The effect of monetary policy shocks on the housing prices of Spain: a VAR model

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Abstract

This paper aims to study the effects of monetary policy shocks on housing prices in Spain. A Vector Autoregressive model is constructed using the variables short-term interest rates, a proxy for the monetary policy shocks, and the house price index. According to the Granger causality test and the impulse response functions obtained, short-term interest rates affect the house price index but not the other way round. The empirical outcomes of the time series data analyzed show how a shock in the short-term interest rate decreases the house price index and stays low in the long run.

Key words: monetary policy, shock, housing prices, short-term interest rate

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1. Introduction

The impacts of monetary policy on prices and output continue to captivate the concern of policymakers and economists alike. There is a strong case to be made for monetary policy playing a role in regulating housing booms in the interest of financial stability (Williams, 2007). Short-term interest rates are considered to be a relevant variable that affects housing prices (Ayuso et al., 2006). What drives the motivation of this study to appoint short-term interest rates is its influence in monetary policy. Bernanke and Blinder (1992) explain that house prices are strongly influenced by credit availability, which is also greatly influenced by the transmission of monetary policy. When supplementary items become more expensive, demand for the majority of commodities decreases. As a result, one would anticipate that as mortgage finance costs rise, the market price of home will decline due to less demand (Harris, 1989).

Despite the fact that it has been more than a decade since the global financial crisis began, market valuations of eurozone banks have not made a full recovery and continue to linger behind those of US banks. This appears to be in direct contrast to the massive efforts undertaken by central banks and governments to help restore transmission following the financial crisis' start (Jung and Uhlig, 2019). The European Central Bank (ECB) has the principal responsibility for monetary policy in the euro region, with the principal aim of maintaining price stability and, although not explicitly stated as an ultimate goal, non-inflationary economic growth (Giuliodori, 2005a).

Regarding the Spanish territory, before the 2008 house bubble burst, the country experienced some years of expansion in the early 2000s which was mostly financed by foreign debt. Deep structural issues were highlighted by the financial crisis of 2008, which also affected Spain's financially independent provinces. Furthermore, the unsolvable monetary issues the eurozone were experiencing were highlighted by Spain's challenges in managing its autonomous regions (Neal and García-Iglesias, 2013). Royo (2020) explains how the Spanish situation after the crisis was a crucial reminder that, under a monetary union, nations only have authority over their respective fiscal policies and labor prices. Spain turned out to be poor in both. It neglected the need that national policy decisions must be compatible with the foreign limitations placed by euro membership and failed to formulate an effective adjustment strategy to succeed within the single currency.

Moreover, there has been evidence that economic policies are an important tool to strengthen economic resilience (Cavalleri et al. 2019). Housing markets tend to be highly volatile and consequently, this comes with a lot of macroeconomic risks. It is well acknowledged that monetary policy instruments have an impact in the price of goods and services as well as in asset prices (Moya-Martínez et al., 2015). Even while short-term price fluctuations are unavoidable, the central bank can nevertheless affect real interest rates, which should have an impact on both real output and nominal prices (Bjørnland and Jacobsen, 2013a). Empirical findings repeatedly show that restrictive monetary policy tends to impede future home price increase while expansionary monetary policy tends to promote it (Christiano et al., 1999).

This paper addresses the question of how monetary policy shocks affect the housing market in Spain and the resilience of this sector. To address this question, short-term interest rates are used to identify the impacts of monetary policy shocks on the real estate prices and how this market responds. This report explores the timeline from 2010 to 2019. That would be the years after the economic collapse of 2008 occured and before the burst of the COVID-19 pandemic. Therefore, contributing to previous studies about the matter that did not have analyzed the years posterior to the financial crisis. In that period, Spain experienced an expansionary period in the real estate market and significant changes were made to the country's monetary transmission system in comparison with the years previous to 2007.

This empirical study uses time series data to estimate a Vector Autoregressive (VAR) model to analyze the shocks of monetary policy on housing prices. In order to properly estimate this model, a number of 8 steps are used to compute the empirical model and investigate the outcomes of the time series. These include checking for stationarity by computing the Dickey-Fuller and the Phillips-Perron tests and taking the first differences if the variables are not stationary. Afterwards, the lag length is selected, choosing the lowest residual correlation using the Akaike's, Hannan and Quinn and Schwarz Bayesian information criterion. Following the stability condition, where the roots have to be less than 1 to be considered stable, and the autocorrelation check using the lagrange multiplier.

Additionally, the Granger causality test is performed, along with the impulse response functions as a tool to interpret and follow the evolution over time of the variables of the VAR model. The last step is the variance decomposition demonstrating how much information is added to the other variables by each variable in the autoregression. Furthermore, this study finds how short-term interest rates affect housing prices, but not the other way round. In fact, an increase in the interest rate decreases the house price index over time. This is due to the fact that higher interest rates cause an increase in the price of owning a house, provoking a decrease in the dwelling prices.

After the years of the financial crash, the housing market was shown to have been affected considerably. It is hard to argue against the fact that the crisis has put monetary theory and practice to the test, and there is still much progress to be made to comprehend the consequences of this threat.

The remainder of the paper is organized as follows. Section 2 presents a literature review on the topic along with a brief discussion of previous investigations found. Section 3 offers a detailed description of the data used in this research and a summary of the statistics of the relevant variables of the analysis. In section 4, the empirical framework is provided by the econometric specification of the variables and parameters of interest defined in 8 different steps. The results of the research are going to be shown on section 5, finalizing with the conclusions obtained in section 6.

2. Literature Review

A wide range of economics and finance studies have looked at the linkages of monetary policy instruments and housing prices. There is a lot of interest among academics and researchers in investigating those relationships (see for instance Taylor, 2017;Bjørnland and Jacobsen, 2013b, Sala, 2003).

Obaid et al. (2020) conducted a VAR model in Saudi Arabia to identify how monetary instruments affected housing prices. They make a comparison between money supply rates and short-term interest rates and conclude how the latter is a much more efficient proxy to identify the effects. In accordance, Sutton et al. (2017) states that short-term rates have the greatest impact on housing prices and that this is progressive rather than instantaneous. Meaning by this that the effects on housing prices occur gradually instead of on impact and that moderate reductions in policy rates are unlikely to quickly spur an increase in home prices. The authors report examining the sensitivity of property prices to changes in short-term and long-term interest rates in advanced and emerging nations. Essays like the just cited are a motivation to use the short-term interest rates to measure monetary policy shocks in this study.

Jacobson et al. (2001) defend how a VAR model is a good approach to analyze shocks of monetary policy and how it can be used in different macroeconomic studies. Bagliano and Favero (1998) also define the VAR model as a mechanism to check monetary policy shocks. As a result, this study has been inspired to use the same empirical model stated by Sims (1980).

There is clear evidence regarding the response of housing prices to monetary policy shocks internationally. Xu and Chen (2012) report that the main factors influencing the change in real estate price increase in China are Chinese monetary policy activities. Moreover, Umar et al. (2019) find that housing costs in Pakistan and the discount rate are inversely related. There are also numerous studies on the matter about the United States. For instance, Ume (2018) explains how monetary policy shocks affected housing, decreasing the dwelling investment, and how that negatively affected the economic situation of the U.S. Another report made about the previous country is by Vargas-Silva (2008). The author's findings show that residential investment and housing costs react negatively to recessionary monetary policy shocks.

Similarly, there is also previous literature about the subject regarding the Eurozone. Giuliodori (2005b) discusses through a VAR model, concerning 9 different European countries, that real home values are negatively impacted in the short term by unforeseen temporary restricting regulations. These being said, there are few empirical studies that narrow the question to only the Spanish territory, showing a lack of empirical research of this country.

Pál (2018) provides a similar examination about the effects of monetary policy on the house prices of Spain through a VAR model using short term interest rates, housing prices and credit aggregates. He devotes particular attention to the property Spanish boom that occured the final years of the 20th and the beginning of the 21st century. The author concludes that the rise of the housing boom, which eventually developed into a bubble, was facilitated by the European Central Bank's considerate monetary policies. The research also addresses how a more responsive adjustment to the ECB's policy rate could have been able to minimize the extent of the Spanish housing bubble given the strong significant connection between interest rates and house prices throughout the Euro era. Although, the author only covers the time period of 1975 to 2008. In this report, I have extended this investigation to more current times, from 2010 to 2019 as there is no evidence of this time period. That would be after the years of the subprime mortgage crisis and right before the outbreak of the COVID-19 pandemic.

By highlighting the influence of monetary policy factors on property prices in Spain, the current research adds to the body of material already cited.

3. Data Analysis

3.1. Variables and data sources

Regarding the data that is going to be used to address this report, two different variables have been defined. To test the effect of monetary policy in housing prices, the dependent variable of the econometric model is the house price index and the independent variable is the short-term interest rate.

The short-term interest rate is used as a proxy to monetary policy shocks. This data has been extracted from the OECD[1]. According to this database, short-term interest rates are defined as the rates at which short-term loans are made between financial institutions. This concept also defines the market prices at which short-term treasury securities are issued or exchanged. Average daily rates expressed as a percentage are typically what short-term interest rates are, and also three-month money market rates serve as the foundation for this variable. The values used go from the first quarter of 2010 and the last quarter of 2019, therefore the time measurement is going to be quarterly.

To address the housing prices, the real house price index data is retrieved from the OECD[2] as well. In the database, housing prices are composed of real and nominal housing prices, along with the ratios of price to income and rent separately. For the econometric model of this examination, the real house price index has been chosen. The latter is constituted by the nominal house price index divided by the consumer expenditure deflator for each nation taken from the OECD national accounts database. It should be noted that seasonal adjustments are made to both indices.

Moreover, both of the aforementioned variables are time series. This data structure is characterized by having one economic agent that is observed at various points in time. Additionally, time is a crucial factor in a time series analysis collection as it can affect future outcomes and because behavioral lags are common in the social sciences. In this kind of data format, the observations are arranged chronologically to present potentially significant information (Wooldridge, 2011a).

The time values chosen go from the first quarter (Q1) of 2010 to the last quarter (Q4) of 2019, therefore the time measurement is going to be quarterly for both variables. Meaning by this that there are 40 observations of each variable in the model. It is true that this number may be too small and more observations and a wider range of data would have been a better approach. This problem could have been solved using monthly data, although the data

[1] OECD (2022), Short-term interest rates (indicator). doi: 10.1787/2cc37d77-en
[2] OECD (2022), Housing prices (indicator). doi: 10.1787/63008438-en

availability has been a limitation to extend this. Regarding the housing price index, there is no monthly data accessible, only annual and quarterly data can be found. However, there is monthly information for the short-term interest rate.

3.2. Summary statistics

A summary of statistics of both variables is computed. *Table 3.1* presents some relevant information about the matter. The latter being the respective values of the maximum, minimum, average and the standard deviation.

Firstly, regarding the variable that refers to the short-term interest rate, the mean of this parameter is 0.1915, the maximum and minimum are -0.4029 and 1.5621. Secondly, with reference to the house price index, which describes the housing prices. Talking about the statistics too, the mean is 111.81, and the maximum and minimum are 95.5918 and 144.4351, respectively. Concerning the standard deviations, it is appreciated how the one from the short-term interest rate is much more clustered around the mean. This referred value is 0.5755. The standard deviation of the house price index, which is 14.3933, indicates that this data variable is much more spread out.

Additionally, time series graphs of both variables have been made to see if there is any trend and to have a better understanding of the observations. *Graph 3.1* corresponds to the short-term interest rates. First of all, there is a decreasing trend that can be appreciated in the graph. Mortgage contracts were not an exception to Spain's real estate market's severe adjustment following the financial crash of 2008. Although there were a lot fewer contracts, the behavior of mortgage interest rates was more chaotic. Before the burst of the housing market bubble, Spain had excessively loose mortgage pricing policies compared to the majority of other euro area nations because of bank rivalry and low market rates (Valverde and Fernández, 2015). Nevertheless, market and competitive pressures on bank profits were not a significant factor in determining mortgage rates during the collapse. In practice, and particularly in 2011 raising fears over public debt, rates rose in Spain more quickly than in other eurozone countries' peers (Hernández de Cos, 2019). It can be seen in the graph of mortgage rates from 2012 onwards and in 2015 the mortgage industry started to show indicators of a light recovery. Although, the values keep decreasing. This is due to a lower propensity to invest and an increased investment tendency as causes for the decline of interest rate (Carreras and Morron, 2019).

Graph 3.2 plots the time series of the house price index. The housing prices also show a decreasing trend until 2015 when the values start to slowly increase again. The lowest value was recorded in the first quarter of 2014. From 2010 to 2014, the real estate market was still suffering the negative impact of the global recession of 2008. The recovery started around 2015 when there was a substantial expansion in real estate supply over the upcoming years. Even so, the indices stayed at relatively moderate levels as a result of a slow population growth (Montoriol, 2020). According to the Directorate General Economics, Statistics and Research (2020) of the Bank of Spain, there are some characteristics related to the expansionary period from 2015 onwards. First, due to an increase in rental demand which the supply was unable to meet, rental costs increased significantly. Moreover, the relatively lesser usage of loans to finance home purchases was another feature of this recent expansionary period. This feature reflected a change in the preferences of the dwelling buyers and is somewhat related to more ambitious credit conditions. Ultimately, there was significant geographical variation between both activity and prices, which can be partly attributed to the disparate rates of population growth in the various areas.

Neither of the two variables has normal fluctuations, they both have declining trends. It should be noted how, due the aforementioned data limitations encountered, both graphs would have been smoother and accurate if there was monthly data available.

4. Methodology

In order to answer the question and test the hypothesis of this investigation to analyze the effects of monetary policy shocks on housing prices in Spain, a specific econometric model is used. The methodology reflects the majority of previous empirical literature, which is a Vector Autoregressive (VAR) model. The latter has been shown to be particularly effective for forecasting and characterizing the dynamic behavior of economic and financial time series (Zivot and Wang, 2003). With this approach, a linear function of all the variables at earlier time points predicts each variable. This model's fundamental presumption is that its variables remain stationary across time (Haslbeck et al., 2021).

Consider a time series vector (n x 1) as $\mathbf{Y_t} = (y_{1t}, y_{2t}, \ldots, y_{nt})'$. The basic VAR model is commonly written as

$$\mathbf{Y}_t = \alpha + \beta_1 \mathbf{Y}_{t-1} + \beta_2 \mathbf{Y}_{t-2} + \ldots + \beta_p \mathbf{Y}_{t-p} + \varepsilon_t, \quad t = 1, \ldots, T \tag{4.1}$$

where α is the intercept, β_i are (n x n) matrix coefficients and ε_t denotes an (n x 1) unobservable white noise vector process with a mean equal to zero. In this study, a bivariate VAR model is used and its equations have the following form

$$Y_{1,t} = \alpha_1 + \beta_{11,1} Y_{1,t-1} + \beta_{12,1} Y_{2,t-1} + \beta_{11,2} Y_{1,t-2} + \beta_{12,2} Y_{2,t-2} + \varepsilon_{1,t} \tag{4.2}$$

$$Y_{2,t} = \alpha_2 + \beta_{21,1} Y_{1,t-1} + \beta_{22,1} Y_{2,t-1} + \beta_{21,2} Y_{1,t-2} + \beta_{22,2} Y_{2,t-2} + \varepsilon_{2,t} \tag{4.3}$$

where $Y_{1,t-1}$ and $Y_{2,t-1}$ are the first lag of the time series Y_1 and Y_2 accordingly.

In the case of this study, the respective equations will be:

$$st\_intrate_{1,t} = \alpha_1 + \beta_{11,1}\, st\_intrate_{1,t-1} + \beta_{12,1}\, hpi_{2,t-1} + \beta_{11,2}\, st\_intrate_{1,t-2} + \beta_{12,2}\, hpi_{2,t-2} + \varepsilon_{1,t} \tag{4.4}$$

$$hpi_{2,t} = \alpha_2 + \beta_{21,1}\, st\_intrate_{1,t-1} + \beta_{22,1}\, hpi_{2,t-1} + \beta_{21,2}\, st\_intrate_{1,t-2} + \beta_{22,2}\, hpi_{2,t-2} + \varepsilon_{2,t} \tag{4.5}$$

Additionally, a few procedures are taken, which will be detailed, in order to regress this model. These steps will help to explain all the measures used to analyze the correspondent VAR model. Thus, first some checks for stationarity will be explained, then what to do if the variables are not stationary, continuing with the lag length selection of the model. This is followed by checking for the stability condition and the autocorrelation, along with the Granger causality test. To finalize the analysis, the impulse response function are computed and the variance decomposition is studied.

4.1. Stationarity check

Stationarity refers to the absence of change in the statistical characteristics of a process producing a time series. It simply means that the series' evolution over time does not impact the development of the evolution itself. The basis of any correlation between adjacent terms must be the same throughout all time periods for stationarity to apply (Wooldridge, 2011b). In order to regress the VAR model, the time series data need to be stationary. To check if the variables of the investigation are stationary to test are being made.

First, the Dickey Fuller test is a single root test that employs a hypothesis test to statistically identify the presence of stochastic trend behavior in the time series of the variables (Dolado et al., 2002). Second, the Phillips-Perron test also checks for stationarity. The authors Cheung and Lai (1997), define this test as another unit root test and test the null hypothesis that a time series is integrated of order 1. The two aforestated tests investigate the possibility that the process creating the data for y_t may have a greater order of autocorrelation than is permitted by the empirical estimation, resulting y_{t-1} endogenous (Phillips and Perron, 1998).

To check for the stationarity in both tests in the model of the presented study, the p-value at the 5% significance level is observed. Consequently, if the resultat p-value is less than 0.05, the variable will be considered stationary. On the contrary, if the value is greater than 0.05, the variable is considered non-stationary. If the latter is the case, the following step explains how to solve this.

4.2. If not stationary, take first difference

After having checked for stationarity with the Dickey-Fuller and Phillips-Perron test, the resulting non-stationary variables need to be stationary. To achieve this, taking the first difference of the non-stationary variable can turn the variable into stationary. The first-difference is the series of adjustments from one period to the consecutive (Witt et al., 1998) and is equal to $y_t - y_{t-1}$.

Accordingly, the p-values are checked again and the same criteria of the previous step is taken. If the p-values are smaller than 0.05 then the variable is stationary and the first difference is chosen.

4.3. Lag length selection

After having analyzed for stationarity, the best lag for the VAR model with the lowest residual correlation is then determined. If the lag length is too small, then the model is misspecified. It also should be mentioned how the selected lag can not have autocorrelation. Differently, if the lag extension is too large, the degrees of freedom are wasted. There are three lang length criteria used in this estimation. First, the final prediction of Akaike's information criteria (AIC), then Hannan and Quinn information criterion (HQIC), and the Schwarz Bayesian information criterion (SBIC). This criteria acknowledges the best lag when the values obtained are significant accordingly (Bierens, 1980).

Once the optimal lag is obtained, the VAR model can be regressed to obtain the results of the model and the values of the lags for the regressed variables.

4.4. Stability condition

To monitor the stability of the VAR model, the eigenvalues stability conditions are obtained after estimating the parameters of the regression. The values of the modulus show "the square root of the summed squares of the real and imaginary eigenvalue components" (Hatemi, 2004). In order for the variable to satisfy the stability condition, all the roots have to be less than 1. If the latter is true, the considered model is considered to be stable.

4.5. Autocorrelation check

Before checking for autocorrelation, the statistics of the error are summarized to check for residual diagnostics. Therefore, after predicting the error, the values of the residual can be plotted into a graph.

For the autocorrelation analysis, a Lagrange multiplier test is stated. It is a procedure to apply when wanting to test hypotheses regarding autoregressive time series models (Hosking, 1980). In this type of check, the null hypothesis defends that the variable has no correlation at the lag order. So, if the p-value of the selected lag appears to be greater than 0.05, the null hypothesis of the test can not be rejected and the model does not have autocorrelation in that lag.

4.6. Granger Causality test

The Granger causality test examines if lagged values of the variable facilitates the prediction of other variables of the model. The null hypothesis determines that, for instance, variable x does not Granger cause variable y (Diks and Pachenko, 2006). As a result, if the p-value of the test is less than 0.05, at a 5% significance level, variable x does not Granger cause variable y . If this statistic is greater than 0.05, x does Granger cause variable y.

4.7. Computing the Impulse Response Functions

An impulse response function (IRF) is a tool used to interpret a VAR model. This type of function also allows to follow the evolution of the model's variables over time (both their present and potential values) up to a one-unit increase in the present value of one of the VAR errors. In other terms, it illustrates how one variable affects another. (Lütkepohl, 2010; Inoue and Kilian, 2013).

Moreover, for creating the IRF the number of time periods that want to be examined have to be specified. The IRF results contain the estimates and standard errors of the multiple sets of impulse-response functions, of the dynamic multiplier functions and the forecast error variance decompositions. Once these results are obtained, they can be easily analyzed with a graph.

4.8. Variance decomposition

The variance decomposition shows how much information each variable in the autoregression adds to the other variables. It establishes the percentage of each variable's forecast error variation that exogenous shocks to the other variables may account for. The variance decomposition also presents the percentage of the error made predicting a variable over time due to a specific shock (Campbell, 1990).

5. Results

In this section, the results obtained of this report's data following the steps explained in Section 4 are presented and further discussed. It is worth mentioning that the variable that indicates the short-term interest rates appears as *st_intrate.* Also, for the house price index the correspondent name variable is *hpi.* The outcomes appear under the aforementioned steps to have an easier understanding of what is done on each point.

5.1. Stationarity check

Firstly, regarding the short-term interest rate (*st_intrate*), the Dickey-Fuller test is performed and shown in *Table 5.1*. The p-value is equal to 0.8767 and greater than 0.05. Therefore, at a 5% significance level, the variable is non-stationary. Secondly, using the same stationary test, the house price index (*hpi*) shows in *Table 5.2* a p-value of 0.0303. So, at a 5% significance level, the variable is stationary.

Regarding the Phillips-Perron test, the short-term interest rate results appear in *Table 5.3* with a p-value of 0.7544. Additionally, the house price index's outcomes in *Table 5.4*. show a p-value of 0.1708. Both variables seem to be non-stationary, as their p-values are above 0.05. For the VAR model, stationary variables are desired. Thus, the first-difference estimator is going to be analyzed to see if the short-term interest rate can become stationary.

5.2. If not stationary, take first difference

As with the previous tests some variables are found to be non-stationary, the next stage is to take the first differences estimator (FDE) for the short-term interest rate and the housing prices. Moving forward, the FDE of the short-term interest rate is denoted as *d_st_intrate*, and for housing prices now is *d_hpi.* Starting with the Dickey-Fuller test using this new estimator, *d_st_intrate* shows in *Table 5.5* a p-value of 0.0869. This value is closer to 0.05 than the one shown in Step 1. Although, it still is not stationary. With regards to the house price index, the p-value is 0.3810 as stated in *Table 5.6* and non-stationary. Recall that in Step 1 this variable was stationary, but as the short-term interest rate was not, both variables have to take the first difference.

Following with the Phillips-Perron using FDE, the *d_st_intrate* (short-term interest rate with first differences) presents a p-value of 0.055 (see *Table 5.7*). Therefore, it is nearly stationary at 5% significance level as it is almost equal to 0.05. It could be said that the time series variable is stationary at a 10% significance level. For the *d_hpi* (house price index with first differences), *Table 5.8* displays a p-value of 0.4438.

As a result, the values are going to be analyzed with the first-difference series along the study. It is true that the short-term interest rate is non-stationary at a 5% significance level as it ideally would be, but it is really close and practically stationary in the Phillip-Perron test. Consequently, the short-term interest rate is stationary at the 10% significance level. Therefore, the first differences are going to be the true variables of interest analyzed throughout the investigation. As mentioned before, the house price index was already stationary in the level and the first difference estimator is not supposed to be used. However, both variables have to be estimated in the same way to make them equal in the VAR model, and to solve the problem with the short-term interest rate we take the FDE.

It should be noted that, after taking the FDE all variables tend to be stationary, the problem encountered here can be caused because of the data limitation previously discussed. Therefore, if there was more data available, the result would be more accurate.

5.3. Lag length selection

As stated in the methodology in order to decide which lag length to select, the criteria shown in *Table 5.9* is observed. The significant values according to AIC, HQIc and SBIC are the observations created in the third lag. These ones being, 1.2391, 1.4539 and 1.8613, respectively. Consequently, the lag length for the final VAR model is 3 lags.

Once the optimal lag is decided, to ensure this one is the best, a VAR model is regressed with the variables in differences of short-term interest rate and the house price index with 3 lags. *Table 5.10* shows the regression statistics of the 3 lag VAR model. Examining the R^2 in the third column, for the short-term interest rate it is 0.5916. This tells that in the difference of short-term interest rate the lags explain about 59.16% of the variance in the series. For the house price index, in the difference of house price index, the lags explain 87,19% of the variance.

5.4. Stability condition

Table 5.11 remarks the outcomes of the eigenvalue stability condition. In the modulus column there is not a unit root that is bigger than 1. Therefore, all the roots lie inside the unit circle and the model satisfies the stability condition.

5.5. Autocorrelation check

Before performing a check for the autocorrelation, the statistics for the residual are analyzed. The outcome of summarizing the error data can be seen in *Table 5.12*, where the mean is found to be equal to 0. Having predicted the error term, allows to plot in a graph the values and *Graph 5.1.* shows so.

In addition, *Table 5.13* shows the Lagrange multiplier test to check for autocorrelation for 3 lags. The p-value in the third lag is equal to 0.15858 and greater than 0.05. As a consequence, at a 5% significance level the null hypothesis can not be rejected and the model does not have autocorrelation at 3 lags.

5.6. Granger Causality test

Table 5.14 displays the Granger causality test. The column *Equation* tells that the dependent variable and the following column called *Excluded* contains the independent variables. When the short-term interest rate is the dependent variable and the house price index the independent one, the p-values are found to be greater than 0.05, being 0.185. This means that the differences in housing prices do not affect differences in interest rates and the effect is not significant.

On the contrary, when the house price index is the dependent variable and short-term interest rate the independent, the p-values are less than 0.05. As a consequence, the differences in short-term interest rate affects the differences in housing prices and the effect is significant.

For this reason, the short-term interest rate granger causes house price index, but not the other way round. This result sticks with the hypothesis and question of this study.

5.7. Computing the Impulse Response Functions

The impulse response functions (IRF) are predicted with 8 steps, corresponding to 8 quarters which is equal to 2 years. The first IRF is shown in *Graph 5.2* and tells the response of the house price index due to one standard deviation shock to short-term interest rate. Here the impulse is the short-term interest rate and how the housing prices respond is analyzed. It is appreciated how a shock in the interest rate decreases the house price index. From the quarter 0 it goes down in the first period, showing a one standard deviation increase in the interest rates decreases the housing prices. Then there is a slight increase and then again decreases in the housing price index in period 2. After that period, it stays practically constant for a while and only increases slightly. The values seem to be approaching 0 as time passes. Which means that the schock in the interest rate on the housing price index stays low in the long run. Besides, in the short run there is a decline in the first period and the third period as previously mentioned. Summing up the conclusion about the content of the graph, an increase in the short-term interest rates decreases the house price index. The cost of borrowing money to purchase a home is determined by interest rates, which also have an impact on the value of real estate. While high interest rates often have the opposite effect, low interest rates tend to promote property demand and raise prices (Iossifov et al., 2008). Therefore, a negative relationship between housing prices and short-term interest rates is found. An increase in the interest rates will cause a decrease in the demand for buying a house, consequently the house prices would decrease. Acquire-to-let investors are encouraged to buy homes and lease out their real estate, especially when borrowing rates are relatively cheap. The cost of mortgage payments on the home will be less than rental revenue at a low rate. As a result, investors have a significant incentive to purchase real estate as a result.

The second IRF is displayed by *Graph 5.2*, acknowledging the response of housing prices due to one standard deviation shock to short-term interest rate. It is important to say that, from the Granger causality test, housing prices do not affect short-term interest rates. Therefore, the information that this IRF provides is not very informative to answer the hypothesis of this study.

The results of these steps make sense because if short-term interest rates increase, housing prices decrease due to a decrease in the market's demand (Reichert, 1990). If there is less demand, now it costs more to mortgage a house. As a consequence, an increase in the short-term interest rates has a negative effect on housing prices. The outcomes obtained in this empirical study are consistent with previous literature (Sutton, 2002).

5.8. Variance decomposition

This final step of the analysis is presented in *Table 5.15* and *Table 5.16.* The first table states the results of the variance decomposition results from the IRF in the variable of the housing price index. The first column of the table tells the effect of short-term interest rate on house price index and the second column tells the effect of short-term interest rate on the same short-term interest rate. On average, it can be seen that for the next ten quarters, about 63.8% of the variation in the housing price index is explained by the interest rates. On the contrary, the housing price index only explains about 36.14% of the variation in the housing price index. This means that interest rates explain more variation (fluctuations) in the housing price index as compared to the housing price index itself.

Table 5.16 explains changes in the short-term interest rate due to interest rate and the house price index. The first column of the table explains the effect of the short-term interest rate on the short-term interest rate*,* where the impulse is the interest rate and the response is the interest rate as well. The second column explains the effect of house price index on short-term interest rate, where the impulse is the hpi and the response is the short-term interest rate. The first column indicates how all the variation in the interest rate is explained by the interest rates themselves (94.46%). In contrast, the second column states how only

5.54% is explained. The latter occurs because the housing price index does not explain the short-term interest rate. That is consistent with the results of the Granger causality test.

6. Conclusion

In conclusion, there is no doubt that monetary policy shocks affect housing prices. The main findings of this empirical study suggest that the Spanish housing market did not have a strong resilience in the years that followed the financial crash of 2008. It was not until 2014 when the country entered an expanditory era but with a much lower expansion rate affected by the slow population growth. A Vector Autoregressive model tests the monetary policy shocks on housing price index in Spain, checking for stationarity, causality, stability, autocorrelation and computing different tests to evaluate all of this. Additionally, the GRanger causality test and the impulse response functions show how short-term interest rates affect housing prices, but not the other way around. As a consequence, an increase in the short-term interest rate decreases the house price index. That leads to a decrease in the demand of the real estate market and an increase of the mortgage cost. Therefore, the short-term interest rates should be considered as a key factor that affects the housing market.

Although this study does not cover the years where the COVID-19 pandemic was initiated in 2020, it will have a severe negative effect on economic activity and on the real estate market, at least in the near short-term. The forecasted predictions of this model are not taking into account this collapse. Possibly, the country after looking at the last negative shocks, the Spanish housing market improves its resilience and knows how to approach better monetary policies to face unfavorable economic situations and troublesome outbreaks.

7. References

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8. Tables and Graphs

Table 3.1. Summary of statistics of the variables of the model.

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
st_intrate	40	0.1915	0.5755	-0.4029	1.5621
hpi	40	111.81	14.3933	95.5818	144.4351

Note: The short-term interest rate is denoted by *st-intrate* and the house price index by *hpi.*

Table 5.1. Dickey-fuller test results for the short-term interest rates.

		Dickey-Fuller critical value		
	Test Statistic	1%	5%	10%
Z(t)	-0.574	-3.655	-2.961	-2.613
Mackinnon approximate *p-value* for Z(t) = 0.8767				

Table 5.2. Dickey-fuller test results for the house price index.

		Dickey-Fuller critical value		
	Test Statistic	1%	5%	10%
Z(t)	-3.052	-3.655	-2.961	-2.613
Mackinnon approximate *p-value* for Z(t) = 0.0303				

Table 5.3. Phillips-Perron test results for the short-term interest rate.

		Dickey-Fuller critical value		
	Test Statistic	1%	5%	10%
Z (rho)	-2.212	-18.152	-12.948	-10.480
Z (t)	-0.997	-3.655	-2.961	-2.613
Mackinnon approximate *p-value* for Z(t) = 0.7544				

Table 5.4. Phillips-Perron test results for the house price index.

		Dickey-Fuller critical value		
	Test Statistic	1%	5%	10%
Z (rho)	-4.193	-18.152	-12.948	-10.480
Z (t)	-2.304	-3.655	-2.961	-2.613
Mackinnon approximate *p-value* for Z(t) = 0.1708				

Table 5.5. Dickey-fuller test results for the first difference short-term interest rates.

		Dickey-Fuller critical value		
	Test Statistic	1%	5%	10%
Z(t)	-2.630	-3.662	-2.964	-2.614
Mackinnon approximate *p-value* for Z(t) = 0.0869				

Table 5.6. Dickey-fuller test results for the first difference house price index.

		Dickey-Fuller critical value		
	Test Statistic	1%	5%	10%
Z(t)	-1.799	-3.662	-2.964	-2.614
Mackinnon approximate *p-value* for Z(t) = 0.3810				

Table 5.7. Phillips-Perron test results for the first difference short-term interest rate.

		Dickey-Fuller critical value		
	Test Statistic	1%	5%	10%
Z (rho)	-14.279	-18.084	-12.916	-10.460
Z (t)	-2.818	-3.662	-2.964	-2.614
Mackinnon approximate *p-value* for Z(t) = 0.055				

Table 5.8. Phillips-Perron test results for the first difference house price index.

		Dickey-Fuller critical value		
	Test Statistic	1%	5%	10%
Z (rho)	-5.427	-18.084	-12.916	-10.460
Z (t)	-1.675	-3.662	-2.964	-2.614
Mackinnon approximate *p-value* for Z(t) = 0.4438				

Table 5.9. Lag order selection criteria

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-59.1301				0.1127	3.4931	3.5283	3.5820
1	-22.7709	72.718	4	0.000	0.1776	1.6441	1.761	1.9107
2	-16.2864	12.969	4	0.011	0.0154	1.5021	1.6555	1.9465
3	-7.6845	17.203*	4	0.002	0.0119*	1.2391*	1.4539*	1.8613*
4	-4.1509	7.0681	4	0.132	0.01245	1.2658	1.5419	2.0656

Note: * denotes the optimal lag

Table 5.10. Statistics of basic var model using first-order difference with three lags.

Equation	RMSE	R^2	chi2	P>chi2
d_st_intrate	0.0921	0.5916	52.1433	0.0000
d_hpi	1.0303	0.8719	244.9421	0.0000

Note: RMSE denotes the Root Mean Square Error

Table 5.11. To check for stability condition - Eigenvalue stability condition

Eigenvalue		Modulus
0.9357		0.9357
0.6531 +	0.4745*i*	0.8072
0.6531 -	0.4745*i*	0.8072
-0.3551 +	0.5085*i*	0.6202
-0.3551 -	0.5085*i*	0.6202
-0.5922		0.5922

Note: All the eigenvalues lie inside the unit circle. VAR satisfies the stability condition.

Table 5.12. Statistics summary of the error term of the VAR model

Variable	Observations	Mean	Standard deviation	Min	Max
error	36	0	0.0839	-0.2409	0.3478

Table 5.13. Lagrange multiplier test to test for autocorrelation.

lag	chi2	df	Prob > chi2
1	4.3584	4	0.35967
2	5.2339	4	0.26413
3	6.6003	4	0.15858

Note: H0: no autocorrelation at lag order

Table 5.14. Granger causality Wald test

Equation	Excluded	chi2	df	Prob > chi2
d_st_intrate	*d_hpi*	4.8299	3	0.185
d_st_intrate	ALL	4.8299	3	0.185
d_hpi	*d_st_intrate*	23.941	3	0.000
d_hpi	ALL	23.941	3	0.000

Table 5.15. Variance decomposition results from the IRF in the variable of the housing price index.

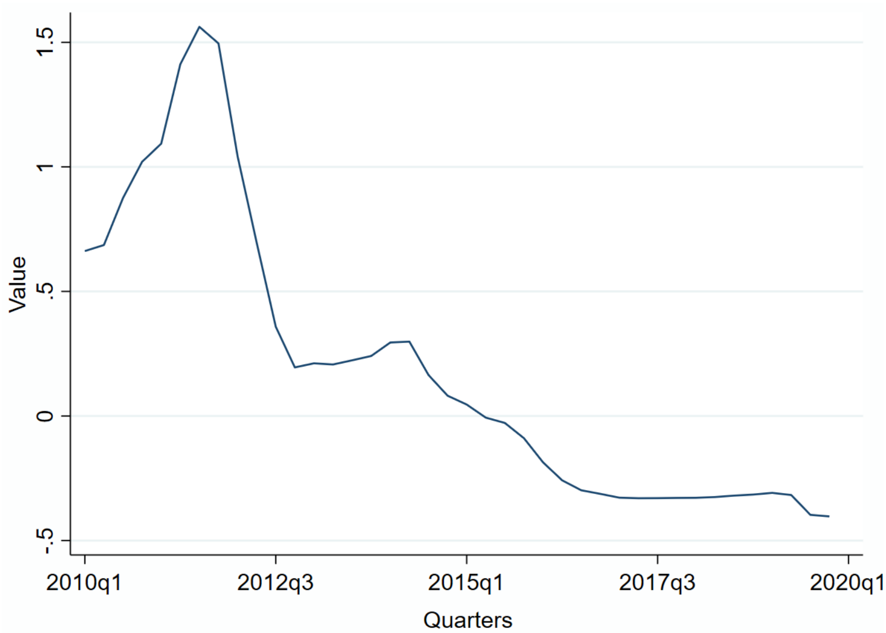
Step	fevd (1)	fevd (2)
0	0	0
1	0.0588	0.9941
2	0.1311	0.8689
3	0.1601	0.8399
4	0.3982	0.6017
5	0.4971	0.5029
6	0.5702	0.4298
7	0.6097	0.3903
8	0.6288	0.3712
9	0.6356	0.3643
10	0.6386	0.3614

Note: (1) Effect of *d_st_intrate* on *hpi.,* (2) Effect of *d_st_intrate on d_st_intrate.*

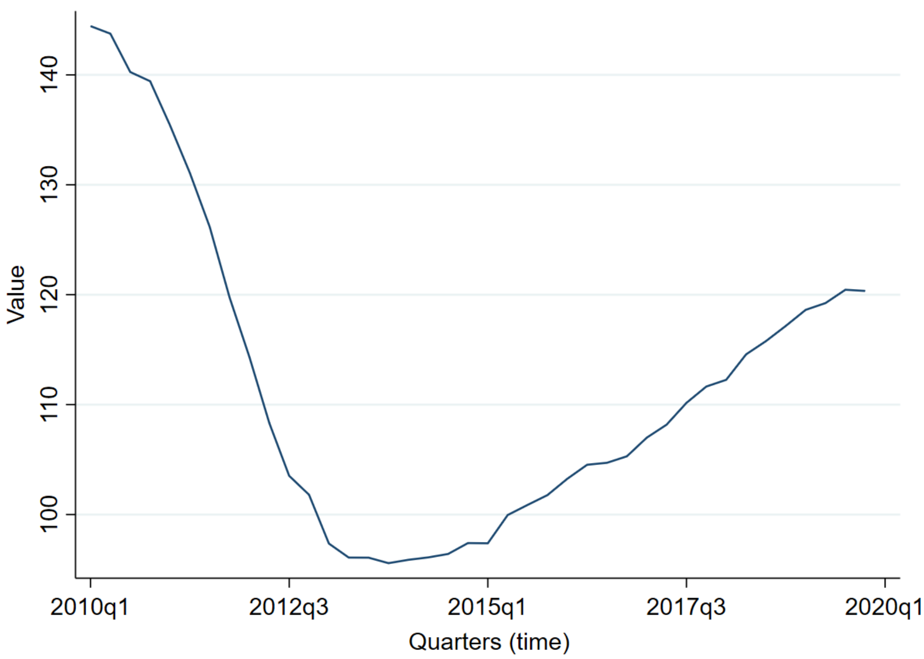
Table 5.16. Variance decomposition results from the IRF in the variable of the short-term interest rates.

Step	fevd (1)	fevd (2)
0	0	0
1	1	0
2	0.9766	0.0234
3	0.9451	0.0549
4	0.9383	0.0617
5	0.9338	0.0661
6	0.9391	0.0609
7	0.9427	0.0572
8	0.9444	0.0555
9	0.9447	0.5529
10	0.9446	0.0554

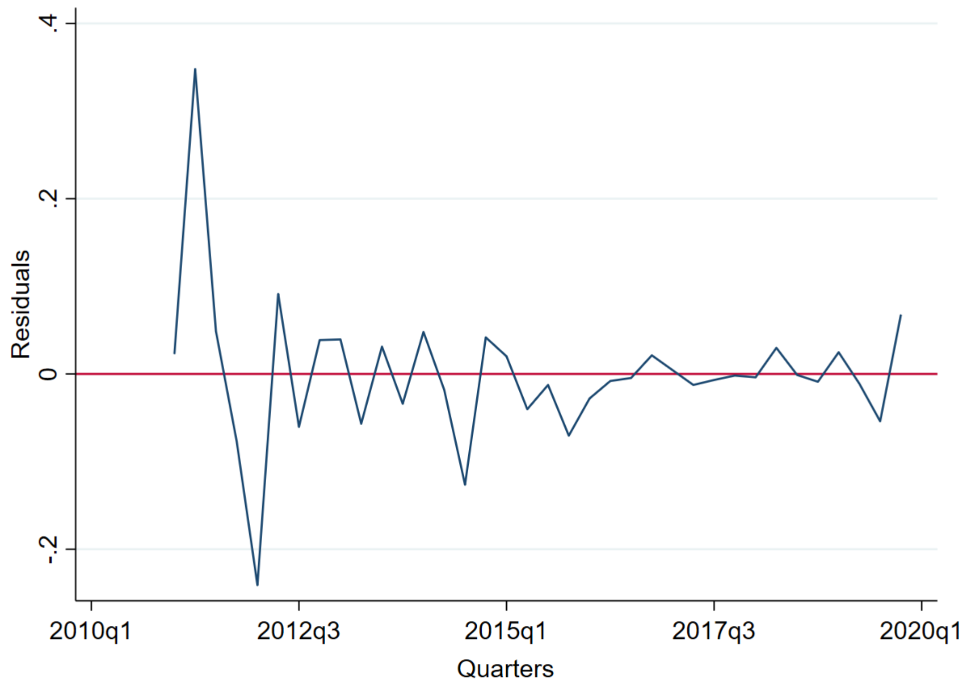
Note: (1) Effect of *d_st_intrate* on *d_st_intrate,* (2) Effect of *d_st_intrate on d_st_intrate*



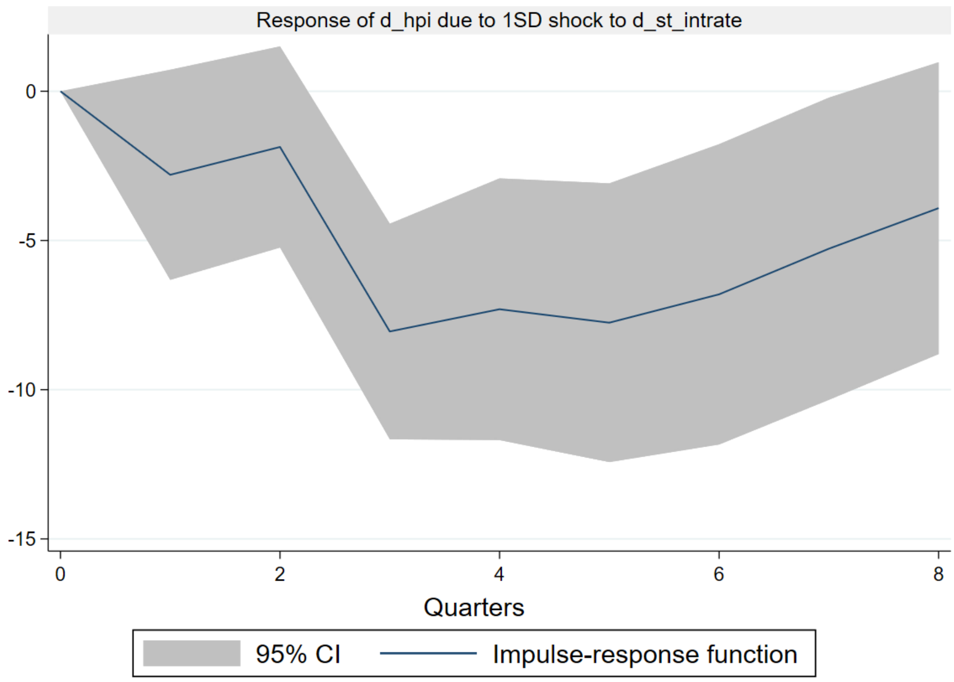
Grap 3.1. *Line plot of time series data of the short-term interest rate variable.*



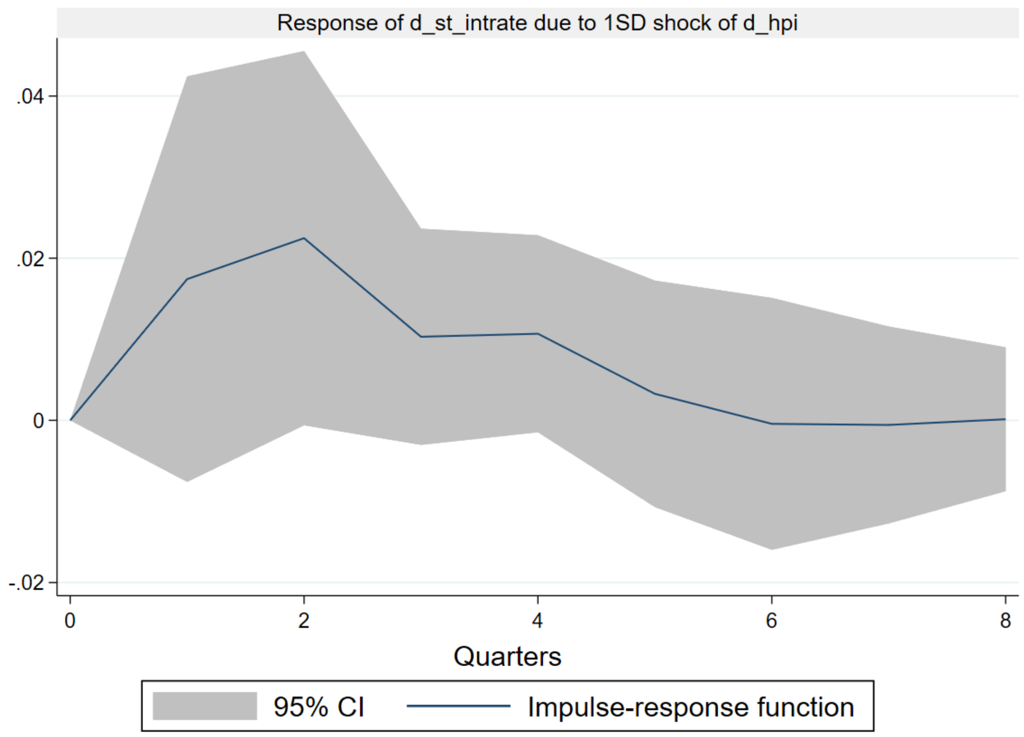
Graph 3.2. *Line plot of time series data of the house price index variable.*



Graph 5.1. *Line plot for the time series data of the error.*



Graph 5.2. *IRF that tells the response of the house price index due to a one standard deviation shock to short-term interest rate.*



Graph 5.3. *IRF that tells the response of short-term interest rate due to a one standard deviation shock to house price index.*