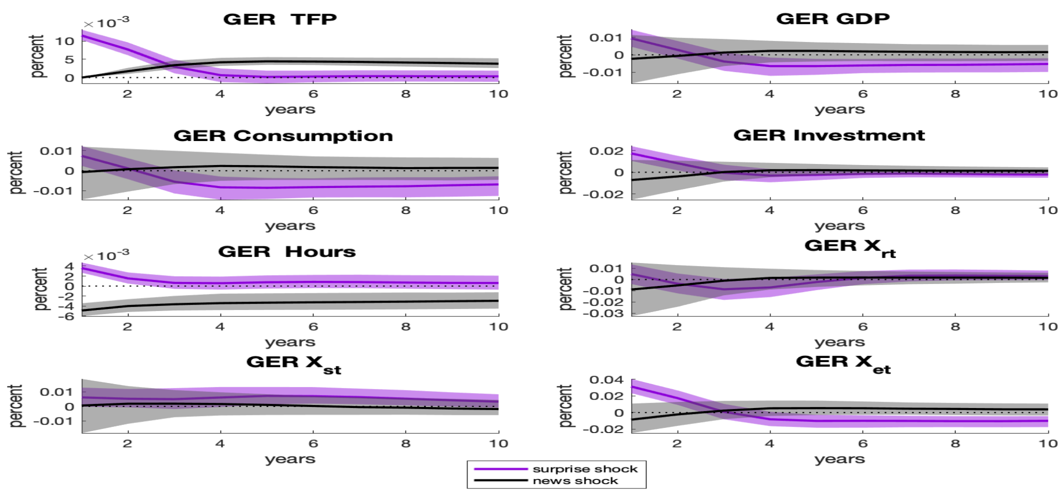
	q_{rt}	GDP_t	C_t	I_t	Hours	X_r	X_s	X_e
Spain								
Median contribution	0.61	0.59	0.15	0.65	0.05	0.80	0.46	0.43
Year	10	3	5	5	9	4	7	5
Germany								
Median contribution	0.31	0.51	0.48	0.39	0.11	-	0.35	0.46
Year	10	2	1	9	10	3	4	10

C.2 Alternative TFP News shocks - Spain and Germany

Figure C.3: **IRFs - TFP Surprise vs News shocks - Spain and Germany**



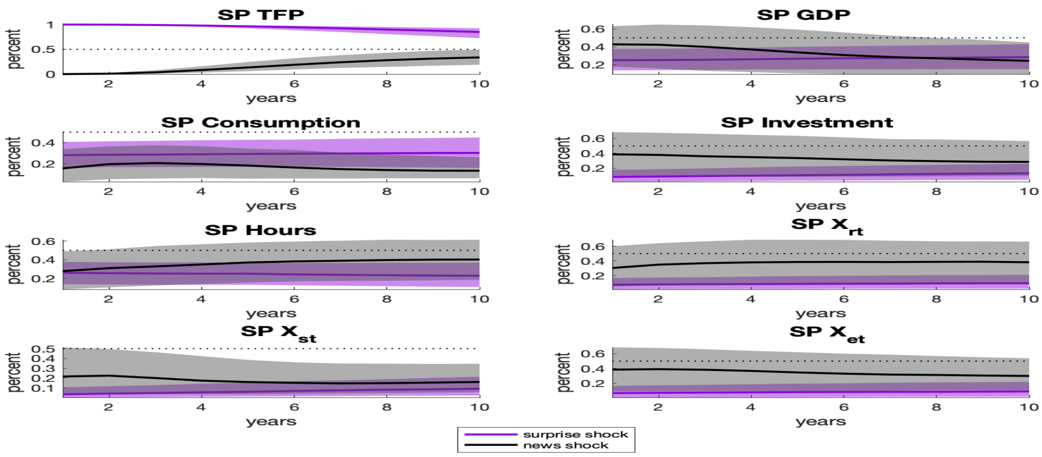
(a) IRFs Spain



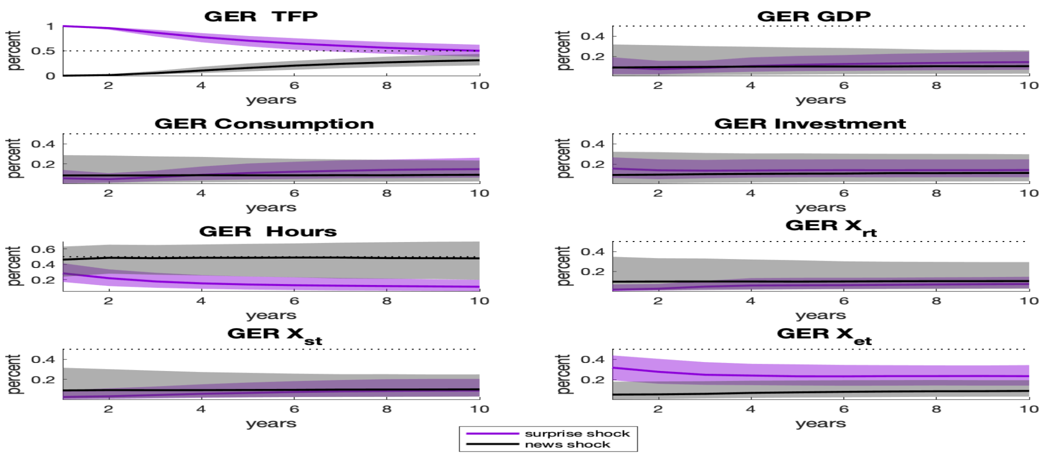
(b) IRFs Germany

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

Figure C.4: **FEVs - TFP Surprise vs News shocks - Spain and Germany**



(a) FEV decomposition Spain



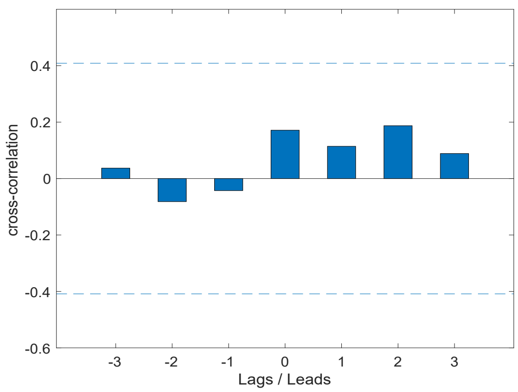
(b) FEV decomposition Germany

Table C.2: Maximum Forecast Error Variance (FEV) - TFP news shock

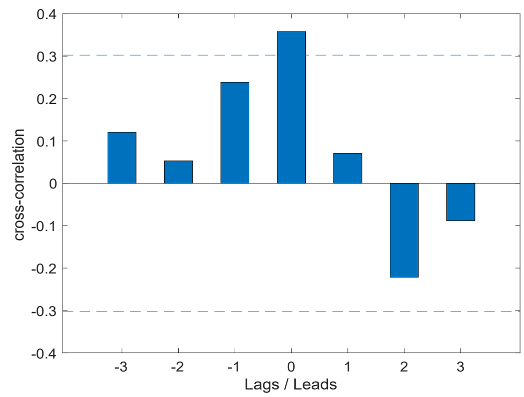
	q_{rt}	GDP_t	C_t	I_t	Hours	X_r	X_s	X_e
Spain								
Median contribution	0.34	0.43	0.21	0.39	0.40	0.39	0.22	0.39
Year	10	1	3	1	10	9	2	2
Germany								
Median contribution	0.31	0.10	0.09	0.11	0.49	0.10	0.10	0.09
Year	10	10	10	10	6	10	10	10

D Alternative shocks: Identified in benchmark VAR or Estimated

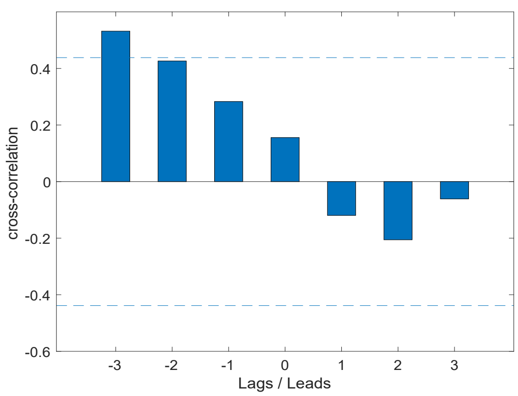
Figure D.1: Spain - Cross-correlation between monetary and credit supply shocks and the identified news shocks. Note (f) corresponds to GZ shock and Germany q_r news.



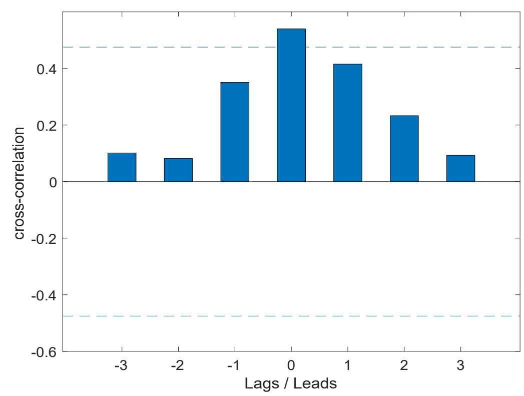
(a) Monetary shock



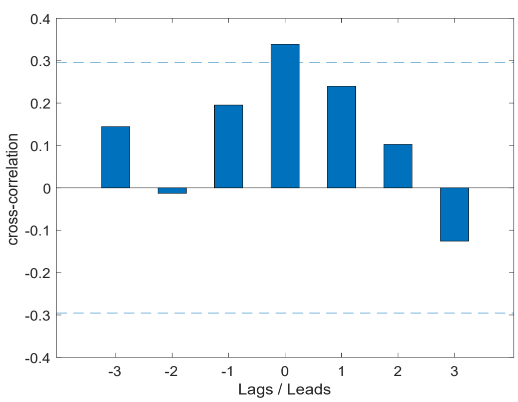
(b) GZ credit supply shock



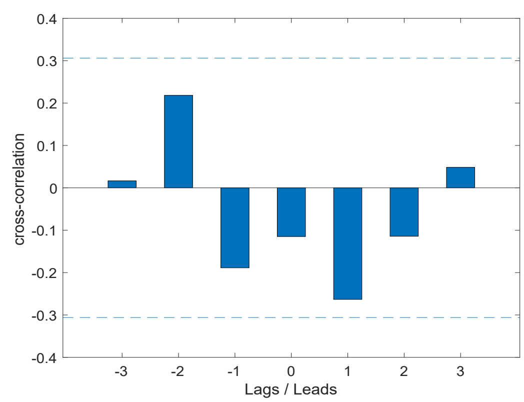
(c) GM credit supply shock



(d) Shadow interest shock

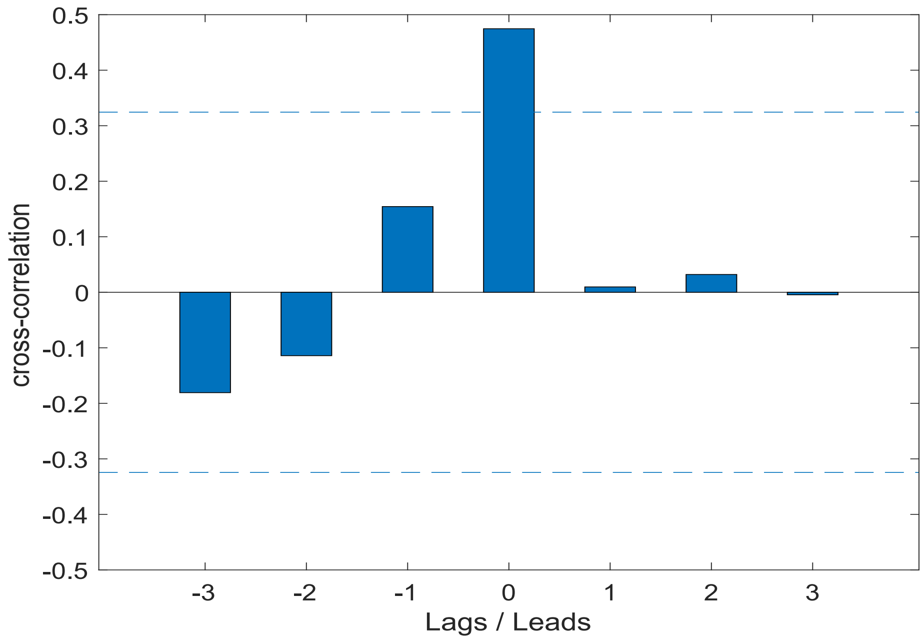


(e) BIS data shock



(f) Germany GZ shock

Figure D.2: Spain – Cross-correlation at lags and leads between the residential RPI news shock and a Gilchrist and Zakrajšek (2012) credit spread news shock. Restricted sample, 1970-2007.



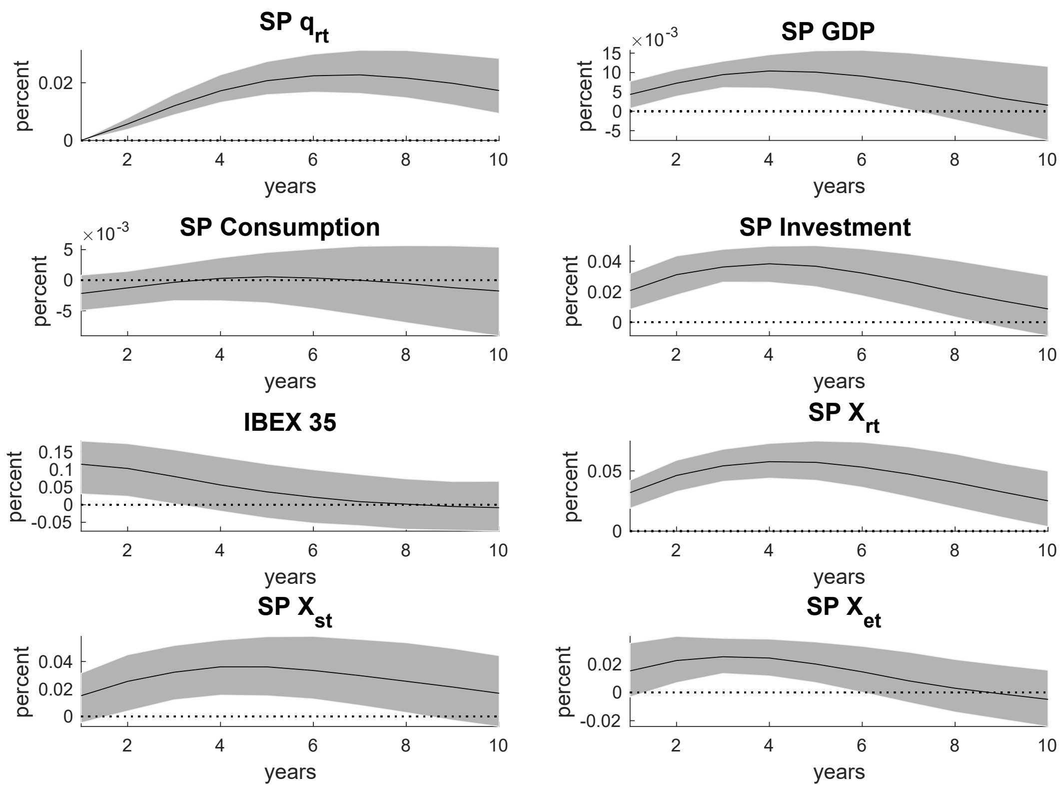
Note: IRFs and FEVs for the restricted sample are available upon request. The restricted sample produces more variability in the response, so slightly less precision.

Appendix for Online Use

E Alternative VAR Identification and Alternative Shocks

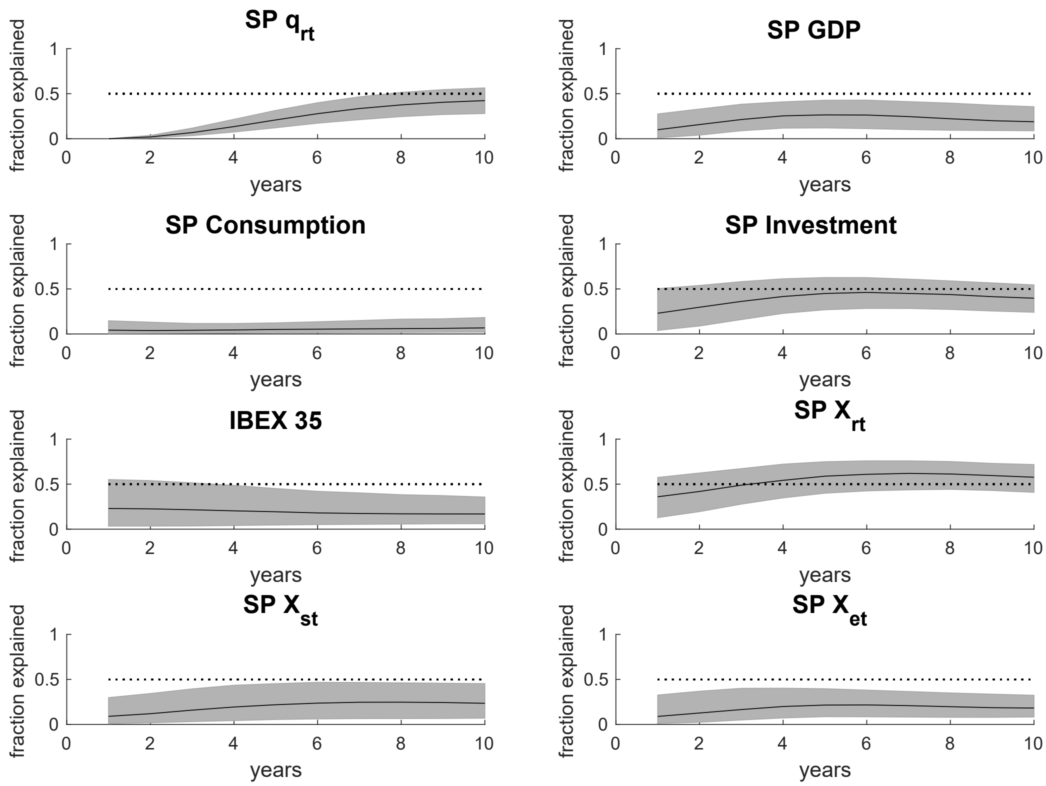
E.1 SPAIN - q_{rt} news shock - alternative VAR

Figure E.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.

Figure E.2: SPAIN - Forecast Error Variance (FEV) - q_{rt} news shock - alternative VAR



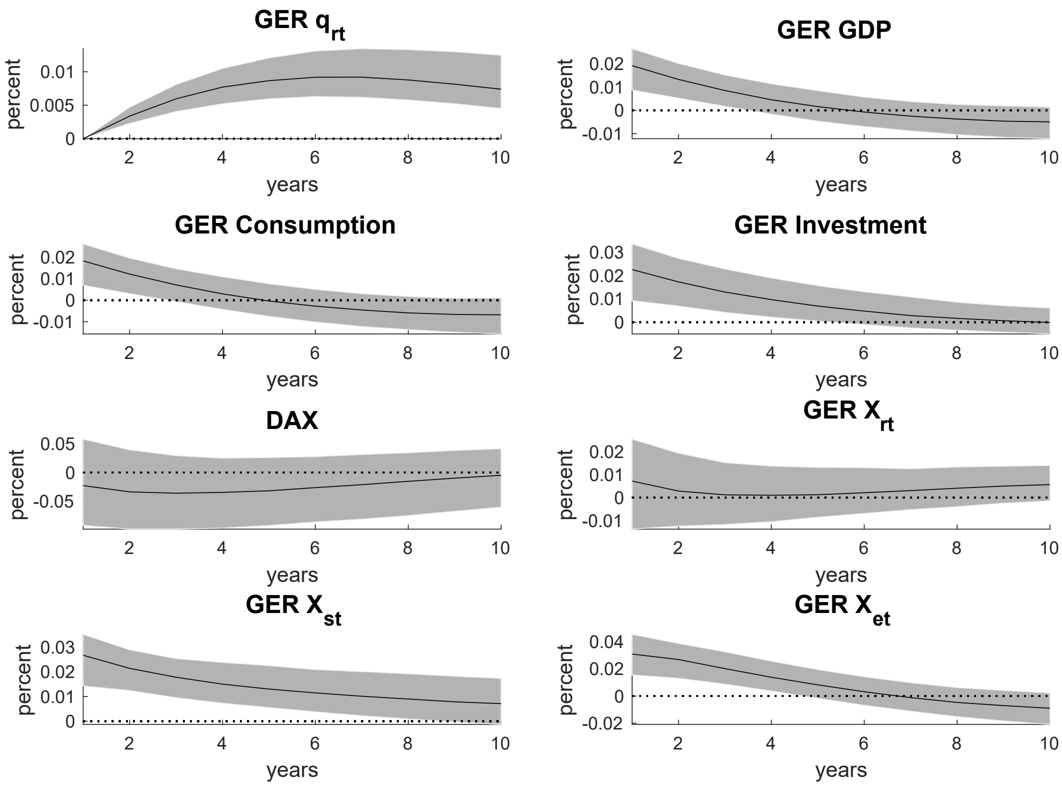
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.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

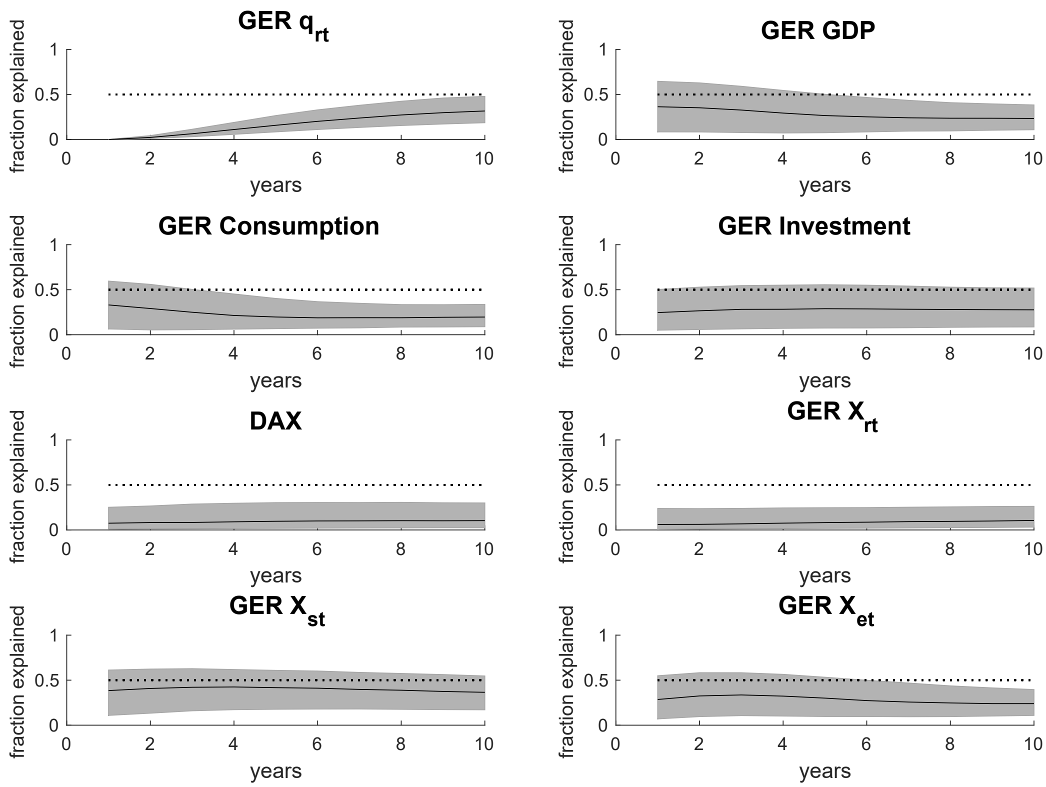
E.2 Germany - q_{rt} news shock - alternative VAR

Figure E.3: GERMANY - Impulse responses to a 1% innov. 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 E.4: GERMANY - Forecast Error Variance (FEV) - q_{rt} news shock; alternative VAR



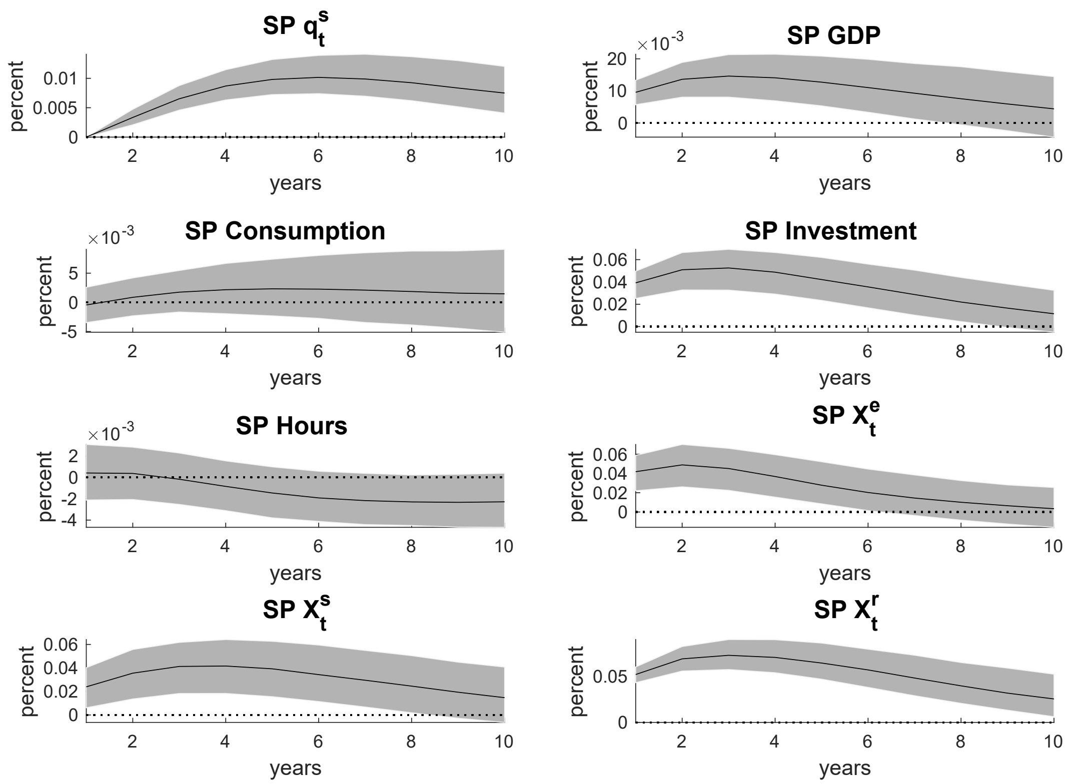
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.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

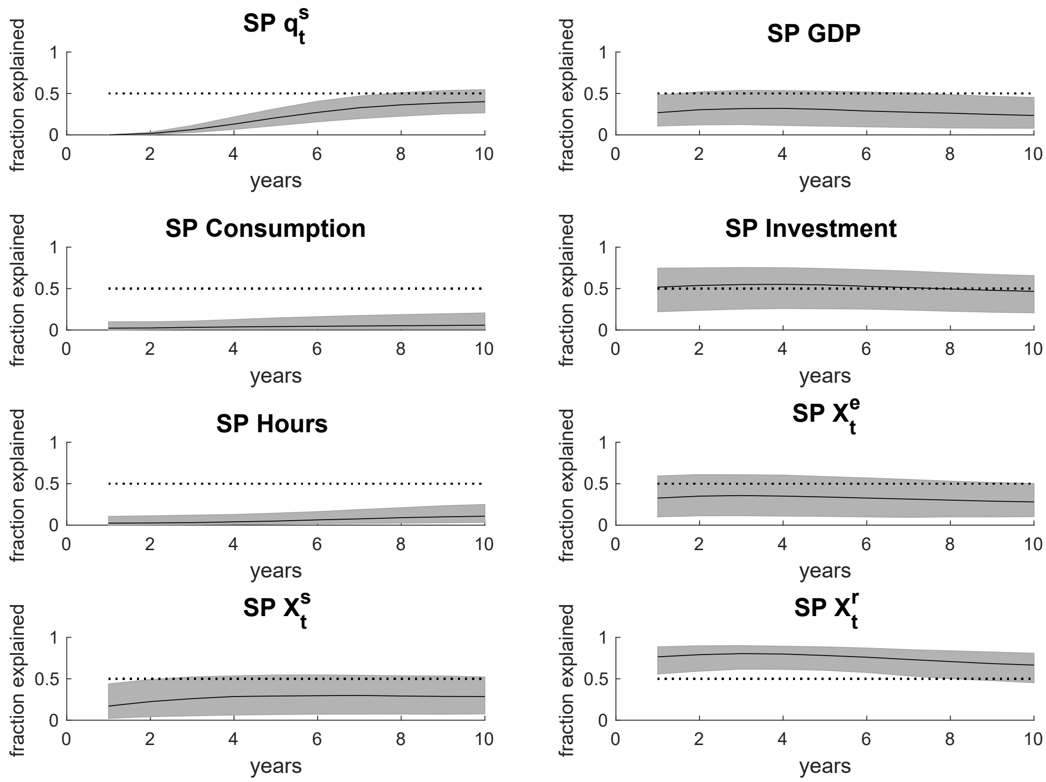
E.3 Spain - q_{st} news shocks - benchmark var

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



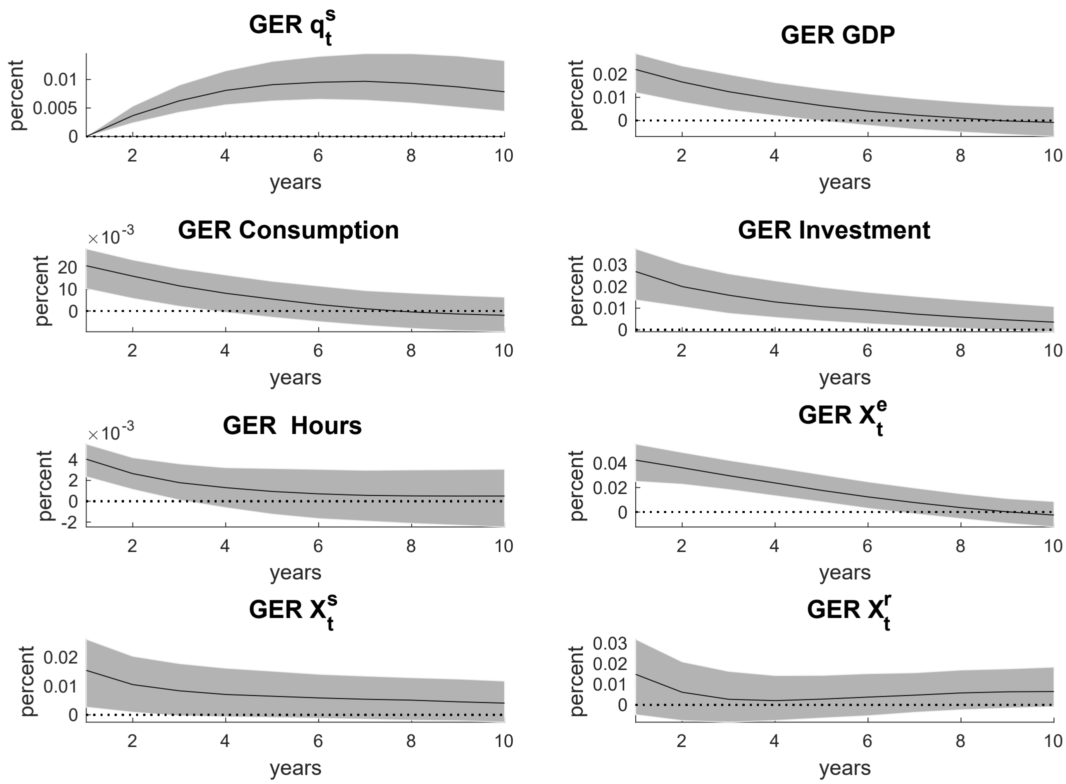
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.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

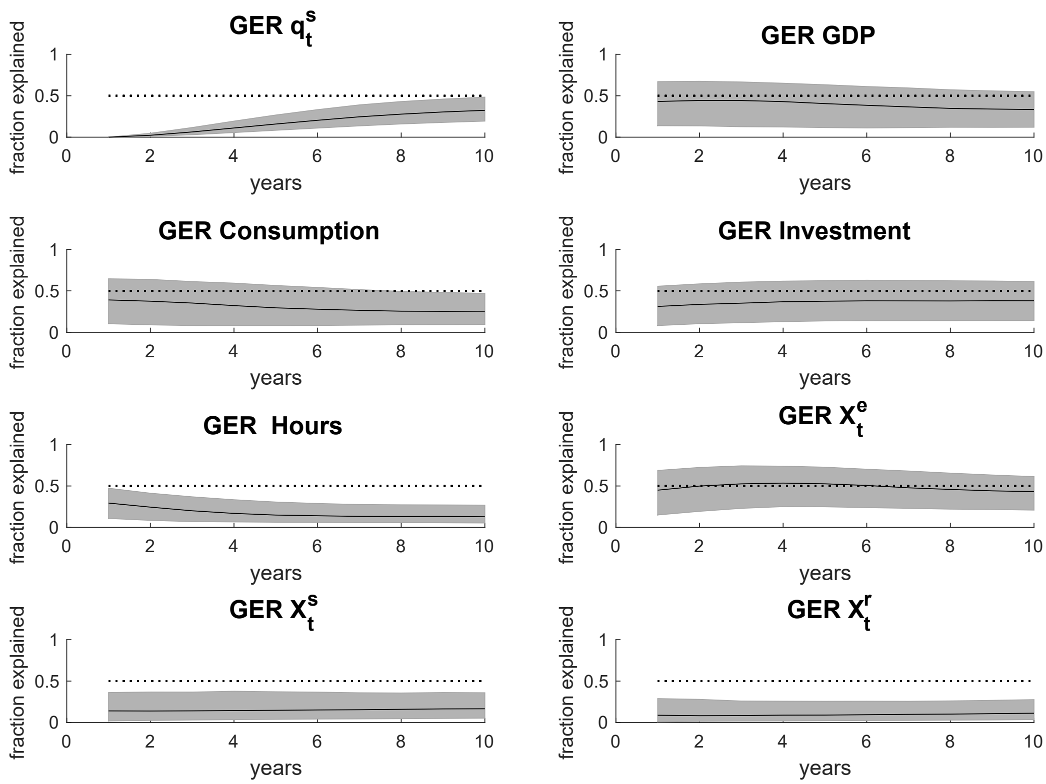
E.4 Germany - q_{st} news shocks - benchmark var

Figure E.7: GERMANY - Impulse responses to a 1% innov. 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 E.8: GERMANY - Forecast Error Variance (FEV) - q_{st} news shock; benchmark VAR



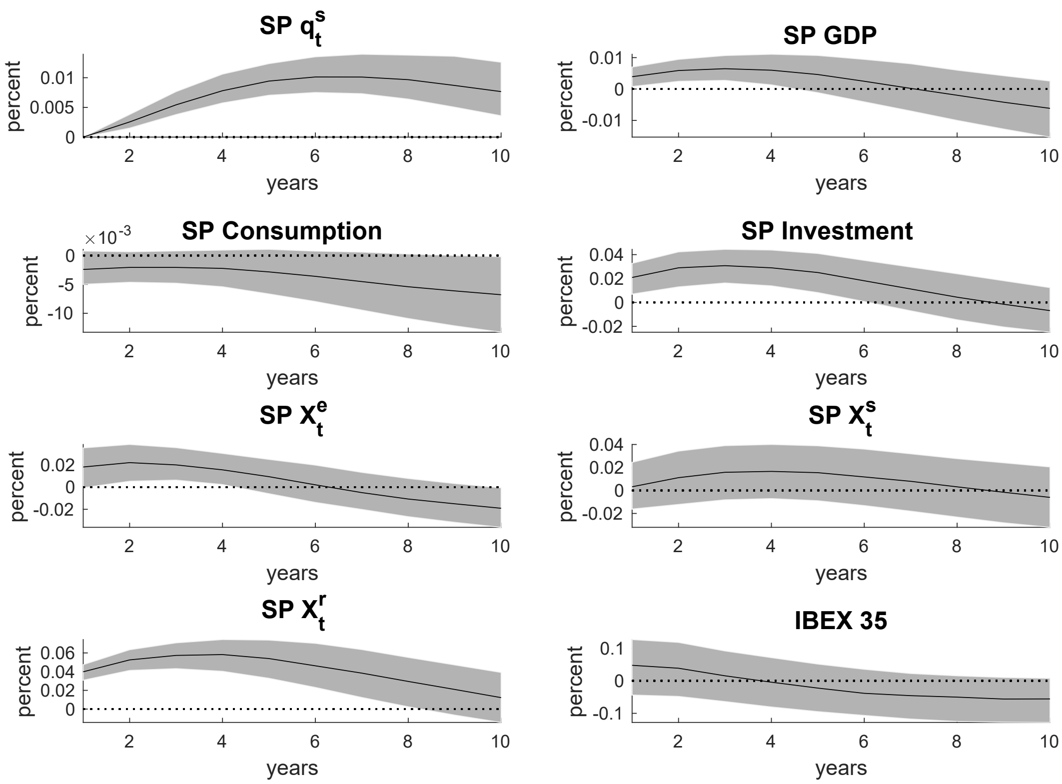
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.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

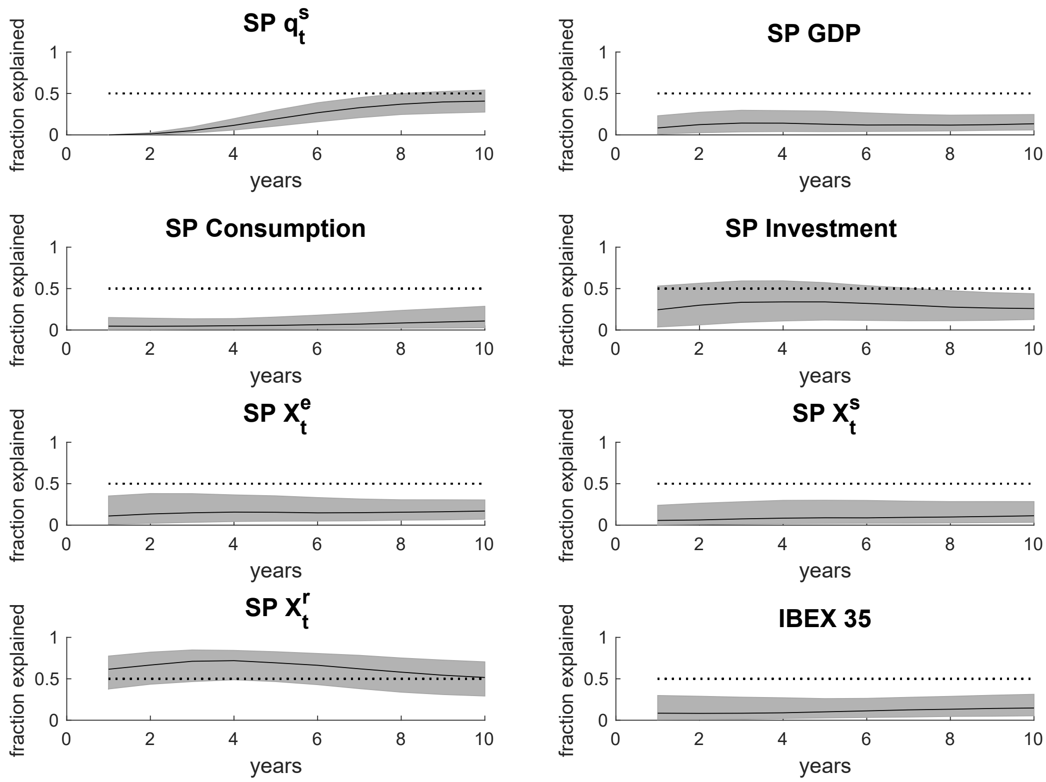
E.5 Spain - q_{st} news shock - Alternative VAR

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



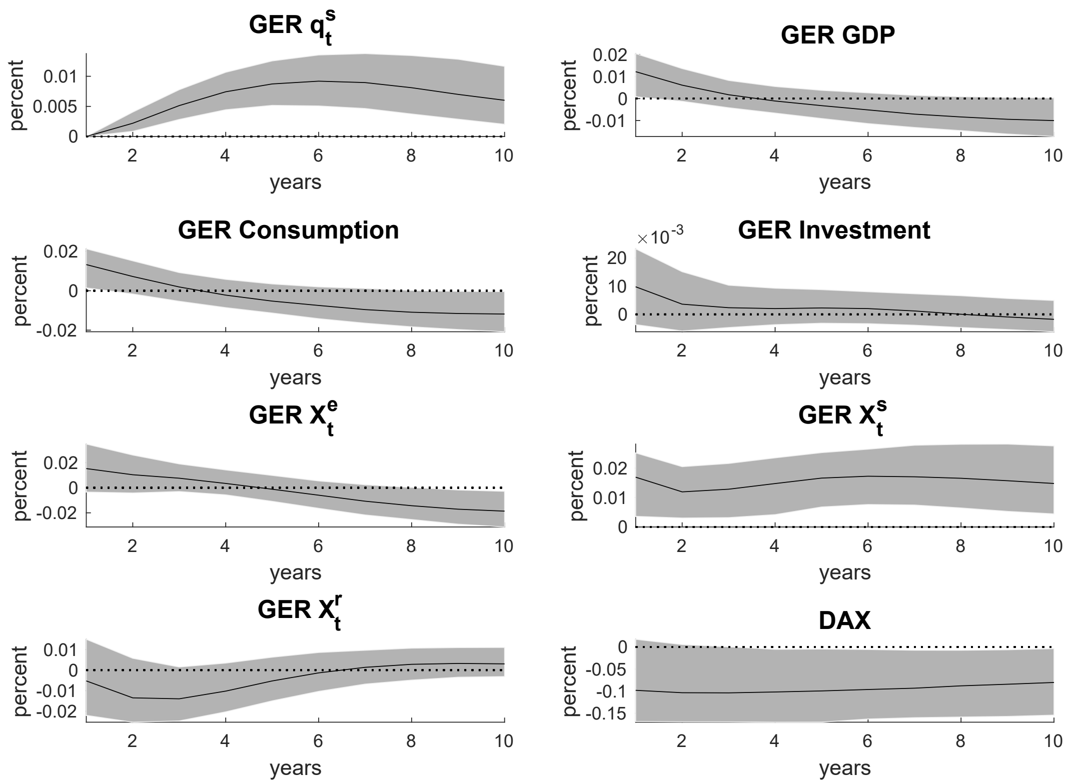
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.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

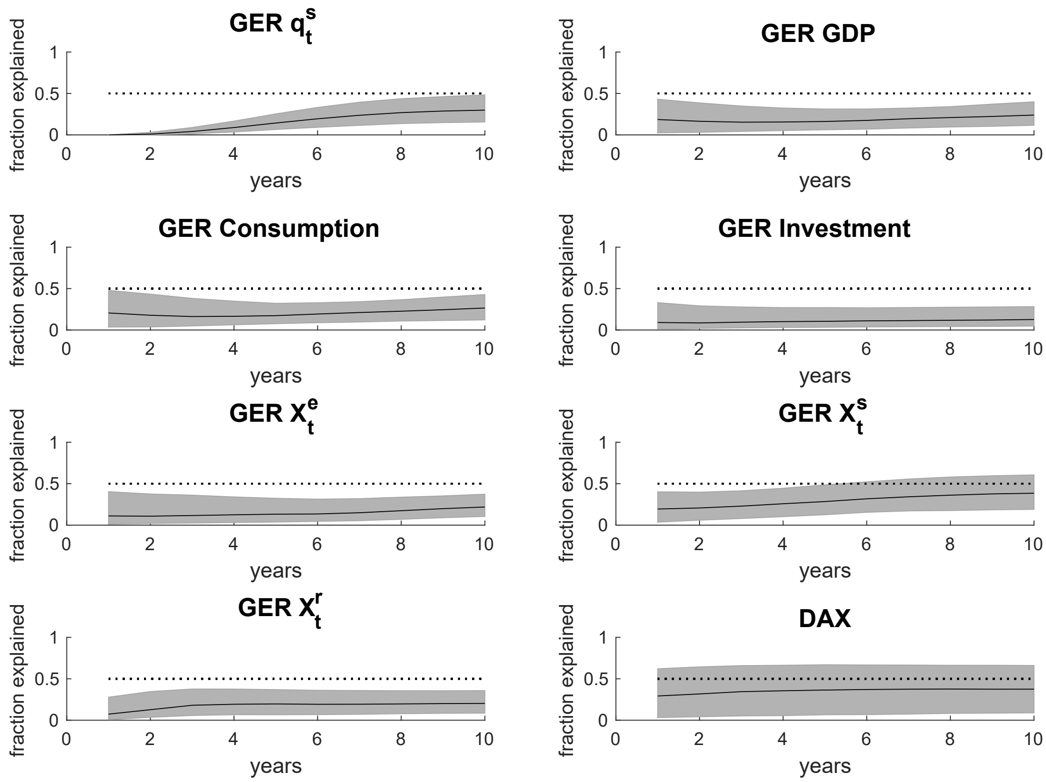
E.6 Germany - q_{st} news shock - Alternative VAR

Figure E.11: GERMANY - Impulse responses to a 1% innov. in 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 E.12: GERMANY - Forecast Error Variance (FEV) - q_{st} news shock; alternative VAR



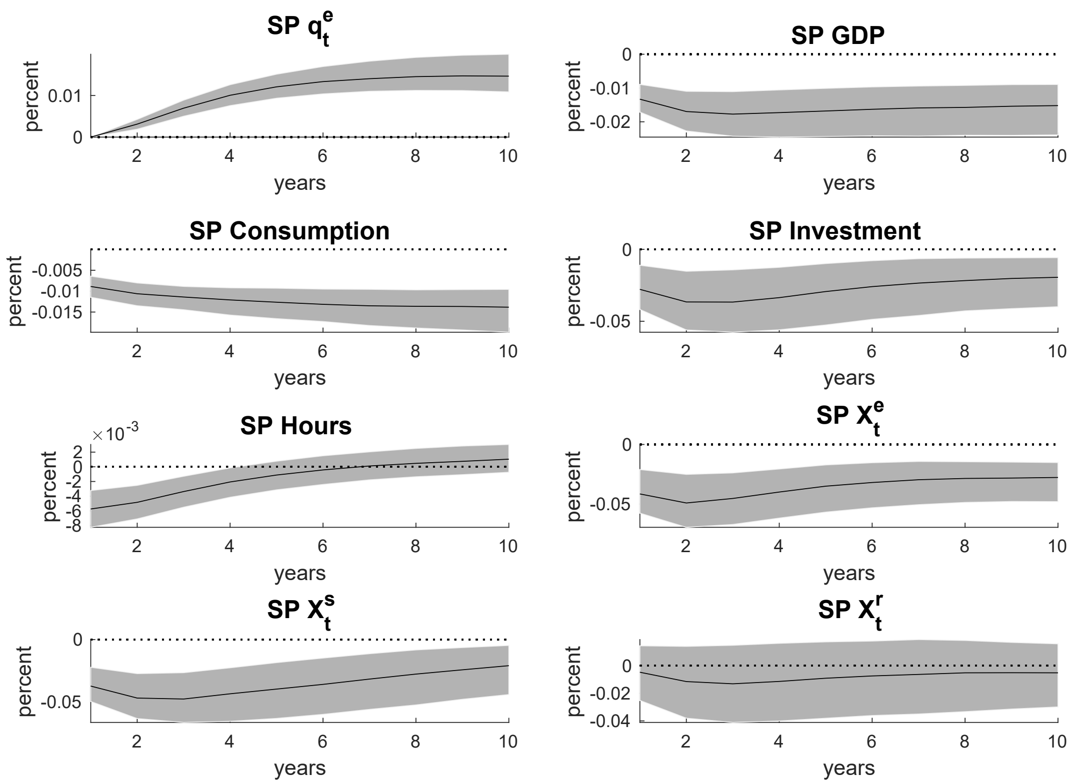
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.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

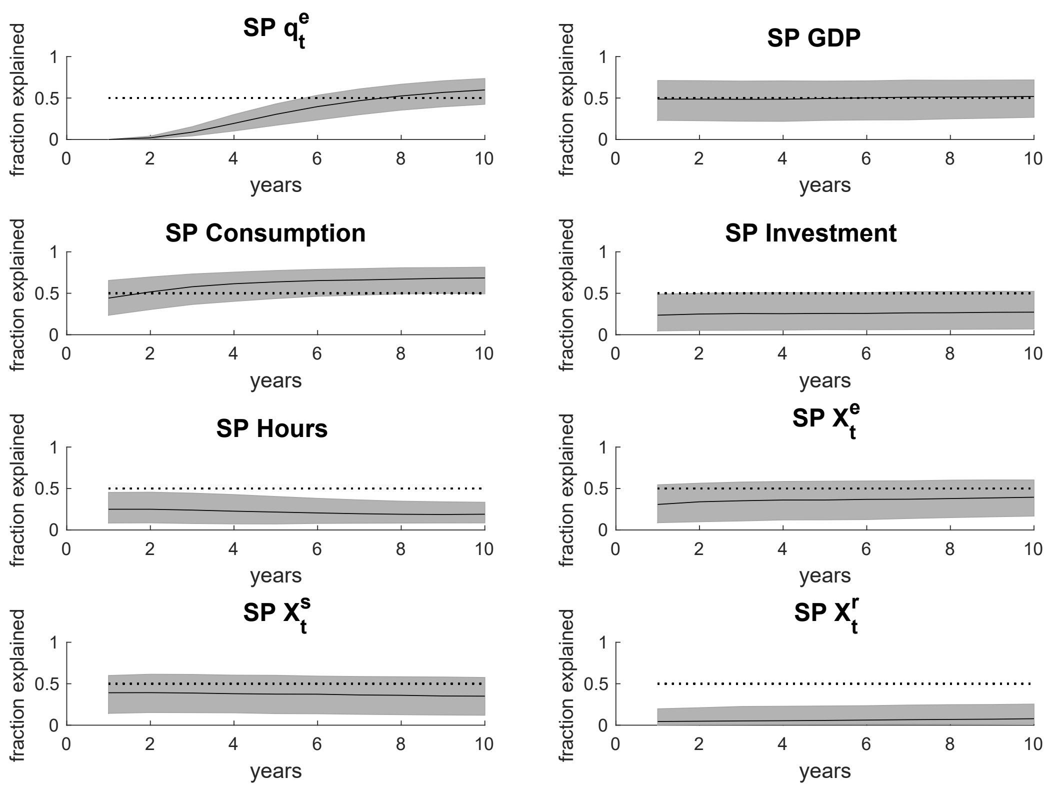
E.7 Spain - q_{et} news shock - benchmark VAR

Figure E.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 E.14: SPAIN - Forecast Error Variance (FEV) - q_{et} news shock; benchmark VAR



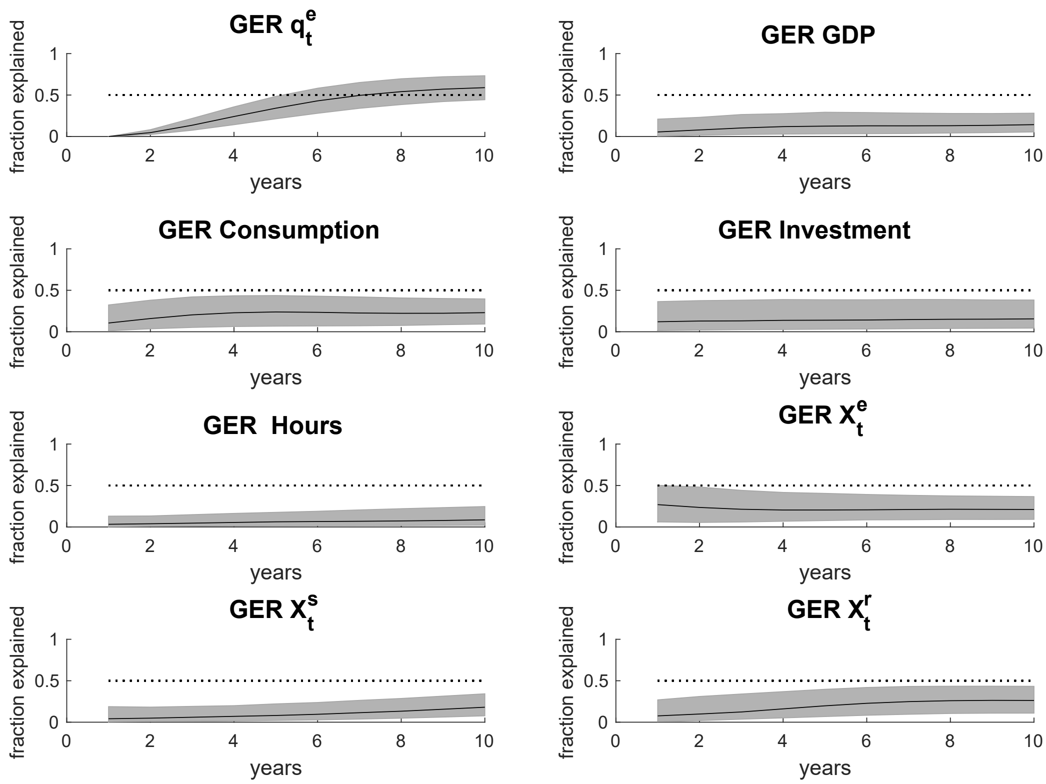
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.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

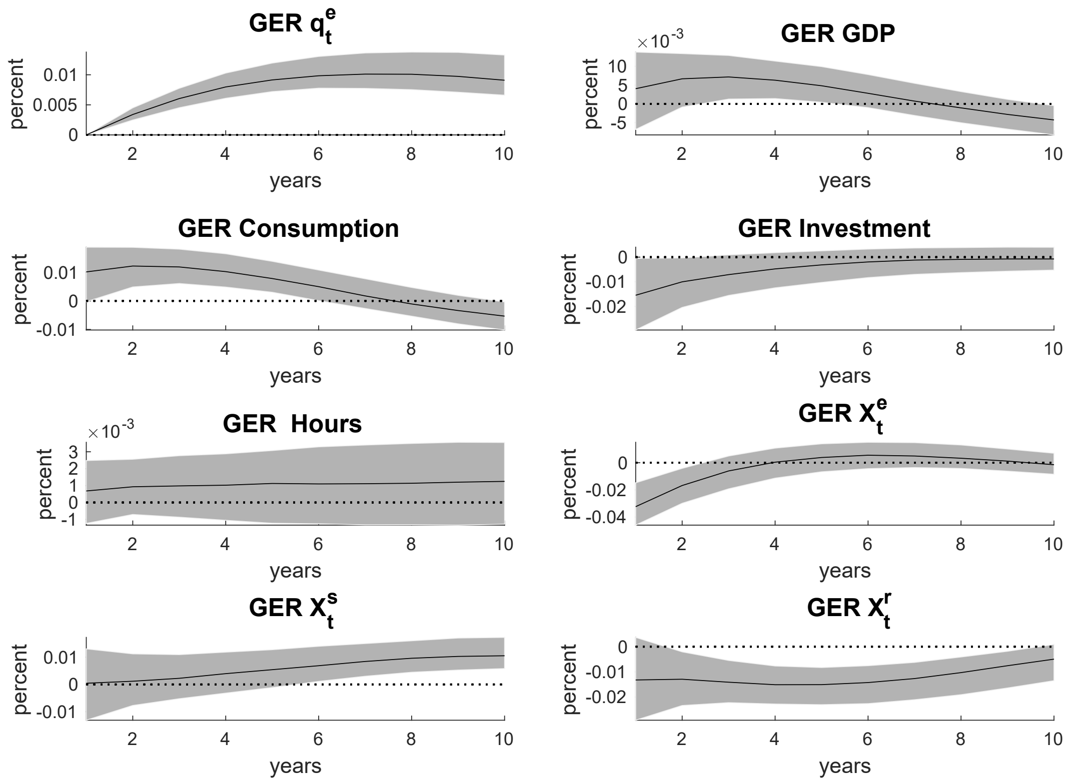
E.8 Germany - q_{et} news shock - benchmark VAR

Figure E.15: GERMANY - Impulse responses to a 1% innov. in 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 E.16: GERMANY - Forecast Error Variance (FEV) - q_{et} news shock; benchmark VAR



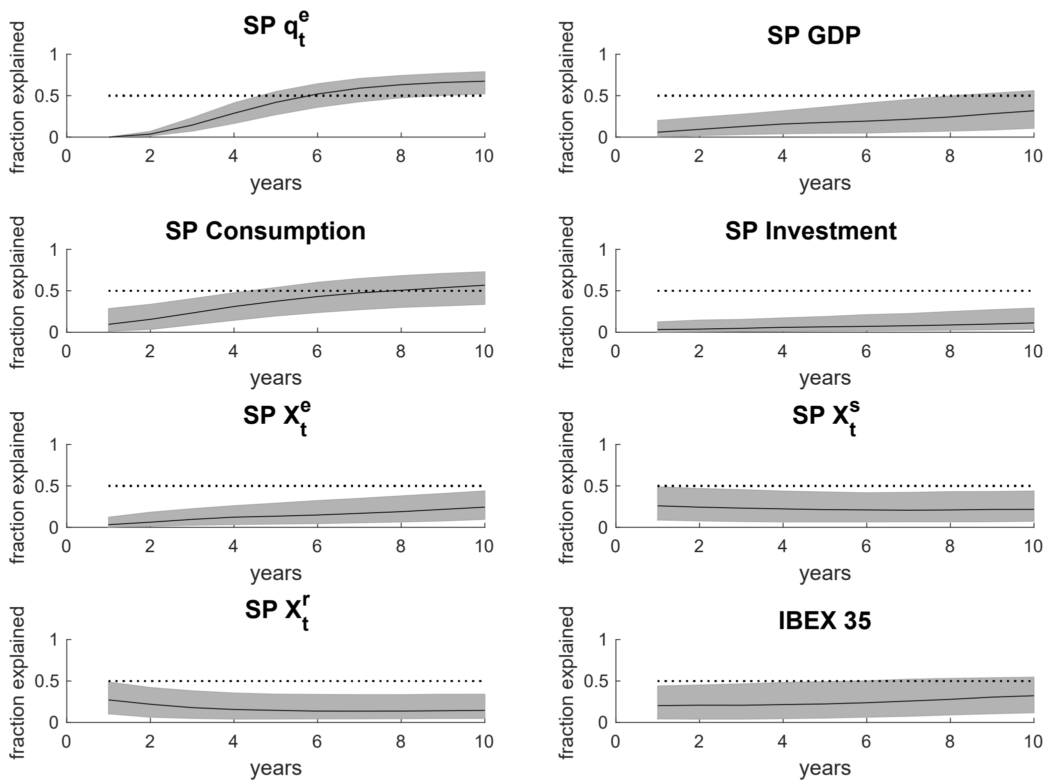
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.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

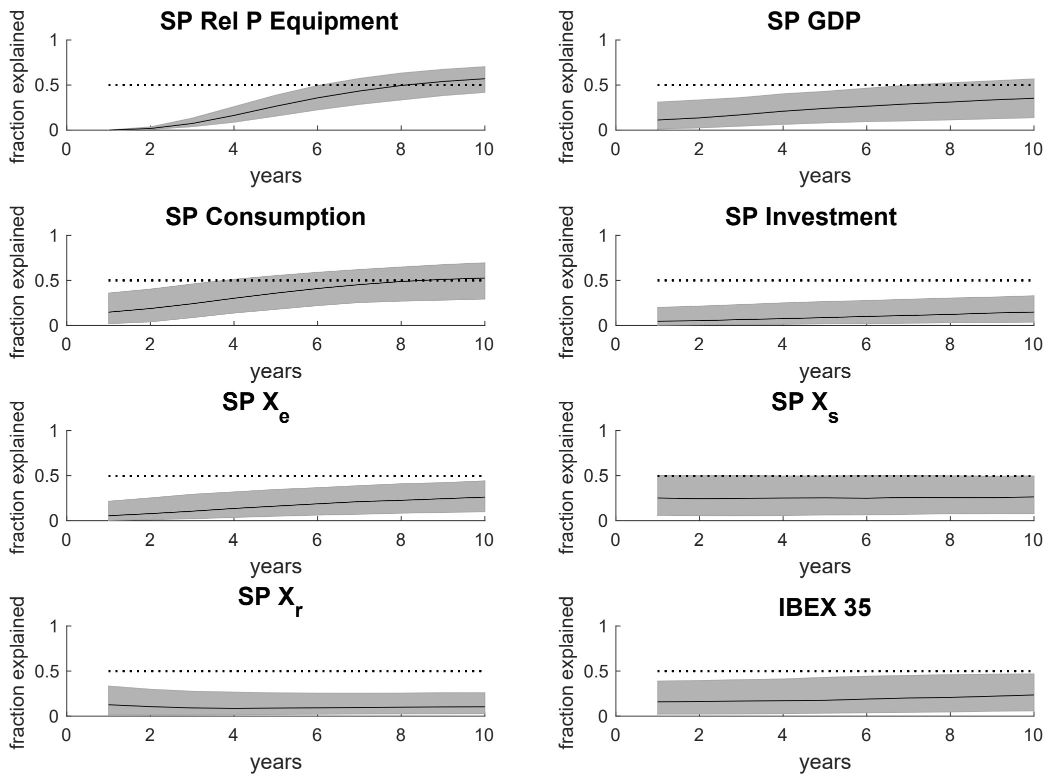
E.9 Spain - q_{et} news shock - alternative VAR

Figure E.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 E.18: SPAIN - Forecast Error Variance (FEV) - q_{et} news shock - alternative VAR



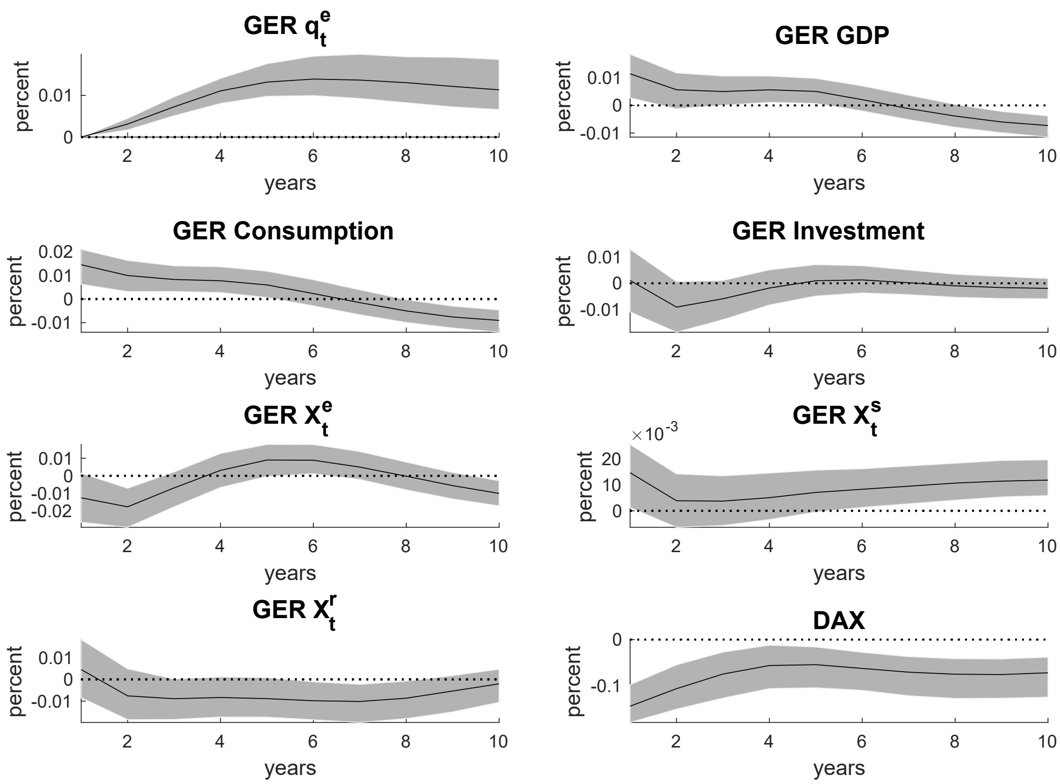
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.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

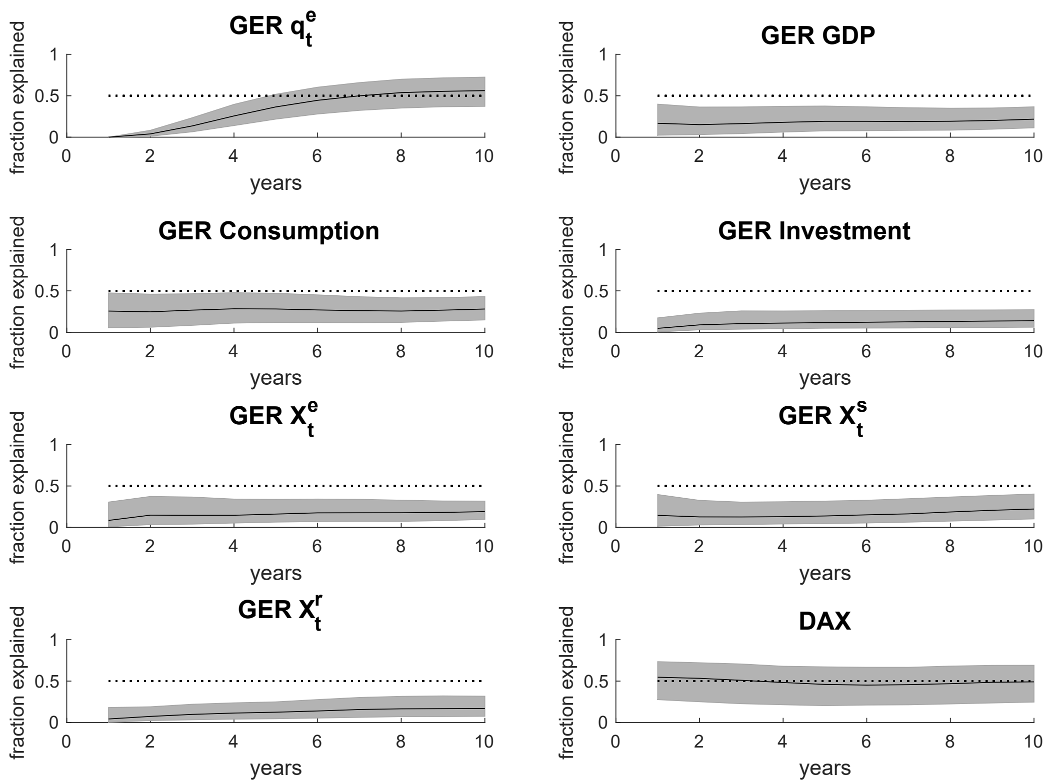
E.10 Germany - q_{et} news shock - alternative VAR

Figure E.19: GERMANY - Impulse responses to a 1% innov. in 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 E.20: GERMANY - Forecast Error Variance (FEV) - q_{et} news shock; alternative VAR



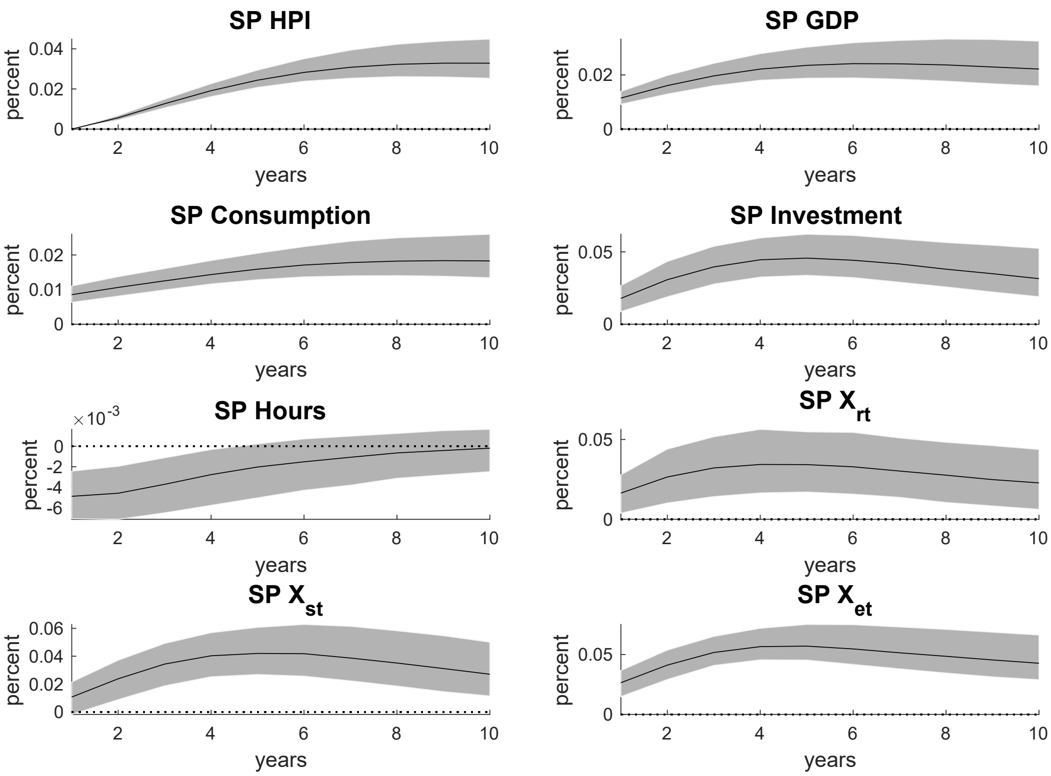
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.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

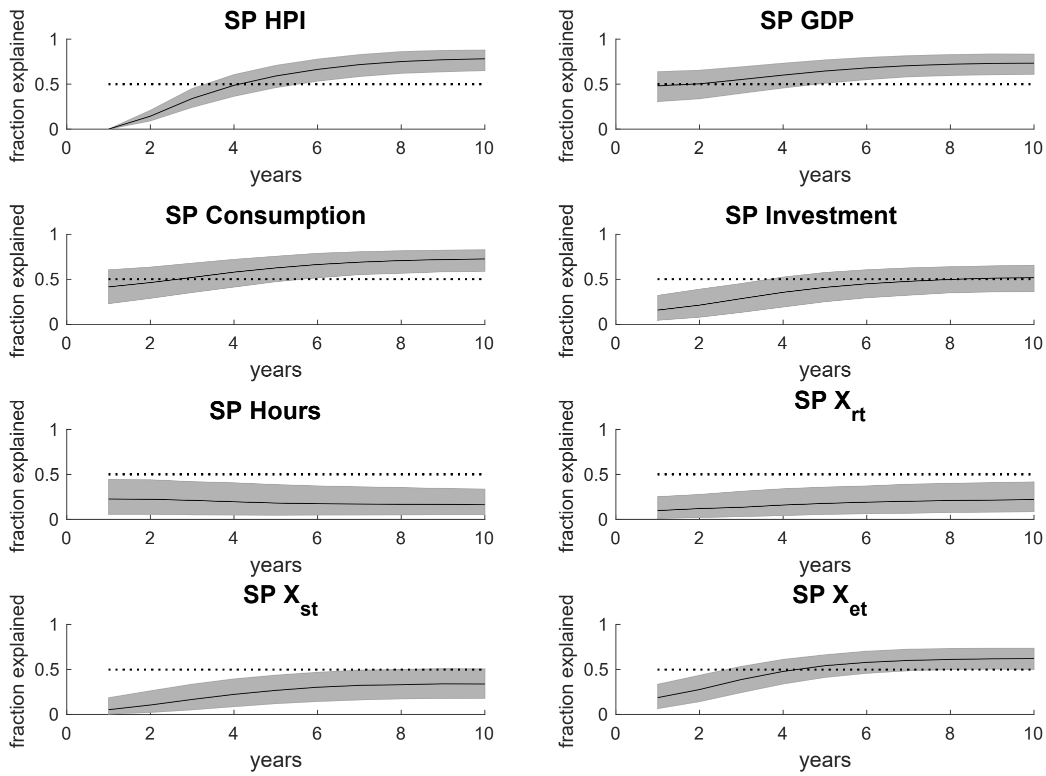
E.11 Spain - HPI news shock - benchmark VAR with housing price news shock

Figure E.21: SPAIN - Impulse responses to a 1% innov. in the HPI 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 E.22: SPAIN - Forecast Error Variance (FEV) - HPI news shock - benchmark VAR



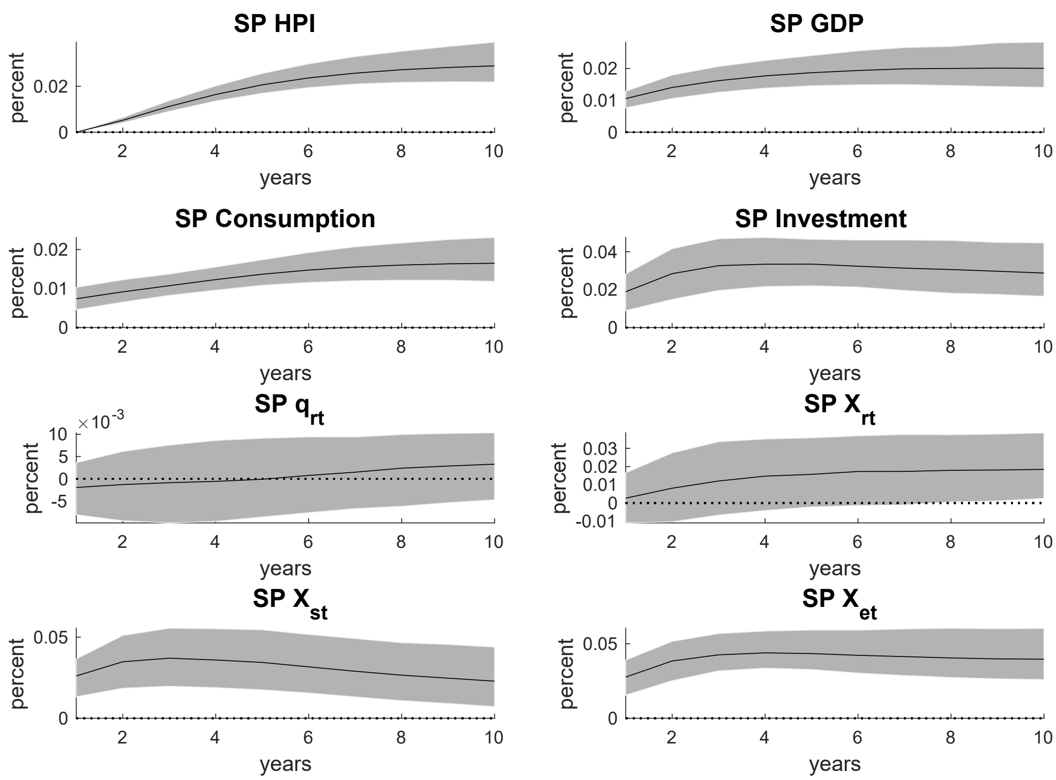
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.11: SPAIN - Maximum Forecast Error Variance (FEV) - HPI news shock; benchmark VAR

Spain	HPI	GDP	Consumption	Investment	X_e	X_s	X_r	IBEX 35
Median contribution	0.73	0.73	0.66	0.57	0.18	0.33	0.40	0.57
Year	10	10	10	9	1	10	9	10

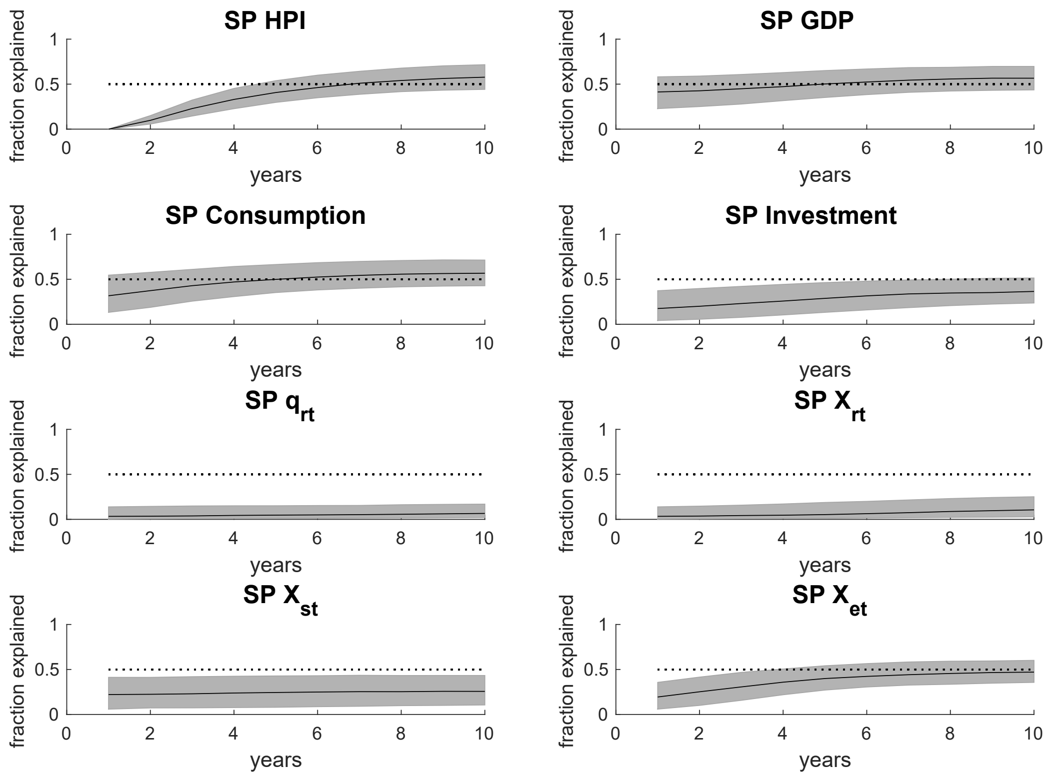
E.12 Spain - HPI news shock - alternative with HPI news shock and RPI in VAR

Figure E.23: SPAIN - Impulse responses to a 1% innov. in the HPI 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 E.24: SPAIN - Forecast Error Variance (FEV) - HPI news shock - alternative VAR



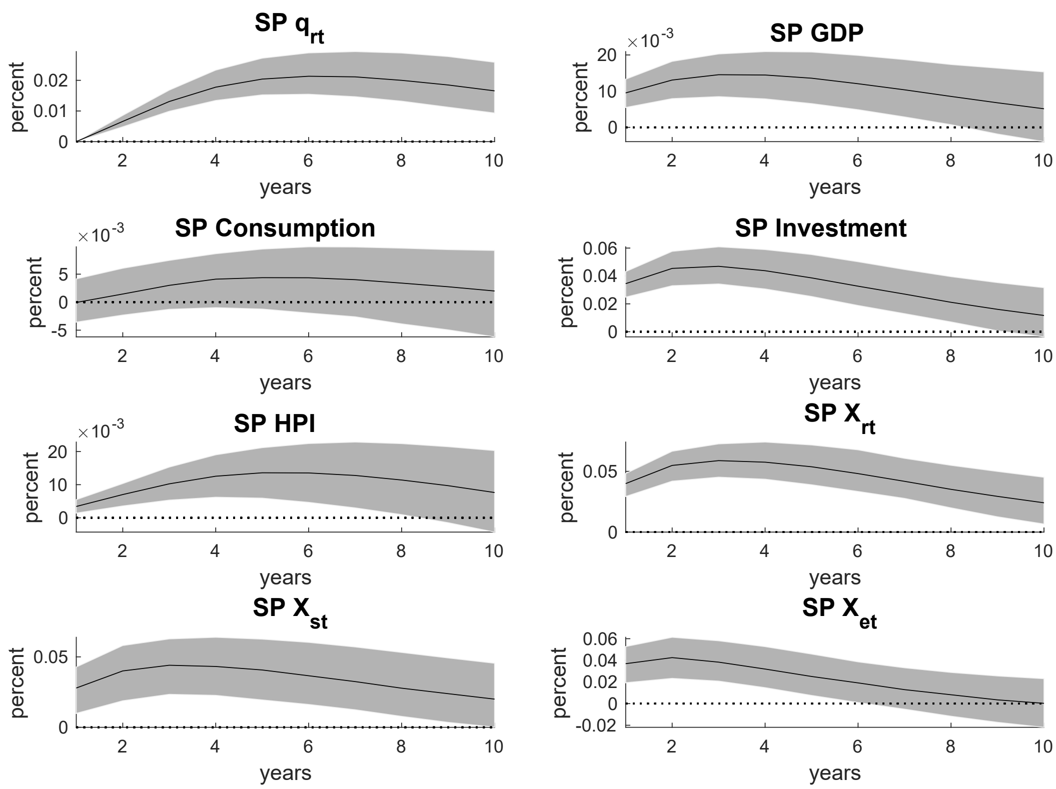
Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.12: SPAIN - Maximum Forecast Error Variance (FEV) - HPI news shock; alternative VAR

	HPI	GDP	Consumption	Investment	q_{rt}	X_r	X_s	X_e
Median contribution	0.55	0.58	0.54	0.40	0.07	0.14	0.28	0.46
Year	10	10	10	10	10	10	10	10

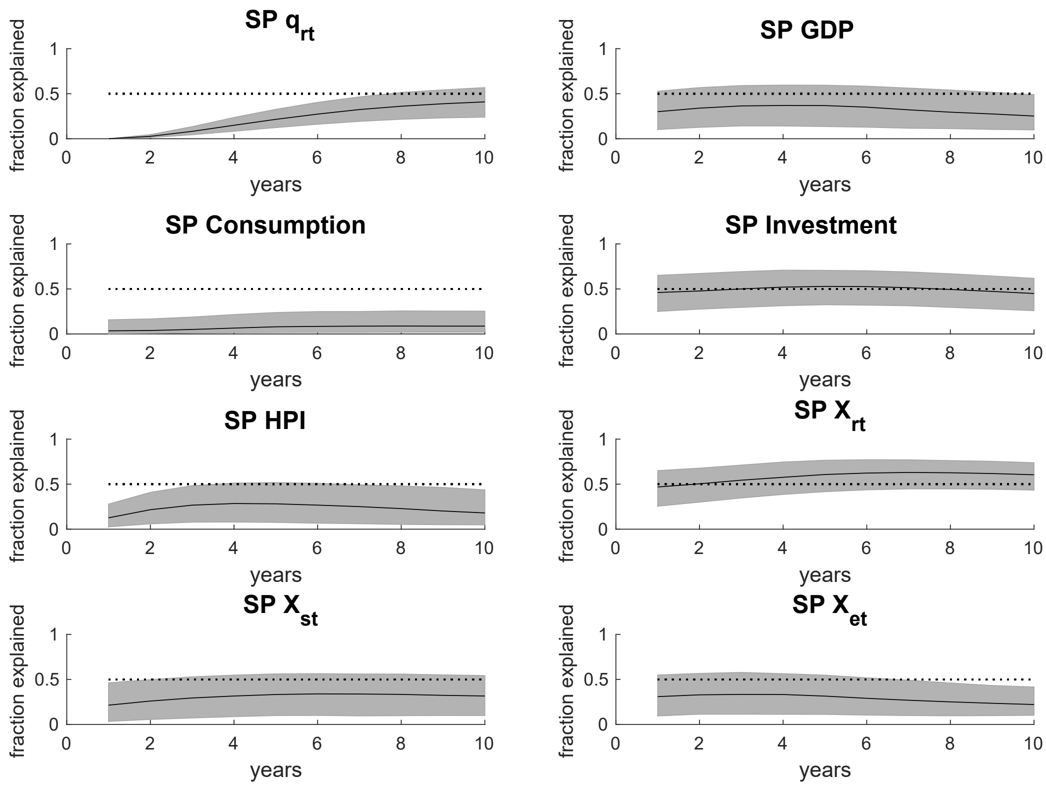
E.13 Spain - HPI news shock - benchmark with RPI and alternative HPI in VAR

Figure E.25: SPAIN - Impulse responses to a 1% innov. in the RPI 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 E.26: SPAIN - Forecast Error Variance (FEV) - RPI news shock - alternative VAR

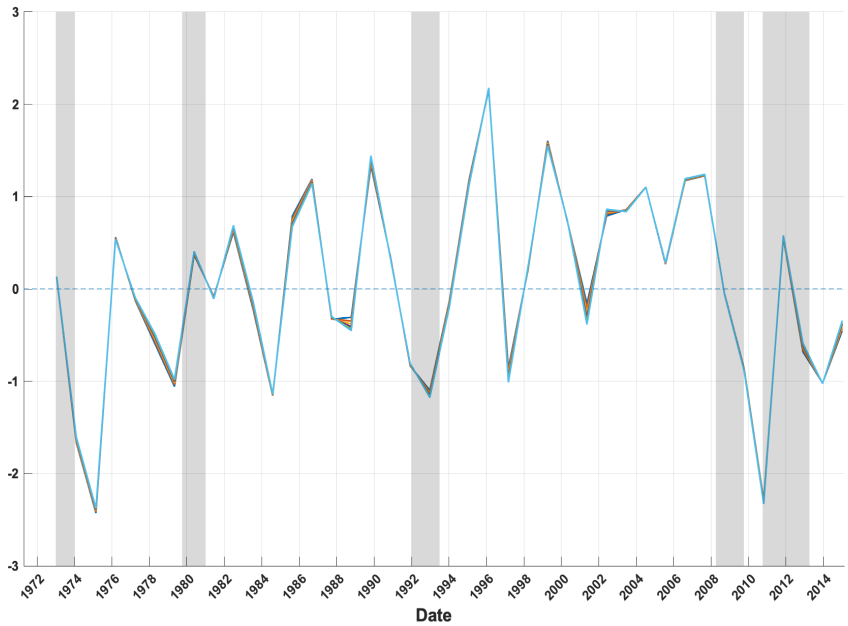


Notes: Median responses to a news shock on relative prices of residential investment (solid line). The shaded gray areas are the 16% and 84% posterior bands generated from the posterior distribution of VAR parameters. The units of the vertical axes are percentage.

Table E.13: SPAIN - Maximum Forecast Error Variance (FEV) - RPI news shock; alternative VAR

	q_{rt}	GDP	Consumption	Investment	HPI	X_r	X_s	X_e
Median contribution	0.41	0.37	0.09	0.53	0.28	0.63	0.34	0.33
Year	10	4	8	5	4	7	6	3

Figure E.27: Spain – The identified news shocks on residential RPI from 10 to 15 periods (years) truncation horizon.



Note: The shaded areas correspond with recession dates for Spain.

Table E.14: Two sample Kolmogorov-Smirnov test for residential RPI news shock from 10 to 15 truncation periods.

Truncation period	11	12	13	14	15
Statistic K-S Test	0.068	0.068	0.068	0.091	0.091
p-value	0.999	0.999	0.999	0.990	0.990

Appendix for Online Use

F Theoretical Model

F.1 q_{rt}, News Shock

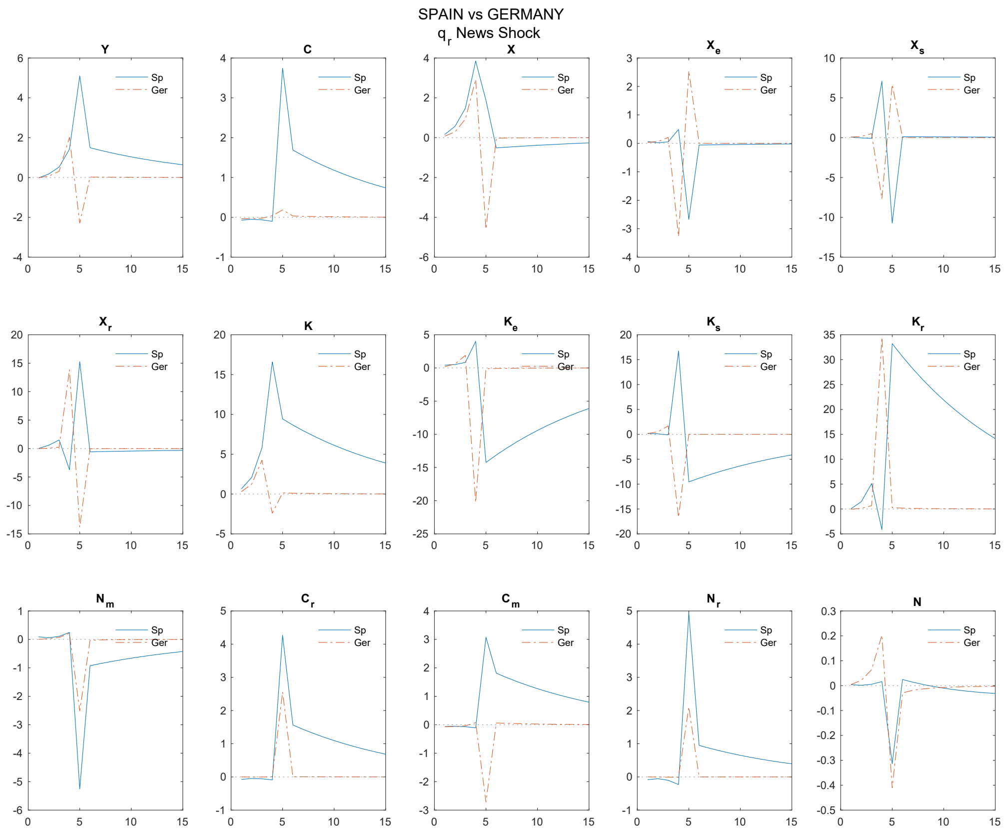


Figure F.1: q_{rt} news shock effects on all model's variables

Figure F.1 shows the overall IRFs of model's variables following a news shock on the relative prices of residential investment increases of 1%.

F.2 q_{st}, News Shock - all var

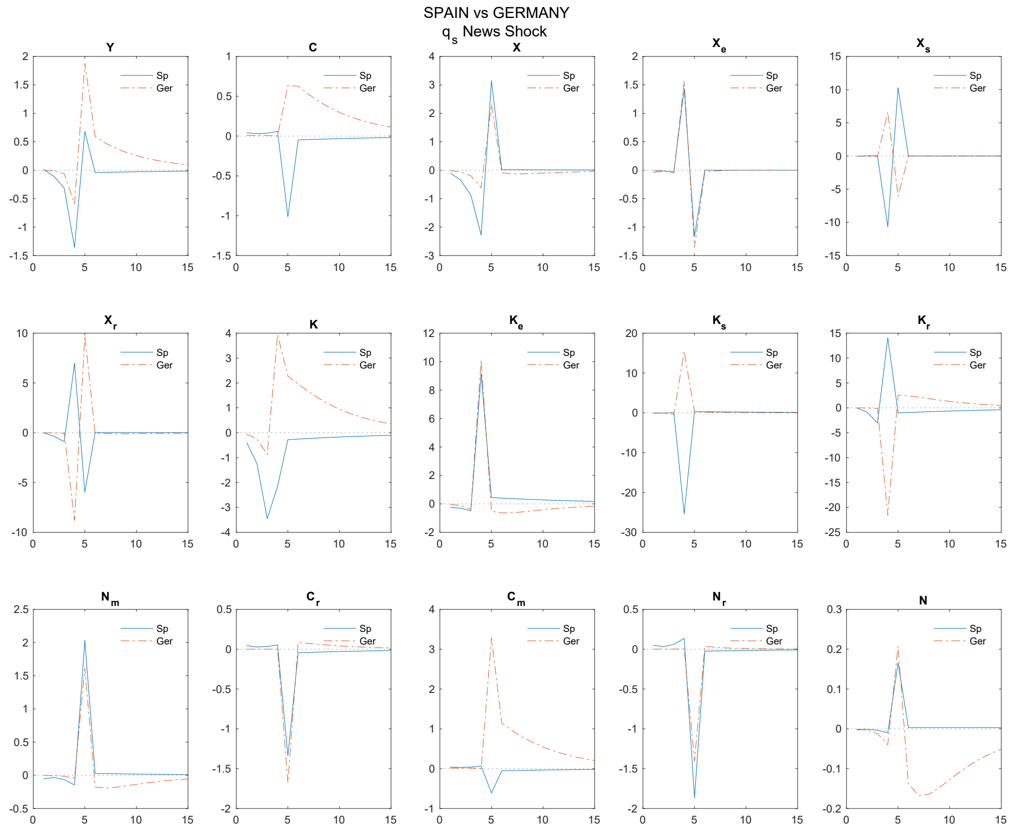


Figure F.2: q_{st} news shock effects on all model's variables

Figure F.2 shows the overall IRFs of model's variables following a news shock on the relative prices of business structures increases of 1%.

F.3 q_{et}, News Shock - all var

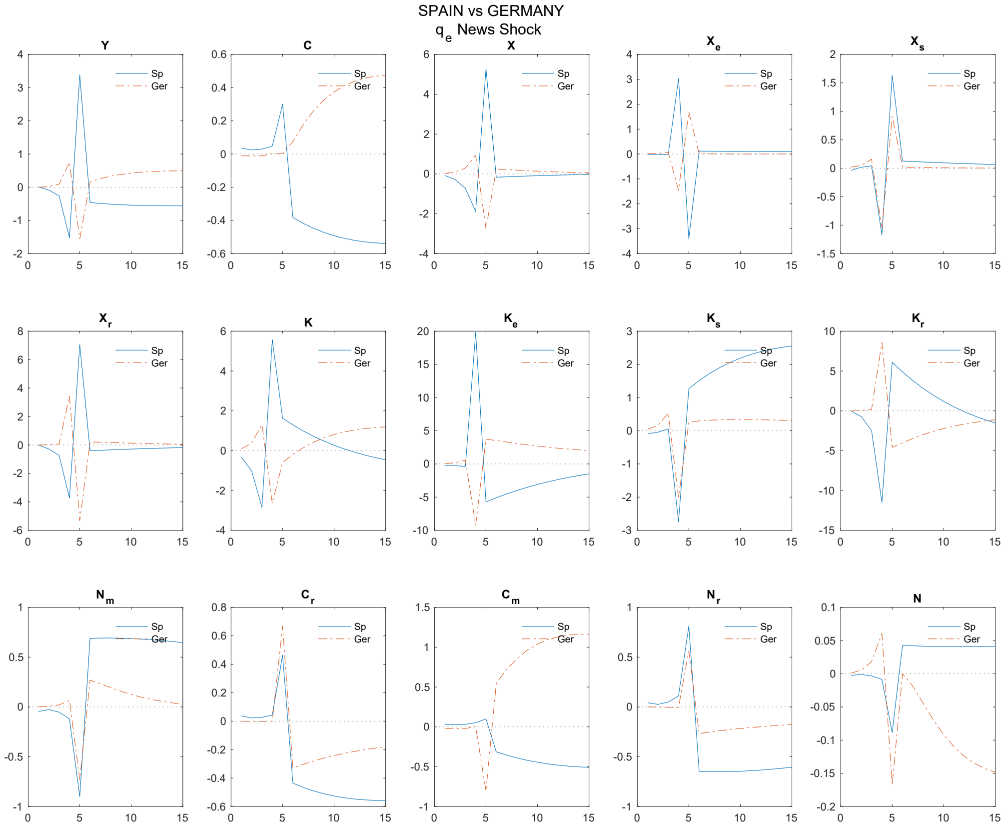


Figure F.3: q_{et} news shock effects on all model's variables

Figure F.3 shows the overall IRFs of model's variables following a news shock on the relative prices of equipment investment decreases of 1%.

F.4 A_t news shock

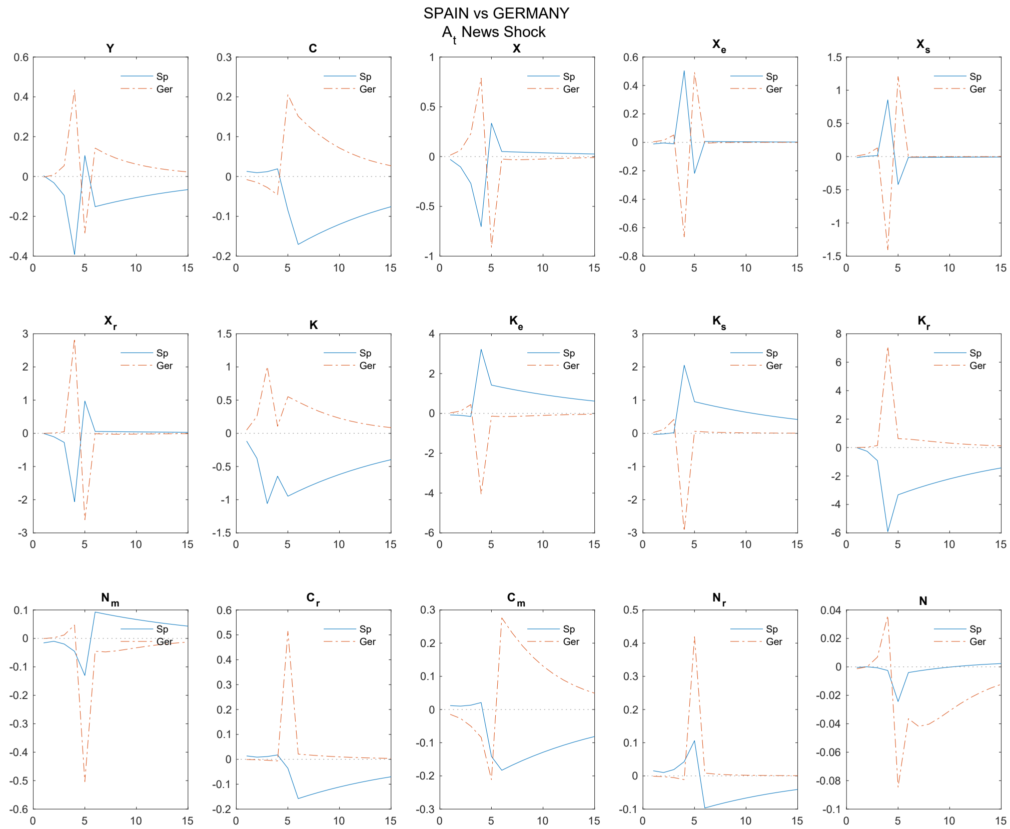


Figure F.4: A_t News Shock

Fig. F.4 shows the IRFs model variables following a news shock on the home production neutral progress of a magnitude of 1%

F.5 TFP vs residential RPI news shock – Spain and Germany

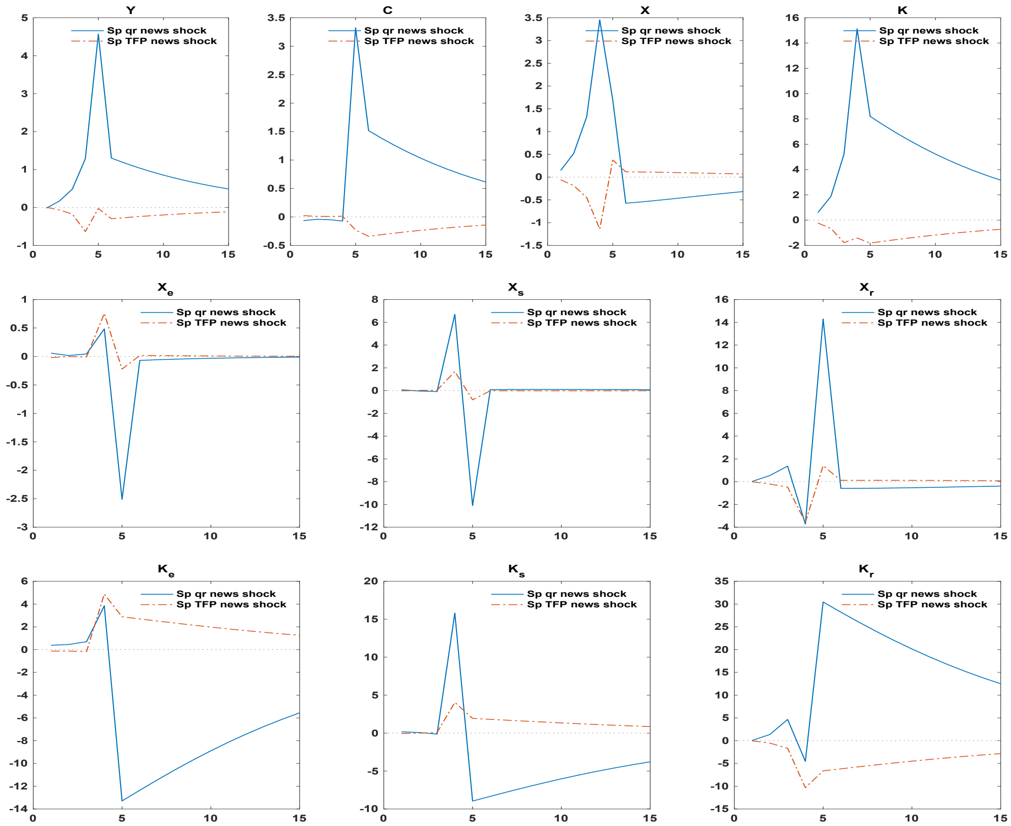


Figure F.5: TFP vs residential RPI News Shock – Spain

Fig. F.5 shows the IRFs of model variables following a news shock either on TFP or the residential RPI of a magnitude of 1%.

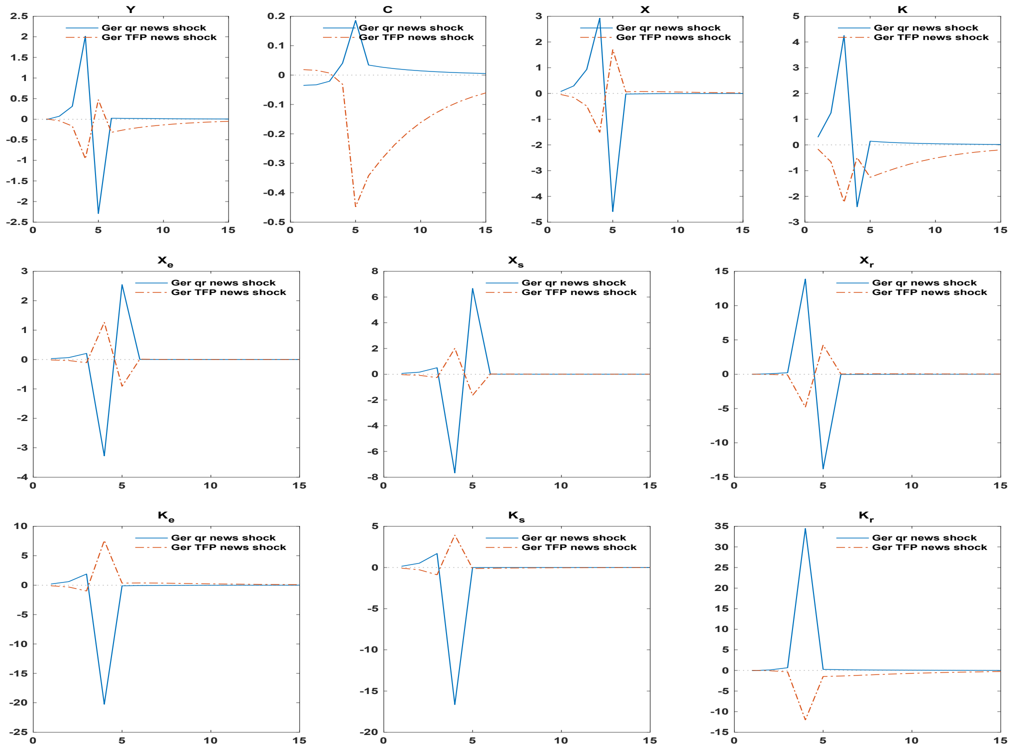
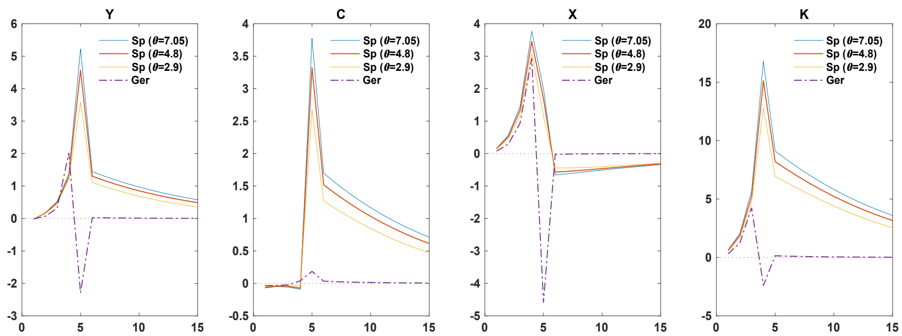


Figure F.6: TFP vs residential RPI News Shock – Germany

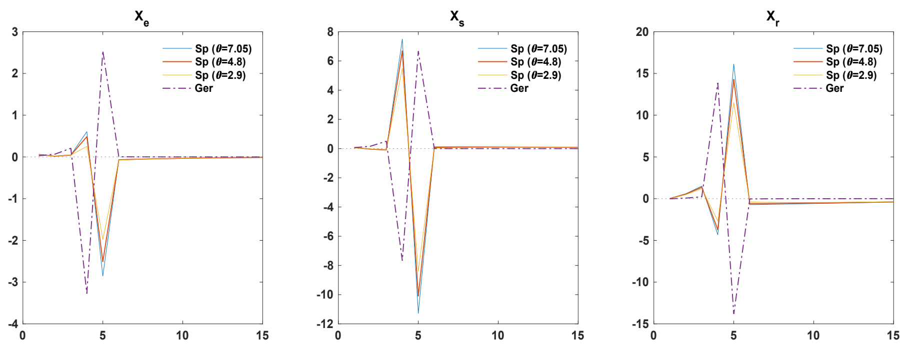
Fig. F.6 shows the IRFs of model variables following a news shock either on TFP or the residential RPI of a magnitude of 1%.

F.6 q_{rt}, News Shock - Response for different θ's (Intertemporal labor supply elast.).

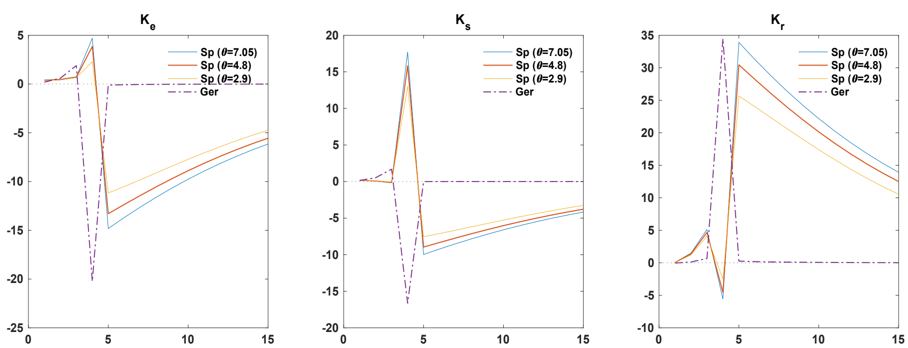
Figure F.7: **Model responses for different θ's Spain vs Germany**



(a) Main aggregates



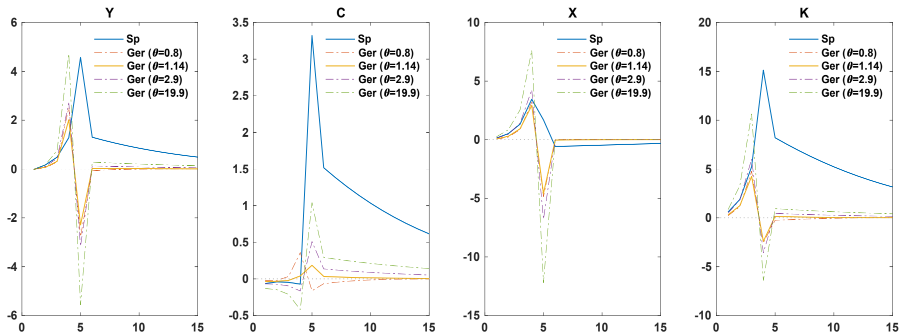
(b) Investment types



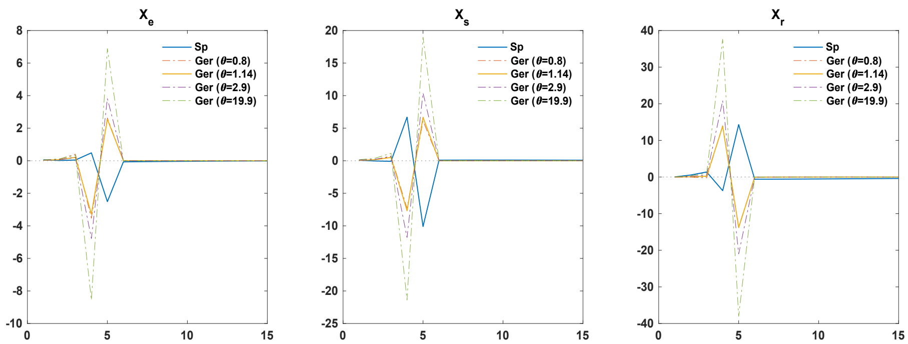
(c) Physical Capital types

Figure F.7 shows the IRFs of model variables following a residential RPI news shock of a magnitude of 1%, for different values of θ in Spain vs Germany.

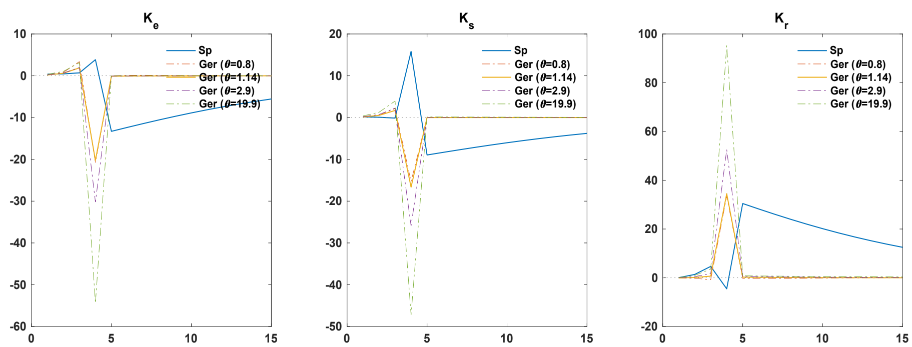
Figure F.8: **Model responses for different θ's Germany vs Spain**



(a) Main aggregates



(b) Investment types



(c) Physical Capital types

Figure F.8 shows the IRFs of model variables following a residential RPI news shock of a magnitude of 1%, for different values of θ in Germany vs Spain.

Appendix for Online Use

G 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:

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

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:

$$C_t = (\omega C_{mt}^{\eta} + (1-\omega) C_{rt}^{\eta})^{1/\eta} \tag{G.2}$$

where C_{mt} is market consumption. Finally, home production is given by:

$$C_{rt} = A_{rt} K_{rt}^{1-\theta_h} N_{rt}^{\theta_r} \tag{G.3}$$

Consequently, the utility function is:

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

and the household budget constraint is

$$\begin{aligned} &C_{mt} + q_{et} K_{et+1} + q_{st} K_{st+1} + q_{rt} K_{rt+1} \\ &\qquad = W_t N_{mt} + r_{et} K_{et} + r_{st} K_{st} + q_{et}(1-\delta_e) K_{et} + q_{st}(1-\delta_s) K_{st} + q_{rt}(1-\delta_r) K_{rt} \end{aligned} \tag{G.5}$$

The Planner solves:

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

s.t.:

$$\begin{aligned} &C_{mt} + q_{et} K_{et+1} + q_{st} K_{st+1} + q_{rt} K_{rt+1} \\ &\qquad = W_t N_{mt} + r_{et} K_{et} + r_{st} K_{st} + q_{et}(1-\delta_e) K_{et} + q_{st}(1-\delta_s) K_{st} + q_{rt}(1-\delta_h) K_{rt} \end{aligned}$$

$$\chi_t = C_t^{\gamma} \chi_{t-1}^{1-\gamma},$$

$$C_t = \left(\omega C_{mt}^{\eta} + (1-\omega) C_{rt}^{\eta}\right)^{1/\eta},$$
$$C_{rt} = A_t K_{rt}^{1-\theta_r} N_{rt}^{\theta_r},$$
$$Y_t = Z_t K_{et}^{\alpha_e} K_{st}^{\alpha_s} N_{mt}^{1-\alpha_e-\alpha_s},$$
$$Y_t = C_t + q_{et} X_{et} + q_{st} X_{st} + q_{rt} X_{rt},$$
$$X_t = X_{et} + X_{st} + X_{rt},$$
$$K_{et+1} = \Theta_{et} X_{et} + (1-\delta_e) K_{et},$$
$$K_{st+1} = \Theta_{st} X_{st} + (1-\delta_s) K_{st},$$
$$K_{rt+1} = \Theta_{rt} X_{rt} + (1-\delta_r) K_{rt},$$
$$q_{et} = 1/\Theta_{et}$$
$$q_{st} = 1/\Theta_{st}$$
$$q_{ht} = 1/\Theta_{ht}$$
$$\log Z_t = (1-\rho_Z) \log barZ + \rho_Z \log Z_{t-1} + \varepsilon_t^Z,$$
$$\log A_t = (1-\rho_A) \log barA + \rho_A \log A_{t-1} + \varepsilon_t^A,$$
$$\log q_{et} = (1-\rho_{q_e}) \log barq_e + \rho_{q_e} \log q_{et-1} + \varepsilon_t^{q_e},$$
$$\log q_{st} = (1-\rho_{q_s}) \log \bar{q_s} + \rho_{q_s} \log q_{st-1} + \varepsilon_t^{q_s},$$
$$\log q_{rt} = (1-\rho_{q_r}) \log \bar{q_r} + \rho_{q_r} \log q_{rt-1} + \varepsilon_t^{q_r} + \varepsilon_{t-1}^{news},$$

G.1 The Household's Maximization Problem

$$\max_{C_t, N_t, K_{rt+1}, K_{et+1}, K_{st+1}, \chi_t} \mathcal{L} : \sum_{t=0}^{\infty} \beta^t \Bigg\{ \Bigg[\frac{\left((\omega C_{mt}^{\eta} + (1-\omega) C_{ht}^{\eta})^{1/\eta} - \psi (N_{mt} + N_{rt})^{\theta_n} X_t \right)^{1-\sigma} - 1}{1-\sigma} \Bigg]$$
$$- \lambda_t \Big(C_{mt} + q_{et} K_{et+1} + q_{st} K_{st+1} + q_{rt} K_{rt+1}$$
$$- w_t N_{mt} - (r_{et} + q_{et}(1-\delta_e)) K_{et} - (r_{st} + q_{st}(1-\delta_s)) K_{st} - q_{rt}(1-\delta_r) K_{rt} \Big)$$
$$- \mu_t \Big(\chi_t - (\omega C_{mt}^{\eta} + (1-\omega) C_{rt}^{\eta})^{\frac{\gamma}{\eta}} \chi_{t-1}^{1-\gamma} \Big) - \xi_t \Big(C_{rt} - A_t K_{rt}^{1-\theta_r} N_{rt}^{\theta_r} \Big) \Bigg\} \tag{G.7}$$

FOCs

$$\frac{\partial \mathcal{L}}{\partial C_{mt}} : \left((\omega C_{mt}^{\eta} + (1-\omega) C_{rt}^{\eta})^{1/\eta} - \psi (N_{mt} + N_{rt})^{\theta_n} \chi_t \right)^{-\sigma} \omega C_{mt}^{\eta-1} (\omega C_{mt}^{\eta} + (1-\omega) C_{rt}^{\eta})^{1/\eta - 1}$$
$$+ \mu_t \Big(\gamma \omega C_{mt}^{\eta-1} (\omega C_{mt}^{\eta} + (1-\omega) C_{rt}^{\eta})^{\gamma/\eta - 1} \chi_{t-1}^{1-\gamma} \Big) = \lambda_t \tag{G.8}$$

$$\frac{\partial \mathcal{L}}{\partial C_{rt}} : \left((\omega C_{mt}^{\eta} + (1-\omega) C_{rt}^{\eta})^{1/\eta} - \psi (N_{mt} + N_{rt})^{\theta_n} \chi_t \right)^{-\sigma} (1-\omega) C_{rt}^{\eta-1} (\omega C_{mt}^{\eta} + (1-\omega) C_{rt}^{\eta})^{1/\eta - 1}$$
$$+ \mu_t \Big(\gamma (1-\omega) C_{rt}^{\eta-1} (\omega C_{mt}^{\eta} + (1-\omega) C_{rt}^{\eta})^{\gamma/\eta - 1} \chi_{t-1}^{1-\gamma} \Big) = \xi_t \tag{G.9}$$

$$\frac{\partial \mathcal{L}}{\partial N_{mt}} : \left((\omega C_{mt}^{\eta} + (1-\omega) C_{rt}^{\eta})^{1/\eta} - \psi (N_{mt} + N_{rt})^{\theta_n} \chi_t \right)^{-\sigma} \psi \theta_n (N_{mt} + N_{rt})^{\theta_n - 1} \chi_t = \lambda_t w_t \tag{G.10}$$

$$\frac{\partial \mathcal{L}}{\partial N_{rt}} : \left((\omega C_{mt}^{\eta} + (1-\omega) C_{rt}^{\eta})^{1/\eta} - \psi (N_{mt} + N_{rt})^{\theta_n} \chi_t \right)^{-\sigma} \psi \theta_n (N_{mt} + N_{rt})^{\theta_n - 1} \chi_t$$
$$= \xi_t (\theta_r A_t K_{rt}^{1-\theta_r} N_{rt}^{\theta_r - 1}) \quad \text{(G.11)}$$

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

$$\frac{\partial \mathcal{L}}{\partial \lambda_t} : C_{mt} + q_{et} K_{et+1} + q_{st} K_{st+1} + q_{rt} K_{rt+1}$$
$$= w_t N_{mt} + r_{et} K_{et} + r_{st} K_{st} + q_{et}(1-\delta_e) K_{et} + q_{st}(1-\delta_s) K_{st} + q_{rt}(1-\delta_r) K_{rt} \quad \text{(G.13)}$$

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

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

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

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

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

$$\log Z_t = (1-\rho_Z) \log \bar{Z} + \rho_Z \log Z_{t-1} + \varepsilon_t^Z \quad \text{(G.19)}$$
$$\log A_t = (1-\rho_A) \log \bar{A} + \rho_A \log A_{t-1} + \varepsilon_t^A \quad \text{(G.20)}$$
$$\log q_{et} = \rho_{q_e} \log q_{et-1} + \varepsilon_t^{q_e} \quad \text{(G.21)}$$
$$\log q_{st} = \rho_{q_s} \log q_{st-1} + \varepsilon_t^{q_s} \quad \text{(G.22)}$$
$$\log q_{rt} = \rho_{q_r} \log q_{rt-1} + \varepsilon_t^{q_r} + \varepsilon_{t-4}^{news} \quad \text{(G.23)}$$

G.2 The Firms problem:

Firm producing final good

$$\max_{K_{et},K_{st},N_t} \Pi_t = Z_t K_{et}^{\alpha_e} K_{st}^{\alpha_s} N_t^{1-\alpha_e-\alpha_s} - r_{et}K_{et} - r_{st}K_{st} - w_t N_{mt}. \tag{G.24}$$

FOCs

$$\frac{\partial \Pi_t}{\partial K_{et}} : \alpha_e Z_t K_{et}^{\alpha_e-1} K_{st}^{\alpha_s} N_{mt}^{1-\alpha_e-\alpha_s} = r_{et} \tag{G.25}$$

$$\frac{\partial \Pi_t}{\partial K_{st}} : \alpha_s Z_t K_{et}^{\alpha_e} K_{st}^{\alpha_s-1} N_{mt}^{1-\alpha_e-\alpha_s} = r_{st} \tag{G.26}$$

$$\frac{\partial \Pi_t}{\partial N_t} : (1-\alpha_e-\alpha_s) Z_t K_{et}^{\alpha_e-1} K_{st}^{\alpha_s} N_{mt}^{-\alpha_e-\alpha_s} = w_t \tag{G.27}$$