Rental prices: Structural VAR and Bayesian Structural VAR analysis for the case of Spain

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Abstract

Rental prices in Spain have been increasing since the end of the 2008 crisis. In order to find out how rental prices have changed from 2008 to 2020 we estimate two VAR models and a Bayesian VAR model including as variables the number of temporary employees, the number of mortgages granted and an index of concentration of the economic activity. The results show that in the long run an increase in temporary employment generates instability that results in higher rental prices. Changes in the index of concentration of economic activity do not lead to significant changes in rental prices. Finally, shocks that facilitate access to mortgages generate, on the one hand, a fall in prices in the short term because houses are bought instead of rented and, on the other hand, a rise in the long term, probably because these loans lead to more buildings being constructed and part of the houses are used for renting, these with a higher price because they are better quality houses than the existing ones.

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Section I: Introduction

The end of the financial crisis of 2008 and the subsequent economic recovery of the last few years has had a significant impact on the Spanish housing market, creating some problems for homebuyers. Some of the problems are the difficulty in obtaining financing (Gruppe and Lange, 2014), the increase in house prices (Fuster, Arundel and Susino, 2019) and a notable rise in demand. The natural substitute for buying a home is renting, but due to the difficulty of buying the property itself and the short duration of contracts in Spain, prices are regularly and rapidly updated upwards.

Average rental prices have been rising steadily for the last 12 years[1]. This generates economic difficulties at household level, especially for young people and low-income families. Difficult access to buying a home or the continuous rises in rent prices when contracts expire highlight the vulnerability of the most affected groups; those renters who cannot afford the prices of new contracts are expelled from their place of residence, abandoning their homes or end up evicted. In addition, this generates other types of urban problems, such as segregation by economic capacity in neighbourhoods or lack of social cohesion (García-Lamarca, 2017).

Rising of rental prices are becoming an issue that is generating social discontent and is already taking the debate to political institutions in many local and regional governments. Access to decent and affordable housing for all is one of the state's priorities and is at the forefront of the political debate. Thus, in the face of the incessant escalation of prices, some of Spain's regional governments, such as the parliament of Catalonia, have decided to regulate rental prices, while the rest of the regional governments have not taken any measures to control the housing rental market.

In July 2020 a first project to regulate rental prices is proposed in the governing body of the Barcelona City Council, this project is transformed into a law of the Catalan Parliament on 18 September 2020. This law, called "*Llei de mesures urgents en matèria de contenció de rendes en els contractes d'arrendament d'habitatge*"[2], aims to contain prices and rental contracts in order to achieve a certain price stability and long-term or

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[1] See Figure 1, Panel A.

[2] The complete name is Llei 11/2020, del 18 de setembre, de mesures urgents en matèria de contenció de rendes en els contractes d'arrendament d'habitatge i de modificació de la Llei 18/2007, de la Llei 24/2015 i de la Llei 4/2016, relatives a la protecció del dret a l'habitatge.

indefinite rental contracts. The containment of rents in this law is based on two fundamental pillars, the first of which is based on determining the maximum amount of rent that can be agreed at the time of formalising the rental contract, which cannot exceed the reference price for the rental of a dwelling of similar characteristics. The second is that the rent must not exceed the rent stated in the last rental contract.

The short-term effect of the approval of this law is evident, it has achieved its objective which was to stop the growth of rental prices in the region, especially in Barcelona (Casais, 2021). The fall in the number of formalised contracts that was feared as a result of the application of this law has not occurred, although it has not been a significant drop. Not enough time has passed yet to be able to know what the long-term effects of the law of the Catalan parliament will be.

The option of regulating prices through legislation seems to be one possibility, although other options can also be considered, such as what are the reasons for price increases and try to modify them to maintain rental prices. Some researchers have investigated this and some research has been done to understand price volatility and what causes it. This report aims to expand on the literature and learn more about the determination of rental prices by adding variables such as the level of concentration of economic activity, ease of access to mortgages and employment stability to the analysis.

In short, knowledge about what causes escalating rent prices should be essential to formulating appropriate rent laws. Politicians should know and be able to try to predict how prices will evolve in the coming years in order to take appropriate measures to provide decent and affordable housing for those sections of the population with lower incomes.

Regarding the structure of the following sections: Section II is a review of the literature on academic research on rental prices, Section III is an analysis of the dynamics of rental prices in Spain where the evolution of the demand and supply of rental housing will be discussed, Section IV is the explanation of the variables included in the analysis and the expectations and hypotheses, Section V will present the data and an analysis of their evolution in recent years, Section VI will present the methodology used for the econometric analysis, Section VII will present the results and finally the eight section will be the conclusions of the report.

Section II: Review of the literature on rental pricing

In this section we will discuss which are the main forms that have been used in the literature for the analysis of rental house prices. Both at the empirical level and at the theoretical level, although the literature on the latter is very scarce. Although the literature on this subject is not very extensive, these are the most important recent research studies, as the articles presented in this section have been prioritized to be as recent as possible.

Over the last few years, several empirical analyses of house rental prices have been carried out, focusing on different countries and different time periods. In addition, different statistical analysis techniques have also been used and many variables that can affect the volatility and movement of rental prices have been considered in the analyses.

Different factors have also been considered to focus the analysis of prices, on the one hand by analysing prices at neighbourhood level and on the other hand by investigating rental prices at regional level. Even so, the literature on rental prices is still limited and rather fragmented.

Regional rental price analyses use data series for a region or economic area. In this type of research, neoclassical economic factors affecting the demand and supply of this rental market are studied.

In relation to the supply of rental flats, some of the factors affecting the supply side are the prices of building land, financing costs and the financial market, the costs of building materials and taxes on rents.

With regard to the demand for rental housing there are other factors that affect it, for example, job opportunities, immigration to the cities, social housing, population growth, the share of students and also the level of wages.

One of the most recent regional studies of rental prices was conducted by Egner and Gabrietz (2017). This is an analysis of rental prices in 68 German cities over a 10-year period. A wide variety of components are used as independent variables, which they separate into four groups: supply-side variables, population characteristics, socio-economic factors and city context. Within each group they consider different variables such as population density, commuting ratio, city public debt, unemployment and many others. Two models are estimated for the statistical study, the first one is a fixed effects model and the second one is a Prais-Winsten model. After their detailed analysis, they end up with two solid conclusions, the first of which is that median income and the size of the academic community are clear drivers of rental prices, while houses per capita and population density could also become determinants as they are important in one of the two estimated models. Furthermore, they add that variables that have a political character do not reach significance in either case.

Another paper of great relevance in the study of rental prices is Saiz (2007). In it, the author develops an economic model that explains the relationship that immigration may have with the price of rents. He then carries out an empirical analysis to test his model. With respect to the data used, he includes variables such as, evidently, immigration in the United States between 1983 and 1997 and also rent prices in different US cities. In addition, the model also includes components such as income, population, unemployment rate, murder rate, proportion of college graduates and climate variables such as temperature and humidity. The methodologies used to estimate the key variables of his economic model are an Ordinary Least Squares estimation, an estimation using instrumental variables and an estimation with fixed effects. The conclusions reached are that immigrants cause a rise in rental prices in the destination areas and that the level of income causes an instantaneous effect on the demand for rental housing and that further research is required to learn more about the exact effect of immigration on housing consumption, local amenities and the evolution of national and local prices.

An older paper that also deals with this issue is Benjamin and Sirmans (1996). This paper analyses the evolution of prices in Whasington DC, including variables such as the characteristics of the rented houses, the rent level, the occupancy rate, the amount of public transport and some other characteristics. The data is for a single year. The methodologies used are Ordinary Least Squares and three least squares (3SLS) estimation. Finally, they reach the conclusions that the level of wages significantly affects rental prices and also that access to public transport is a significant factor in the price of rents.

Regarding the analysis of prices in a neighbourhood context, they focus on the fact that price movements depend on the neighbourhood in which the house is located and that it is the characteristics chosen by the tenants, the conditions of the area and the amenities of the location that determine price volatility. Among some of the characteristics that have been studied in this type of research are transport structures, educational conditions in the area, proximity to universities, hospitals or parks, and easy access to shopping areas.

The big problem with research at this neighbourhood level is access to the data, as a very high level of disaggregation of the data is needed, because it requires very small areas to be delimited and most institutions that generate this type of data do not create such specific databases, and it can also create privacy issues for the residents of these rented houses. For this reason, most researchers conducting research at the neighbourhood level are responsible for creating their own databases solely for the analysis presented in these papers.

One of the most current papers on house rental research is Li, Wei and Wu (2019). In it, a study is conducted at the intra-urban level in the city of Shanghai, where a variety of variables are included in the analysis at the neighbourhood level, such as proximity to public transport stations, distance to parks, banks, hospitals, schools and other variables. To collect the data, they use a technique known as web-crawling through a Python application. Regarding the methodology, they generate an econometric model where the dependent variable is house rent and the others are independent variables, and estimate the model with Ordinary Least Squares, Simple Linear Regression (SLR) and Multiple Linear Regression (MLR), as well as other urban economics techniques for geographical distribution and inequality between neighbourhoods. The conclusions they reach in the paper are that job opportunities, wage levels, availability of public transport and amenities in the service sector are clear drivers of rental prices in the city of Shanghai.

Another recent paper by Schläpfer, Waltert, Segura and Kienast (2015) analyses prices at neighbourhood level across Switzerland. In this case, there is a database that contains the appropriate level of disaggregation of the data for such an analysis and it is the one used by the authors for this research. In this paper, more than 40 explanatory variables are taken into account in the models and rent price is used as the explanatory variable. They estimate 7 different models using a technique known as Hedonic Pricing. Finally, they conclude that at the suburban level there is a higher volatility in prices and they estimate many of the variables that can have an effect on prices, some of the variables that have not been discussed so far are the noise level which has a negative effect on the price and whether there is a view of a lake, which has a positive effect.

Finally, after a review of the literature, it can be said that there is not a large number of theoretical models dealing with the determination of rental house prices. One of the authors already discussed Saiz (2007) proposes a theoretical model for the evolution of rental prices, but it focuses only on the effect of immigration and does not take into account a large number of variables and possibilities that have been studied empirically, so it does not seem to be a very complete model. Apart from that model, there are also no models that focus specifically on rents, what some authors have done is to consider a model on the housing market, such as the one presented by Rosen (1974), but the evidence is that there are no complex and comprehensive theoretical models that attempt to determine the evolution of rental prices.

In summary, for the analysis of rental prices, most researchers have done empirical work, focusing on a regional or neighbourhood level. Most of the research does not rely on a theoretical model; the authors simply use intuition for the inclusion of variables or follow the line of other previously published empirical work. Restrictions in the quantity and disaggregation of the data are the limiting elements for analyses at the neighbourhood level, but with the new data generation techniques this problem should be solved and facilitate the study at interurban and suburban levels of rents.

Finally, as for the Spanish level, there seems to be no recent analysis of rental prices in the literature.

Section III: Dynamics of the Rental Housing Market in Spain

In this section we will discuss which are the main forms that have been used in the literature for the analysis of rental house prices. Both at the empirical level and at the theoretical level, although the literature on the latter is very scarce.

The share of Spanish population living in rented accommodation is low as in comparison to principal EU economies (López-Rodríguez and de los Llanos, 2019). Nonetheless, since the financial crisis of 2008 it has been produced a noticeable increase in the proportion of rental housing in the Spanish residential market, in addition, it can be observed an increase in the rent-price of housing during the last decade. Some groups of population such as temporary workers, immigrants, undergraduate students or young households have led to this boost in the trend of rented accommodation, particularly, in largest cities and island territories.

A regional scale analysis of the Spanish rental housing market must consider both, supply dynamics of the lessors and the demand dynamics of the leased. On the one hand, supply of houses for rent has been rigid during the last years, on the other hand, demand of residential housing has been pushed by economic and financial factors. The increase in demand set against a stable supply would explain the movement of rental prices.

With respect to the Spanish supply of rental housing, López-Rodríguez and de los Llanos (2019) consider that supply has remained constant during the last decade because there were not important reductions in the costs of production of new buildings, the decade since the Great Recession have been characterised by very stable interest rates, so there have been no major changes in the prices for financing real estate projects, moreover, there have been no noticeable variations in material costs, labour prices and construction taxes.

In addition, the rise of popularity of holiday rentals may enter into opposition with the supply of residential rents, in other words, lessors have an attractive alternative to the traditional residential rent that is renting their residences only during the vacation months through applications that have grown in popularity such as *Airbnb* and *HomeAway*.

Regarding of the Spanish demand of rental housing, it may be affected by some factors that would promote an increase in the search of rental homes. Authors consider that, first that all and most important, demand of rental houses might be affected by the difficulty of the poorer groups to obtain a higher salary, these difficulties should be materialized because the labor market instability, such as unemployment or temporary work. Households have low income and risk of job loss what hamper access to loans for purchasing a house and consequently they must look for renting a house.

In addition, the ease of access to loans can also be considered one of the factors driving the increase in demand for home rentals, since the more difficult it is for a bank to lend money to a homeowner, the more incentivized people will be to rent homes. Difficulties in lending institutions or reluctance of banks to grant money could generate very large changes in rental housing demand.

Finally, the concentration of economic activity could induce population to migrate to these areas with higher economic activity, boosting the demand of residential renting. In other words, when determined municipalities offer greater opportunities for training, for studying and for employment, there is an increasing of migration flow that affects the rental housing market demand.

Considering that there is stability in the supply but changes in the demand, it may be interesting to study the magnitude of the effect of these variables, such as instability of labor market, access to mortgages and concentration of economic activity, influencing the demand of rental houses and modifying the prices of renting.

Section IV: Variables included in the analysis.

In this section the variables included in the analysis are presented. The decision to include these variables has been taken after the observation of the models that have been previously carried out and presented in the Literature Review section and after the analysis of the dynamics of the rental apartment market presented in the previous section.

Assuming the stability in the supply of rental flats that we have considered in the previous section and the fluctuations in demand, for an empirical analysis of rental prices over the last few years, it should include variables that affect tenants' intention to look for rental flats.

The first of the factors that are consider to affect the demand for rental flats is the employment stability of the Spanish population. Permanent employment contracts are considered to be a source of financial and employment stability, while those jobs that are temporary do not encourage workers to buy their own homes and therefore look for rental homes. For this reason, the level of temporary employment is included in the analysis of the prices of renting a property. Egner and Gabrietz (2017) include the unemployment ratio in their analysis, in a different way, this report considers temporary employment to understand labour market instability.

Increases in the level of temporary employment in a country could cause rents to rise. This is because increases in the level of temporary employment do not create stability for residents and may encourage employees who end their contracts in one city to seek new contracts in another city, driving up the demand for rental housing. Similarly, decreases in temporary employment would mean that workers have more stability in their jobs, so they will look for permanent housing in a city, neighbourhood or area close to where they work.

The second of the variables contemplated in the analysis is the access to funding, the more expensive it is to acquire loans or mortgages to buy houses, the higher the demand for rented flats, as it is the main alternative to buying a house.

Taking into account the level of mortgages granted can have an effect on rental prices through two different channels. First, as there is a lot of lending, the immediate effect will be that households will buy houses and no longer demand rental housing, causing prices to fall. In addition, over a longer period of time, more mortgages granted means an increase in businesses and projects, part of these projects will be real estate, and a proportion of these new buildings will be for rental housing, so there will be an increase on the supply side, also leading to a drop in prices in the medium and long term.

The last variable included in the analysis is the concentration of the economic activity. It affects the demand of the rental housing because students and young workers intend to move to the areas with the greatest economic activity to maximize their academic and work opportunities.

Cities with higher level of concentration of economic activity provide more possibilities for students and more academic opportunities for researchers, additionally, most projects and business are born in areas with high level of concentration of economic activity, which is a motivation for the arrival of young population from areas with a lower density of economic activity, boosting the demand of rental flats. The increase in the demand of flats in this type of cities significantly rises the price of the local rental housing, dragging with it the average rental price of the country. A country with a trend of concentration of the economic activity in a few cities generates movement of the population to these cities pushing up the demand and the prices of the rental housing at local level and, as a consequence, at regional level.

Access to finance and the concentration of economic activity are two variables that may affect rental prices in the report by López-Rodríguez and de los Llanos (2019).

Therefore, the variables under consideration affecting rent prices could be summarised as follows:

$$Rental\ Prices\ \perp\ (Employment\ Stability\ + Access\ to\ Funding\\ + Concentration\ of\ Econonmic\ Activity)$$

Section V: Data

This section explains which are the sources of the data used, how the data are treated to obtain homogeneous data series and also gives a brief explanation of how each time series is and how it has evolved during the study time contemplated in this report. Finally, it will consider in which direction the variables may affect the price of rents.

The analysis will examine how the employment instability, the ease of access to loans and the concentration of economic activity affects the behaviour of rental housing prices. Taking this into account, this report uses data from a variety of sources. Firstly, the information about rent price of houses[3] is obtained from OECD database. In this database, the rental price of housing is expressed as a value relative to the reference year, which in this case is 2015 with a value of 100.

Secondly, the data about the employment instability is the temporary employment[4], in this respect, the source of the data is Eurostat. This data extracted contains the level of temporary employment measured in thousands of workers, including both genders and all educational levels.

Thirdly, the information concerning the access to loans is provided by the *Instituto Nacional de Estadística* (INE), that is the Spanish statistical office. The data used in this topic is mortgages constituted on dwellings, namely, the number of mortgages[5] registered in the property register. In this case, the frequency of the data is monthly, and the data of the previous series considered is quarterly, then, we have aggregated the monthly data into quarters.

Finally, an index of the degree of concentration of economic activity is required. Nonetheless, to the best of our knowledge there is not any statistical indicator of the economic activity concentration for Spain published in official statistical institutions. For this reason, we have considered some methodologies carried out by economists in previous literature.

The level of concentration of economic indices is a common tool in Industrial Economics, a must-have paper in this literature is the one by Ellison and Glaeser (1997), in which the authors develop a methodology and tests for measuring the concentration and agglomeration of individual manufacturing industries in the United States. Their result confirms that there is a trend of agglomeration of almost all industries. Moreover, Maurel and Sédillot (1999) slightly modify the methodology previously mentioned with the objective of investigate the geographic concentration of the French industries, with

[3] Housing Rent Prices: OECD (2021), Housing prices (indicator). doi: 10.1787/63008438-en (Accessed on 09 July 2021)

[4] Employment and unemployment (LFS) Eurostat. https://ec.europa.eu/eurostat/databrowser/bookmark/7894f0f6-0438-4b51-9b2e-a4f710129c28?lang=en (Accessed on 09 July 2021)

[5] Monthly Mortgages constituted on dwellings. INE https://www.ine.es/uc/r5JEb4pv (Accessed on 09 July 2021)

the result that extractive and traditional industries and some advanced technological industries are highly concentrated in specific regions.

Concerning Spain, Alonso-Villar, Chamorro-Rivas and González-Cerdeira (2001) analyse the concentration of the industrial economic activity during the period 1993 to 1999. They used Maurel and Sédillot (1999) methodology previously mentioned, and they conclude that the higher level of technology required for the industry, the higher level of concentration.

In this report, we are using a less complex methodology than the previous considered, just because we do not have access to such specific data. What we propose is to use the Gini (1909) coefficient to the number of new companies established at province level, as the creation of new firms is a clear indicator of economic activity. The number of companies created[6] at province level is provided by the INE. This is also a monthly indicator, for this reason we aggregate the data in quarters as we did with the number of mortgages registered in the property register. Then, we applied the Gini (1909) coefficient with the aim to obtain an index for economic activity concentration.

The construction of the index for a discrete population follows this equation:

$$C_q = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}\left|x_{in} - x_j\right|}{2n\sum_{j=1}^{n} x_i} \quad where\ i = 1, 2, 3 \ldots n$$

Where C_q is the coefficient of the concentration of economic activity for the quarter q, n is the number of provinces of Spain. n_{iq} is the number of companies established during the quarter q in the province i and x_j is the individual number for each province.

As a result, we obtain a value a value greater than 0 and lower than 1 which indicates the level of concentration of new firm creation for each quarter, we can consider this value as a measure of concentration of economic activity.

Our dataset consists of time series processes. All the data used is for Spain and for the same period. Table 1 shows a summary and some additional information about the datasets.

[6] Companies' summary. INE https://www.ine.es/up/urw7Wvq0 (Accessed on 09 July 2021)

Table 1: Data summary

Variable	Source	Frequency	Localization	Time	Unit
Rent price of houses	OECD	Quarterly	Spain. National level.	2008Q1 to 2020Q4	Relative value, base year 2015 = 100.
Temporary work	Eurostat	Quarterly	Spain. National level.	2008Q1 to 2020Q4	Thousands of workers.
Number of mortgages on dwellings	INE	Monthly, but data is aggregated for obtaining Quarterly data	Spain. National level.	2008Q1 to 2020Q4	Number of Mortgages.
Number of companies created	INE	Monthly, but data is aggregated for obtaining Quarterly data	Spain. Province level.	2008Q1 to 2020Q4	Originally, companies but we create an index between 1 and 0.

Figure 1: Time series plot

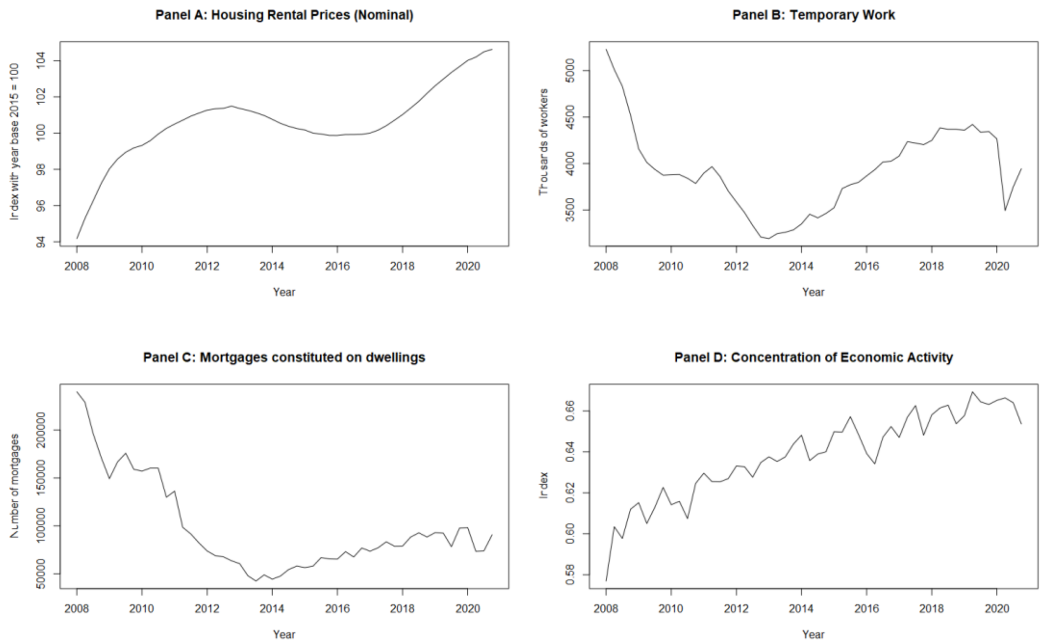


Figure 1 presents the plots of the time series. Panel A shows that there is an increase in nominal rental prices during the post-crisis years, as López-Rodríguez and de los Llanos (2019) rightly point out. This clear positive trend is interrupted by a decline between 2013 and 2016. It should also be noted that the covid19 pandemic has not led to a change in nominal rental prices that can be seen in this graph.

Panel B is the graph of temporary employment, in this we can observe the great destruction of jobs after the bursting of the real estate bubble, evidently, temporary jobs were the most destroyed due to the nature of their contracts, from 2008 to 2013 39.05% of temporary jobs were destroyed. From 2013 onwards there has been a recovery in temporary jobs, with a clearly positive trend, the creation of this type of jobs had a growth rate of approximately 5% during the years of expansion until the arrival of the pandemic. Temporary jobs were hit hard by the health crisis, the national and regional governments used resources to avoid massive job destruction, but even so, the pandemic caused a sharp drop in temporary contracts. The subsequent recovery seems equally steep.

The number of mortgages granted is shown in Panel C. This graph shows a drop in mortgages granted since the crisis, as a large part of the Spanish banking system was bankrupt and many financial institutions were reluctant to lend money without clear guarantees. At the end of 2013, a certain stability was reached and a period began in which the number of loans made began to grow at a very low rate. The health crisis affects the number of mortgages granted, causing a slight drop, but the effect is much less than with temporary employment.

Finally, Panel D shows how economic activity in Spain has become more concentrated, the constant growth of this variable means that there is more and more business creation and opportunities in certain areas or cities while in other areas or regions business activity is declining.

An overview of Figure 1 can give us some intuition of what we can expect in terms of how the variables we include in the analysis relate to each other. The similarity of the graph of nominal house rental prices (Panel A) and the graph of the economic activity concentration index (Panel D) seems to suggest that there is a positive correlation between the two variables.

The correlation between rental prices (Panel A) and the number of mortgages granted (Panel B) should be negative, since in general there is a growth in prices while there is a reduction in mortgages granted.

These correlations are in line with Section IV where it is considered that an increase in economic activity concentration would lead to an increase in rental prices and that a rise in the number of mortgages granted may reduce the rental prices.

Conversely, in Section IV it is commented that the increase in temporary employment should increase rental prices, looking at Panel A and Panel C, this only seems to happen after 2016, but not for previous years.

In summary, we should expect that, first, a shock that increases the number of temporary employment contracts should generate a higher degree of uncertainty among workers and, therefore, they will seek to live in rented housing, pushing up demand and price, both in the short run and in the long run.

Second, we should expect that a positive shock in the number of mortgages granted should facilitate access to home ownership, so rental demand should fall in the short term, as should the price. Moreover, in the long run, easier access to mortgages should lead to more housing being built in the following years, some of which will be destined for rental housing, so that the supply of rental housing will increase, reducing the price.

Finally, a greater concentration of economic activity should generate a migration process towards cities with more employment opportunities, so that the demand for rental housing in these areas should grow strongly, generating price-increasing trends.

Section VI: Methodology

This section explains the methodologies applied for data analysis. First of all, tests are used to know the order of integration of the data series, then it is explained what type of model is estimated, a VAR, and also its prerequisites and the specification, causality and iteration tests, and then another model is explained, which is a Bayesian VAR, where it is explained, in essence, what the informative priors are and how they are chosen in this report, in addition to commenting on the characteristics of the iterations.

Unit roots testing methodology

In this dissertation, firstly, we apply unit roots test with the objective of discriminate between test and stationary time series, in other words, we test for the order of cointegration of the variables.

First, we apply the Augmented Dickey-Fuller test, it consists of testing the significance of the parameter δ for a specification. There are three types of specifications: without constant, with constant and with constant and trend.

$$\Delta y_t = \beta_1 + \beta_2 t + \delta y_{t-1} + \sum_{j=1}^{k} \gamma_j \, \Delta y_{t-j} + u_{1t} \; (with\ constant\ and\ trend)$$

$$\Delta y_t = \beta_1 + \delta y_{t-1} + \sum_{j=1}^{k} \gamma_j \, \Delta y_{t-j} + u_{1t} \; (with\ constant)$$

$$\Delta y_t = \delta y_{t-1} + \sum_{j=1}^{k} \gamma_j \, \Delta y_{t-j} + u_{1t} \; (without\ constant)$$

The intuition of this test is that there is a unit root in the time series that we are testing if the value $\delta = 0$ and there is not integration of order 1 if $\delta < 0$. All the specifications of the test are considered for all the variables and the critical values are provided from Dickey and Fuller (1981).

Moreover, we use an additional test for testing unit roots, this method is known as ERS test or ADF-GLS test (Elliot, Rothenberg and Stock, 1996) and it eliminates trends and constants of the data and applies a ADF test in the transformed data.

We apply both versions of the test, the "P-test" which considers serial correlation of the error term and the "DF-GLS" version which is an Augmented Dickey-Fuller test applied to the data with without intercept and detrended. Detrended and without constant specifications are considered and the critical values are from MacKinnon (1991) and Elliot, Rothenberg and Stock (1996).

Vector Autoregression methodology

Two Stationary Vector Autoregressive Models are performed, these models have been popular during the last 30 years because the influence of Sims (1980). They are a hybrid model between univariate time series models and simultaneous equations models. At a theoretical level, all components of the VAR should be stationary, the presence of unit roots in the variables can be resolved by taking first differences of the variables, however, by doing so any long-run relationship between the variables is lost.

Therefore, the first of the SVAR models to be estimated is in first differences. First differences are taken to eliminate unit roots and thus have stationary time series of the changes in the variables. By taking first differences, we lose part of the information contained in the database but we can estimate a short-term model and we can study the instantaneous effects of some variables on others.

The second SVAR model estimated is in levels, estimating a model in levels we can examine the long-run relationship, but first the stability of the model must be ensured by testing if in the VAR process there are roots in or on the complex circle. If it is the case that there are unit roots in the time series, but the VAR model has roots outside the complex circle, it means that there is some degree of cointegration in the variables, which is captured in the VAR model.

It has to be noticed that the order of the variables is important for the decomposition and the orthogonal iterations, for this reason an order of variables must be chosen that makes economic sense. The order considered for the variables is:

Concentration of economic activity (A), Temporary Employment (T), Mortgages (M) and House Rent Prices (R). This ordering means that the fluctuations of the prices for renting a house can be affected contemporaneously by the other variables. What is expected in this order of variables is that the concentration of economic activity is an engine of employment generation, so it will directly affect the amount of temporary employment contracts signed, likewise, the employment and economic stability of the population should affect the amount of mortgages granted to citizens and finally all the variables should affect the nominal price of rental houses, so this should be in the last position being affected by all the others components.

Then, we can formally write the notation of these SVAR models with 4 variables and k lags:

$$\begin{pmatrix} R_t \\ T_t \\ A_t \\ M_t \end{pmatrix} = \begin{pmatrix} \beta_{R0} \\ \beta_{T0} \\ \beta_{A0} \\ \beta_{M0} \end{pmatrix} + \begin{pmatrix} \beta_{R1} & \alpha_{R1} & \gamma_{R1} & \delta_{R1} \\ \alpha_{T1} & \gamma_{T1} & \delta_{T1} & \beta_{T1} \\ \gamma_{A1} & \delta_{A1} & \beta_{A1} & \alpha_{A1} \\ \delta_{M1} & \beta_{M1} & \alpha_{M1} & \gamma_{M1} \end{pmatrix} \begin{pmatrix} R_{t-1} \\ T_{t-1} \\ A_{t-1} \\ M_{t-1} \end{pmatrix} \dots \begin{pmatrix} \beta_{Rk} & \alpha_{Rk} & \gamma_{Rk} & \delta_{Rk} \\ \alpha_{Tk} & \gamma_{Tk} & \delta_{Tk} & \beta_{Tk} \\ \gamma_{Ak} & \delta_{Ak} & \beta_{Ak} & \alpha_{Ak} \\ \delta_{Mk} & \beta_{Mk} & \alpha_{Mk} & \gamma_{Mk} \end{pmatrix} \begin{pmatrix} R_{t-k} \\ T_{t-k} \\ A_{t-k} \\ M_{t-k} \end{pmatrix} + \begin{pmatrix} u_{Rt} \\ u_{Tt} \\ u_{At} \\ u_{Mt} \end{pmatrix}$$

Or we can use the more compactly version, where g is the number of variables of the system, in this case $g = 4$ and capital Y, u and beta are matrices of variables, error terms and betas:

$$\underset{gx1}{Y_t} = \underset{gx1}{\beta_0} + \underset{gxggx1}{\beta_1 Y_{t-1}} \dots + \underset{gxggx1}{\beta_k Y_{t-k}} + \underset{gx1}{u_t}$$

Prior to the estimation of the model, we need to determine the appropriate lag length of the VAR model, in this problem, economic theory is of little help. To make the choice we can use two methodologies, the first one the cross-equation Restrictions VAR lag length or alternatively, the information criteria for VAR lag length selection. We will use the second methodology for the election. Since we want to apply these criteria to a VAR model, we must use the multivariate versions of the information criteria:

$$MAIC = \ln|\sum| + 2\,\varphi/T$$

$$MHQIC = \ln|\sum| + \frac{2\varphi}{T}\ln(\ln(T))$$

Where $\sum$ is the variance-covariance matrix of the residuals, T is the quantity of observations and φ is the total number of regressors in all equations which will be equal to $p^2k + p$ for p equations and variables and k lags. The chosen number of lags is than minimizes the value of the information criteria.

Once the VAR model has been estimated, we perform some specification tests on the residuals of the model. The autocorrelation test used is multivariate Portmanteau and Breusch-Godfrey test, which the null hypothesis is that there is not serial autocorrelation. Moreover, a test for normality is performed, in this case the one used is a multivariate Jarque-Bera test which the null hypothesis is the normality of the residuals and finally, a multivariate ARCH-LM test for a VAR is carried out, with a null hypothesis of absence of ARCH effects in the residuals, then we would consider that there is not heteroskedasticity. The aim of these test is to validate whether the VAR is correctly specified.

Then, we test for stability of the model, using CUSUM test based on OLS residuals, this test computes an empirical fluctuation process according to a specified method from the generalized fluctuation test framework. In concise manner, we try to find out whether any shock die out quickly or deviations are no transitory or if the model is unbounded and the process is explosive.

Moreover, a condition for the stability of the VAR model is that it has not roots in or on the complex circle. The VAR model can be written in a first-order vector autoregressive form, the companion form:

$$y_t = \beta_0 + \beta_1 y_{t-1} \dots + \beta_k y_{t-k} + u_t$$

$$y_t - \beta_1 y_{t-1} \dots - \beta_k y_{t-k} = \beta_0 + u_t$$

$$(I - \beta_1 y_{t-1} \dots - \beta_k y_{t-k}) y_t = \beta_0 + u_t$$

$$B(L) y_t = \beta_0 + u_t$$

Where $B(L)$ is an n+n matrix polynomial in the lag operator L.

The stable VAR, that has roots outside the complex circle must satisfy that:

$$I - \beta_1 z - \beta_2 z^2 \dots - \beta_k z^k = 0$$

This is analogous to the condition that all eigenvalues of the companion matrix B have value lower than 1.

$$Y_t = \beta_0 + \beta_1 Y_{t-1} \dots + \beta_k Y_{t-k} + u_t$$

$$Y_t = \beta_0 + B(Y_{t-1} \dots Y_{t-k}) + u_t$$

Where B is the companion matrix of the parameters.

Then, if the eigenvalues of the companion matrix B are computed and all of them are below 1, it means that the model is stable, regardless of whether the variables that have been used have a unit root.

And the test of causality of the variables (Granger, 1969) are carried out. These tests are based on F-tests of the jointly significance of parameters in the equations estimated by the VAR model. These tests try to determine whether the lags of a variables causes effects on the current value of other variable (or the same variable). The examination of the causality in a VAR indicates which variables have statistically significant effect on the subsequent values of each of the variables of the system, nonetheless, the test of causality can not indicate the sign of the relationship or the persistence of the shocks.

Finally, using bootstrapping a shock in the error term is generated and the effect is transmitted to the variables of the VAR model, the iteration is the representation of the effects of this variable. The impulse response affects all variables, and the shocks of these variables influence of the variables themselves and so on. Some of the characteristics of the impulse response used in this report are: the effect of the shock is taken into account up to 30 subsequent periods, the cumulative effect and the time effect of each period are presented separately, the confidence interval for the bootstrapped error band is 0.68 and the number of runs per bootstrap is 5000.

Bayesian VAR methodology

Complementary to the VAR model, a Bayesian VAR model is estimated, which is a VAR model by introducing prior information within Bayesian framework. In the context of Bayesian Econometrics, a prior information is specific information about a variable. To be a bit more specific, in Bayesian VAR analyses, prior information is the imposition of structure on the coefficients of the model. By applying an informative prior to the model, we are adding an additional constitution to the model that can be very useful to avoid the over-estimation of parameters, known as the curse of dimensionality, and to improve out-of-sample predictions, as well as making the model more flexible and reducing estimation errors.

Moreover, using Bayesian VAR, inference is not performed through t-statistics and frequentist asymptotic theory, so the order of integration of the variables is not a drawback and the variables do not need to be stationary for the analysis.

The use of informative priors can have the benefits discussed above, but it is an essential point in Bayesian VAR analyses and the choice of which informative prior to use is important. Therefore, it is also an important line of research for academics, who have already tested many types of priors in the previous literature. Some of them have used flat priors (Stein, 1956), others with the intention of maximising out-of-sample forecasting (Litterman, 1980) or have used in-sample fit as a decision criterion (Bańbura, Giannone, and Reichlin, 2010).

Giannone, Lenza, and Primiceri (2015) propose a form of prior selection, this methodology is based on hierarchical modelling, that is, the decision of which information prior to apply is made on the basis of data-fashion, in other words, the informative priors are treated as another parameter to be estimated. In this report is used this methodology for the prior information selection.

In a BVAR analysis, Bayes theorem is applied to obtain the posterior distribution for the parameters using the likelihood function obtained from the sample and the information priors. The posterior probabilistic distribution can be expressed as:

$$p(\delta|y) = \frac{f(y|\delta)p(\delta)}{f(y)}$$

$$p(\delta|y) \propto f(y|\delta)p(\delta)$$

Where $p(\delta|y)$ is the posterior distribution conditional to the sample information included in the vector y, $f(y|\delta)$ is the likelihood function acquired from the data, $p(\delta)$ is the prior distribution about the parameters. In fact, $f(y)$ is only for standardising so we can consider the second version on the equation.

However, considering the methodology of Giannone et al. 2015, where the prior information depends on hyperpriors and hyperparameters, the Bayes theorem and the posterior probabilistic distribution can be rephrased as:

$$p(\mu|y) \propto f(y|\delta,\mu)p(\delta|\mu)p(\mu)$$

Where μ is the set of hyperparameters.

Giannone et al. 2015 uses as a baseline the Minnesota prior (Litterman, 1980) and in addition to this the sum-of-coefficients prior and the single unit-root prior for refinements of the Minnesota. These complementary priors are intended to improve the prior baseline.

The hypothesis of the Minnesota prior (Litterman, 1980) is that all individual variables follow random walk processes. Generally, this process generates good predictions of macroeconomic variables in the time series and it is commonly used to assess the quality of models.

The Minnesota prior is characterized by the following moments:

$$\mathbb{E}\left[(\boldsymbol{A}_s)_{ij}|\Sigma\right] = \begin{cases} 1 \ \ if\ i = j\ and\ s = 1 \\ 0 \quad otherwise. \end{cases}$$

$$cov\left[(\boldsymbol{A}_s)_{ij}, (\boldsymbol{A}_r)_{kl}|\Sigma\right] = \begin{cases} \lambda^2 \dfrac{1}{s^{\alpha}} \dfrac{\Sigma_{ik}}{\psi_j/(d-M-1)} \ if\ l = j\ and\ r = s \\ \qquad\qquad 0 \quad otherwise. \end{cases}$$

The essential hyperparameter λ regulates the tightness of the prior, that is, it ponders the relative influence of prior and data. Governing the variance deteriorate with increasing lag order, α adjusts the degree of contraction for more distant observations and finally, ψ_j , the j-th variable of ψ conduct the priors standard deviation on lags of variables different than the dependent (Kuschnig and Vashold, 2020).

In the model that we estimate, the value of Lambda (λ) is estimated using hyperparameters. Lambda hyperparameters have been set to minimum 0.0001 and maximum of 5. Alpha (α) and Psi (ψ) are set automatically by default. In relation to the sum-of-coefficients prior and the single unit-root prior the Minnesota, they have been assigned a maximum value of 50 and a minimum value very close to 0. The values of the priors are estimated by the software using the parameters and the data provided.

The estimation of the BVAR also requires a selection of the number of lags to be considered by the model, in this instance the number of 2 lags has continued to be used. Once estimated we also generate the iterations of the shocks in the variables, in this case 10000 iterations have been used as this number of iterations is common when using the R software (Kuschnig and Vashold, 2020).

As in previous VAR models the order of the variables has been taken into account, the identification of nominal rental price shocks has been done using the Cholesky factorisation, maintaining the order that has been used so far. Recall that in this order the last of the variables is the nominal price of rental houses, so it can be affected by the other components of the analysis.

Finally, as previously discussed, inference in Bayesian VAR models is not done through the t-statistics. For this reason, iterations cannot have confidence intervals; instead of confidence intervals, confidence bands are used to find out whether the effect of a shock is statistically significant.

The next section will present the results achieved by applying the methodology described in this section and will comment on the results, with more emphasis on the graphs of the iterations.

Section VII: Econometric Results

This section presents and discusses the results of applying the methodologies considered in the previous section. The results of the unit roots tests, the estimates generated by the VAR models in first differences and in levels and the estimates generated by the Bayesian VAR model are displayed.

Unit root test results

Before estimating the models, it is necessary to know whether the variables are stationary. A brief glance at figure 1 shows that none of the variables is an I(0) process. Nevertheless, in this section some tests will be carried out to confirm what type of process each variable is.

Table 2: Unit Roots Augmented Dickey-Fuller tests

Augmented Dickey-Fuller test	Model with Trend & Constant			Model with Constant		No C & T
	τ_τ	$\emptyset_2$	$\emptyset_3$	τ_μ	$\emptyset_1$	τ
R	-1.51	1.92	2.25	0.08	0.60	1.10
T	-2.38	1.93	2.86	-2.29	2.66	-0.47
A	-2.74	5.03 (**)	4.72	-1.80	4.15 (*)	2.14
M	-1.42	2.10	2.81	-2.1	2.55	-1.57

Table 3: Unit Roots Elliot-Rothenberg-Stock Test

Elliot-Rothenberg-Stock Test	Model Trend & Constant		Model Constant	
	P_T^τ	$DF-GLS^\tau$	P_T^μ	$DF-GLS^\mu$
R	35.36	-2.36	85.15	0.38
T	26.95	-1.60	18.45	-0.73
A	19.18	-0.83	71.23	0.77
M	67.18	-0.80	88.91	-0.26

The results of the Augmented Dickey-Fuller tests are provided in table 2, the 3 types of test specifications used are: without constant, with constant and with trend and constant. For each test, the number of lags for endogenous variables to be included is 3.

From the results, it can be observed that none of the δ[7] values are not significantly different from 0, for that reason, we cannot reject the null hypothesis that the process is I(1) and therefore, all variables can be considered to be unit root processes, in other words, all variables are not stationary.

In order to confirm what is stated in the previous paragraph, an additional test is applied to check for unit roots in the time series. The results of the ERS test for the unit roots are presented in table 3. The conclusion is exactly the same, we cannot reject the null hypothesis that there is a unit root. With this additional information, it can be confirmed that the variables are unit root processes and, therefore, are not stationary time series.

First differences model results

Table 4: First differences model - lag length selection

	Maximum lags = 2	Maximum lags = 4
$MAIC$	2	2
$MHQIC$	1	1

Table 5: First differences model - specification tests

	Chi-squared	Degree of freedom	p-value
Portmanteau and Breusch-Godfrey test (Autocorrelation)	162.64	240	1.00
Multivariate Jarque-Bera test (Normality)	634.94	8	0.00 (***)
Skewness	85.80	4	0.00 (***)
Kurtosis	549.14	4	0.00 (***)
Multivariate ARCH test (Heteroskedasticity)	450	500	0.95

Once we know that the time series have unit roots, we estimate a Stationary VAR model with the variables in first differences, for the purpose of finding out how the variables are related in the short run.

First, the appropriate number of lags must be chosen for the model to be estimated, for which the information criteria methodology for VAR lag length selection is applied. For each information criterion a maximum of 2 and 4 lags have been chosen, the results are shown in table 4, where it can be seen that the MAIC criterion selects the model with 2 lags while the MHQIC criterion selects the model with 1 lag.

As there is no clear choice between estimating the model with 1 lag or with 2 lags, it has been chosen to use 1 so that a smaller number of parameters are estimated.

[7] The values to which this delta refers are the equations explained at the beginning of section VI: Methodology.

Once the number of lags in the model has been chosen, it is estimated. The coefficients of the VAR model are not presented as they do not have a clear interpretation by themselves. The estimated parameters are not important information, especially if we have taken first differences for the short-run interpretation. For this reason, the model itself is not presented in this section.

Table 5 displays some specification tests of the fist differences VAR model. The first of the tests presented is the null hypothesis of no autocorrelation of errors. Looking at the results presented in the first row, we cannot reject the null hypothesis of this test, so we can say that there is no autocorrelation in the errors.

In addition, in the next three rows the normality, kurtosis and skewness tests are reported. In this case, we do reject the null hypotheses, so we can consider that the errors are not normally distributed, which is not optimal, but this is not a big problem at a practical level.

Finally, the last row of the table shows the results of the ARCH-LM test for a VAR. The null hypothesis of this test is that there are no heteroskedasticity problems. The null hypothesis of the test cannot be rejected, so it can be considered that there is no heteroskedasticity.

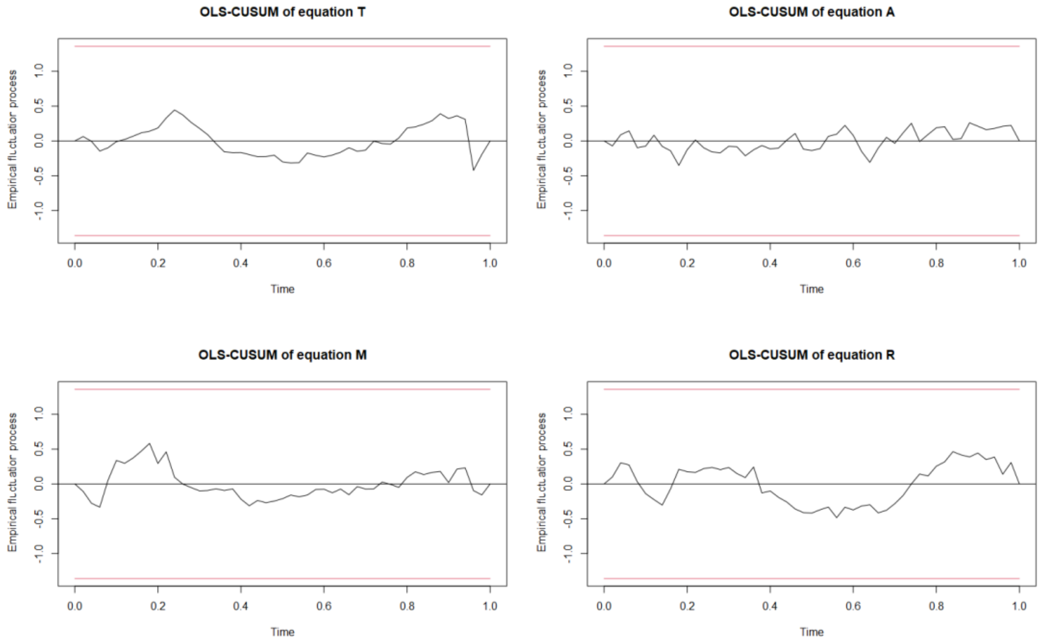
Therefore, in summary, the specification tests show that there may be problems in the non-normal distribution of the errors but there is no problem of heteroskedasticity or autocorrelation. So, we should have no problems in using this model for the analysis of short-run house rental prices being affected by the other components of the VAR.

Table 6: First differences model – causality tests

	Granger Causality				Instantaneous Causality		
	F-Test	Df1	Df2	p-value	Chi-squared	df	p-value
R	3.22	3	176	0.02 (**)	3.08	3	0.38 (**)
T	0.08	3	176	0.97	7.60	3	0.05 (**)
A	1.94	3	176	0.12	1.34	3	0.72
M	0.94	3	176	0.96	5.13	3	0.04 (**)

Furthermore, to ensure that the model is adequate it is required that it is also stable, for this, in figure 2 the stability tests of the first difference model are presented, a quick look at the graphs presented allows us to know that the models are stable, none of the variables exceed the confidence intervals, so there is none of the variables that are explosive.

Figure 2: First differences model - stability test



Moreover, a VAR model will be stable when it has no roots in or on the complex circle or equivalent, the eigenvalues of the companion matrix are below 1. The eigenvalues of this model are 0.88 0.23 0.23 0.03, for this reason we can consider that the model of first differences is stable. This was very much expected, because by taking first differences we make the resulting time series stationary, so it should never give stability problems.

To study the causality of the variables, two tests are carried out, the Granger test and the instantaneous causality test. The results of both are displayed in Table 6. Regarding the Granger tests we can comment that only the price of rental flats affects the other variables. In relation to the instantaneous causality tests, there are more variables that affect the other variables: rental prices, the amount of loans and the level of temporary employment affect each other and also the other variables. In contrast, the level of economic concentration does not affect the other components of the model, it does not have a significant causal effect.

Once the causality of the variables has been examined, the next step is to know the sign or direction of the changes and the magnitude of the variation that prices would have in the event of a shock. Specifically, the graphs in the first figure refer to the effects of the shocks at each individual period while the other figure contains the graphs of the cumulative effect of the shocks.

For each graph, the horizontal axis is the number of quarters that have passed since the shock occurred while the vertical axis measures the effect of the shock on the variable under study, in this case, the index of house rental prices. It should be noted that the index of nominal house rental prices is a value judiciously close to 100, since over the whole time series its minimum value is 94.18 and the maximum 103.67, therefore, the value of the vertical axis will be a value reasonably close to the percentage change in nominal house rental prices.

Panel A of Figure 3 shows the effect of a positive nominal rental price shock of one standard deviation on the same variable. In the presence of a shock of this category, prices initially grow by 0.08 and the effect is maintained for almost 25 periods, although it is gradually reduced.

Similarly, Panel A of Figure 4 shows the cumulative effect of this shock, reaching after 30 quarters a total increase in nominal rent prices of 0.7, so that the shock increases by about 0.7%.

The representation of a one standard deviation shock in the number of temporary jobs is shown in Panel B. The effect of the shock is not sufficient, it is not significantly different from 0 although graphically it can be seen that the effect is positive, with a rise in temporary employment prices seem to tend to increase. In Panel B of Figure 4 we see that the cumulative effect is not significant either.

Panel C of Figure 3 shows the effect of a shock in the quantity of loans granted; a shock in this variable causes an initial fall of 0.02 in nominal rental prices. The effect remains significant until 10 quarters after the increase in mortgages, at which point the effect of the initial shock disappears.

In Figure 4 we can observe the cumulative effect of the shock, where we can see that the total effect of the shock after certain periods, so we can conclude that a one standard deviation shock by increasing the number of mortgages granted causes a fall in the price of rents of 0.17, which would be a fall of about 0.17% in rental prices.

Finally, the effect of a shock on the level of concentration of economic activity does not have a significant effect on nominal rent prices. Panel D of both figures shows that there is no sufficient effect, so it is statistically equal to 0.

Summarising the iterations of the model in first differences, we can say that the effect of a shock on rental prices is obviously transmitted in a short-run rise in the nominal price of rents. In addition, we also know that a shock where the number of mortgages granted increases leads to a short-run fall in rental prices. Shocks in the other variables do not have a significant value for rental prices in the short run.

In levels model results

Once the VAR model in first differences has been carried out, a second VAR is estimated using the variables in levels with the aim of ascertaining the medium-long term effect of the variables. To do so, the same steps are followed as those used in the VAR in first differences.

Table 7: In levels model - lag length selection

	Maximum lags = 2	Maximum lags = 4
$MAIC$	2	2
$MHQIC$	2	2

Table 8: In levels model - specification tests

	Chi-squared	Degree of freedom	p-value
Portmanteau and Breusch-Godfrey test (Autocorrelation)	155.44	224	1.00
Multivariate Jarque-Bera test (Normality)	873.53	8	0.00 (***)
Skewness	113.36	4	0.00 (***)
Kurtosis	760.18	4	0.00 (***)
Multivariate ARCH test (Heteroskedasticity)	450	500	0.95

Figure 3: First differences model - Impulse responses

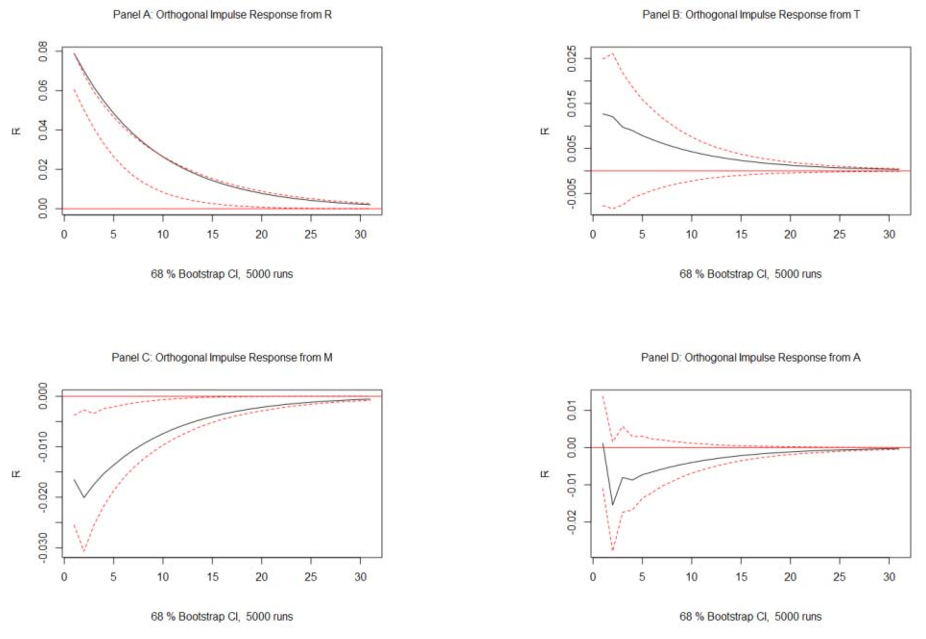
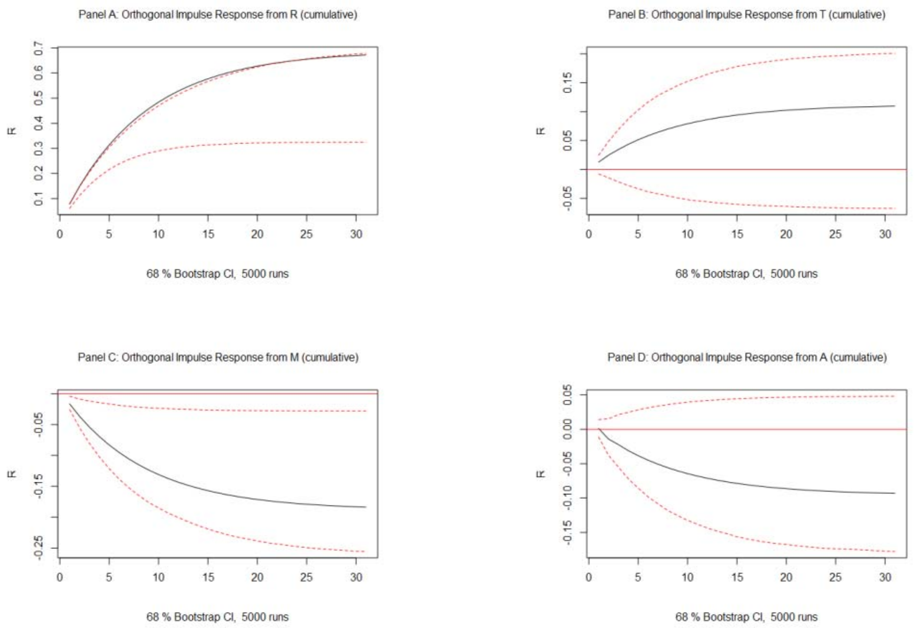


Figure 4: First differences model - Impulse responses (cumulative)



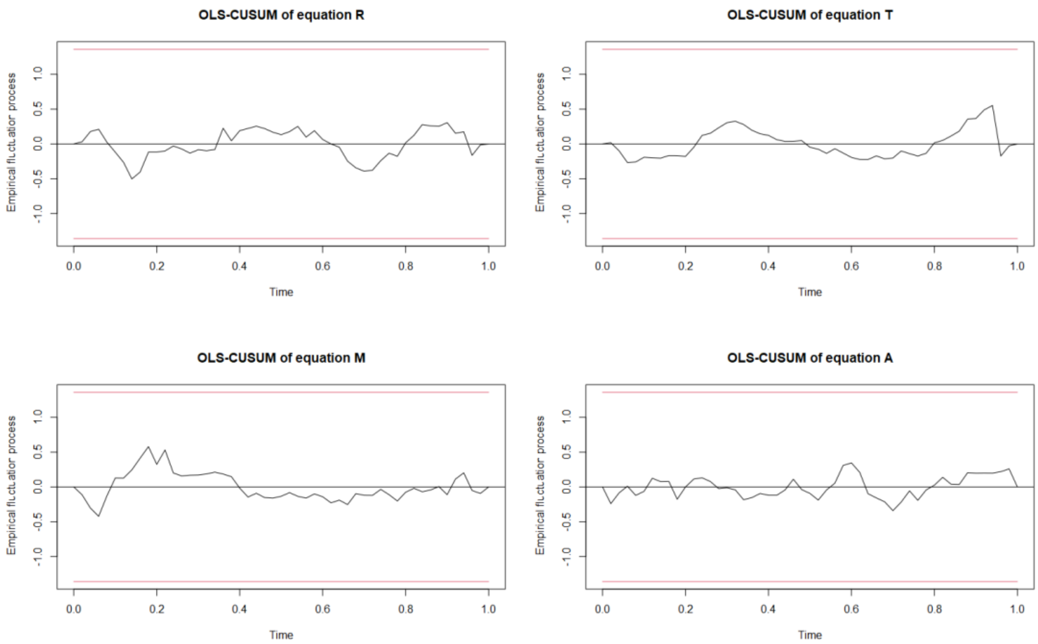
For the data in levels, the number of lags selected is two as can be seen in table 7, in this case both criteria do coincide, therefore the decision is taken directly from the test results. Therefore, we now estimate the VAR model with 2 lags and using the time series without taking first differences. Again, we do not present the coefficients of the model VAR because the same reasons that were previously explained for the first differences model.

Table 8 displays some specification tests of the in levels VAR model. We can see that the problems are the same as in the first difference model. First of all, it can be seen that there is no problem of autocorrelation of the errors since the null hypothesis of the test presented in the first row of the table cannot be rejected.

On the other hand, there are problems of normality, the errors are not distributed following a normal distribution, to which we can also add that there are problems of kurtosis and skewness as shown in the following rows of the table.

Finally, we cannot reject the hypothesis of no heteroskedasticity which is presented in the last row of table 8. Therefore, there are normality problems but no autocorrelation or heteroskedasticity problems, just as in the VAR model in first differences presented above. It is not a big problem not to satisfy the normality hypothesis for the interpretation of iterations and causality.

Figure 5: In levels model - stability test



In the same way as with the first VAR model, after knowing that the model is adequate we need to ensure that it is a stable model, for this we apply the stability tests presented in Figure 5. As none of the graphs the value of the variable explores and exceeds the red edges, we can say that the model is stable and that no variable explodes in the face of shocks.

Moreover, the roots of the companion matrix must be examined, for a stable VAR model the eigenvalues must be below 0. In this model the eigenvalues are: 0.93, 0.93, 0.56, 0.56, 0.43, 0.43, 0.18 and 0.18. Because all the eigenvalues are lower than 1 it can be considered that the model has not roots in or on the unit circle. Knowing this result and knowing that non-stationary components have been used, it can be said that the model has picked up part of the trends and that there was some cointegration between the variables taken into account by the VAR model.

Table 9: In levels model - causality tests

	Granger Causality				Instantaneous Causality		
	F-Test	Df1	Df2	p-value	Chi-squared	df	p-value
R	2.12	6	160	0.05 (**)	4.90	3	0.18
T	2.16	6	160	0.05 (**)	8.79	3	0.03 (**)
A	1.40	6	160	0.21	1.11	3	0.77
M	1.64	6	160	0.14	7.07	3	0.07 (*)

Once we know that the model is stable and has no major problems in its specification tests, we can test the causality of the variables on each other. Table 9 presents both the Granger causality tests and the instantaneous causality tests for each variable.

Granger tests suggest that changes in nominal rent prices have a significant effect on the other variables, they have an effective causality. In addition, the level of temporary employment in the country also influences the other variables, changes in temporary employment cause changes in the other components of the model. In contrast, neither the number of mortgages granted nor the level of concentration of economic activity has a significant causal effect on the other variables.

With respect to the instantaneous causality tests, the results are quite different. In that tests it is the price of house rents and the index of concentration of economic activity that have no instantaneous causality on the other variables in the model. In contrast, the level of temporary employment and the number of mortgages granted do have instantaneous causality, so that shocks to these variables will have an immediate effect on the other variables.

In the end, Figures 5 and 6 present the iterations of the VAR model that affect the nominal prices of rental flats.

Panel A of Figure 5 shows the effect of a one standard deviation rental price shock. In the first period there is a rise in the price index of 0.06 and the effect grows until period 5 where the shock reaches its maximum effect, causing rises of 0.1. From the sixth period onwards, the effect decreases every quarter until it dies out between periods 15 and 20, when it ceases to have a significant effect.

Regarding the cumulative effect, Panel A of Figure 6 shows that such a shock causes a rise of 1.5 in the nominal price index of rental houses, which would be approximately a 1.5% rise in prices.

A shock of a one standard deviation increase in the level of temporary employment is depicted in Panel B of Figure 5, in this graph it can be seen that the effect of the shock does not start to become significant until the second or third period, where a rise in rental prices is observed. This effect continues to grow until period 6 where the shock reaches its maximum effect and from that point onwards the effect starts to decrease, becoming insignificant again in quarter 15 after the shock occurs. Figure 6 Panel B also shows the total effect of the shock on rental prices, raising prices by 2 points, which would be approximately 2% higher after the full effect of the shock.

In relation to the concentration of economic activity, a shock in this variable would cause what is represented in Panel D of Figure 5. Although the sign is as expected, a greater concentration in economic activity would cause a rise in rental prices, the effect of the shock, as can be seen, is not significant, therefore we can say that it is not statistically different from 0.

Finally, Panel C of Figure 5 shows the effect of a shock on the number of mortgages granted. As can be seen in the graph, the effect does not appear until period 5, until just over a year after the shock occurs. Surprisingly, the effect on prices is upward, it causes a rise in rental prices, which is surprising and just the opposite of what happens in the first-differences model seen in Figure 3 Panel C. In the fifth quarter the price starts to rise, and it reach the maximum at the period 15, From period 15 onwards, the effect of the shock begins to diminish but is persistent until beyond the 30th trimester.

Panel C of Figure 6 shows the total effect of the shock on the number of mortgages signed, generating a rise in the nominal price index of rents by 3 points, which in percentage terms would be close to a 3% rise in the price of rents.

Among the conclusions of the VAR model in levels, once the long run is analysed, it can be observed that, obviously, a rise in nominal prices causes them to grow. Moreover, a positive shock to temporary employment also causes an increase in nominal rental house prices in the long run and the concentration of economic activity still does not have a significant effect as in the first-differences model where the short run is analysed. Finally, a shock that increases the amount of loans granted in the long run generates a rise in prices, the complete opposite effect to that observed in the short-run analysis.

Bayesian model results

Finally, the analysis using the Bayesian VAR model is presented. As mentioned in section VI Methodology, we follow the process of choosing priors based on Giannone et al. (2015), where the base-line prior is Minnesota while two complementary priors are also added, namely the sum-of-coefficients prior and the single unit-root prior. In addition, the parameters of these priors are calculated hierarchically based on the data.

The estimated values for the priors are the Lambda of the Minnesota prior is 0.01719, the value of the sum-of-coefficients prior is 4.4127 and the estimate of the single unit-root prior is 2.42812.

Once the parameters of the priors have been estimated and the number of lags chosen, which were two lags, the model is estimated. As in the previous models, we do not present the coefficients generated by the model since their interpretation is not relevant and we will focus on the analysis of the shocks, their effects and the iterations.

Figure 6: In levels model - Impulse responses

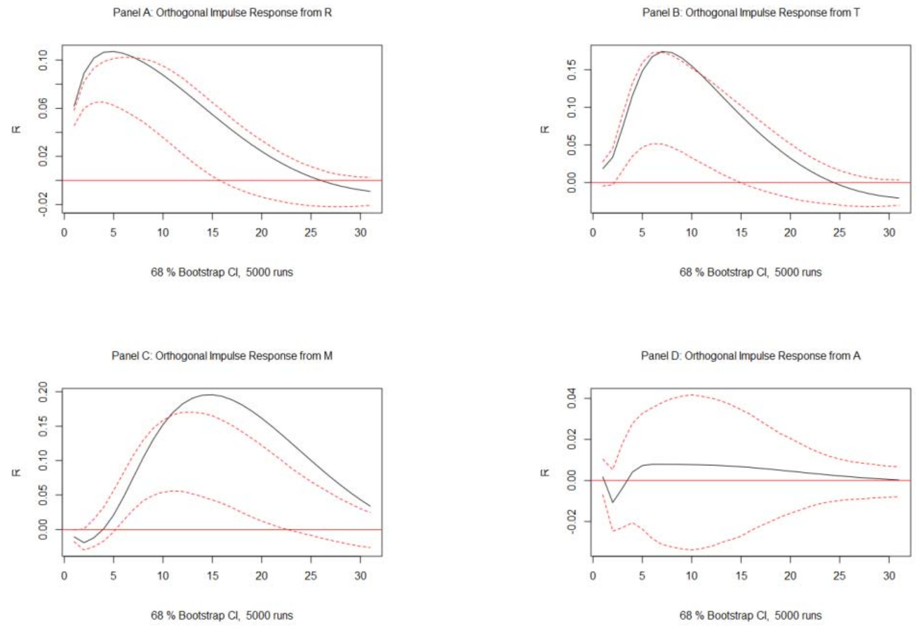
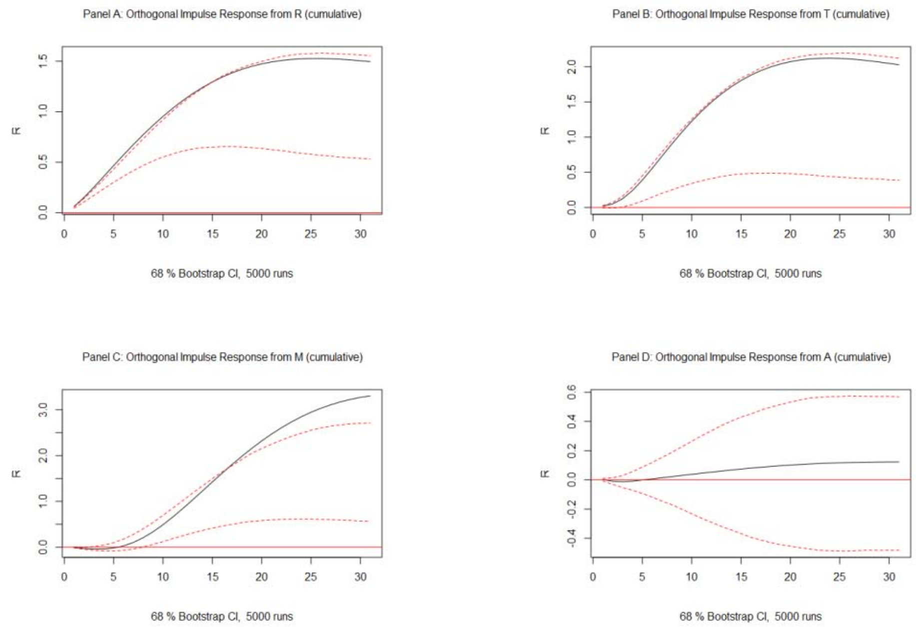


Figure 7: In levels model - Impulse responses (cumulative)



A Bayesian VAR model takes into account the long-run relationships of the variables, and of course, this long-run relationship is reflected in the shocks and in the graphs of the iterations presented below.

Figure 8: Bayesian model - Impulse responses

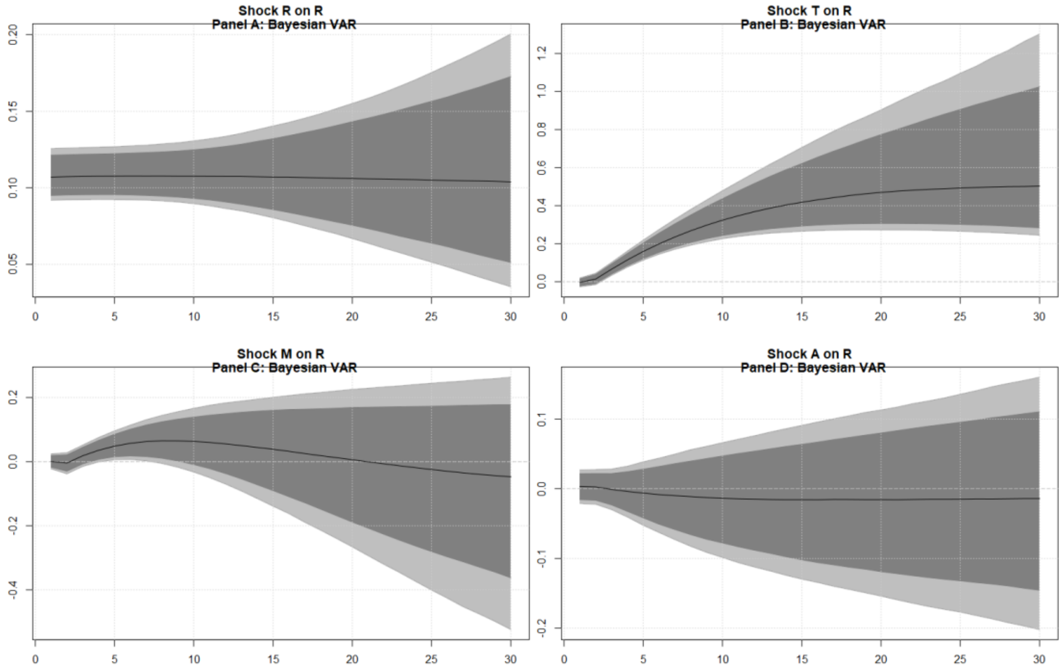


Figure 8 is displaying the iterations of the shocks and their effects on nominal rental house prices estimated by the Bayesian VAR model. On the horizontal axis we can see the periods after the shock and on the vertical axis the change in the price index.

In Panel A we can observe the effect of a shock in nominal rental prices on the same prices, in the graph we can see that it has a clear significant and positive effect, that is, prices grow as expected. The magnitude of the effect is a rise of about 0.1 in the rent price index.

A shock in the number of temporary employment contracts signed and its effect on the price of rents is presented in Panel B of Figure 8. This graph is very similar to the one shown in Panel B of Figure 7, where the cumulative frequency of the VAR model with the variable in levels was presented. The big difference between the models is that the magnitude of the effect in the Bayesian VAR is notably smaller, reaching a rise of only 0.4 points in the rental price index, while in the other model the variation was up to 2 points in the price index.

Panel D shows the effect on rental house prices of a shock to the level of concentration in economic activity, which as in the previous two models is not significant, as the value of 0 is always contained within the confidence bands.

The last of the shocks is depicted in Panel D. In this panel we can observe the effect of a shock in which the number of mortgages granted grows by one standard deviation. The effect on rental prices is a negligible increase, a very low value and not significant until period 5. As in the VAR model with the variables in levels, the variation in prices is an increase, although the magnitude is much smaller than in the VAR model. As can be seen, the increase in prices is the opposite effect to what was observed in Panel C of Figure 4, where in the VAR with the variables in first differences a shock of these characteristics generated a fall in the nominal prices of rental houses.

A summary of the analysis of the BVAR iterations is that the effects of the shocks are very similar to the shocks in the VAR model with the variables in levels, except that the magnitude of the changes is much smaller in the Bayesian VAR model. Both models measured the relationship in the long run, so it seems reasonable that the iterations generated are similar in both models.

Section VIII: Conclusions

This section discusses the conclusions drawn from the analysis of the results.

VAR models are useful to know what the relationships are in the short run, in case of using variables in first differences, or in the long run, in case of using variables in levels. In addition, the estimation of the Bayesian VAR model also captures the long-run relationship between the variables, which reinforces the conclusions drawn from the use of the VAR models.

It was expected that increases in the variable for the number of temporary employment contracts would generate job and wage instability for workers, so that instead of buying their own homes, they would live in rented housing for the duration of their temporary contracts, and for this reason, an increase in the price of rents should be observed.

Once we observe the short-run relationship of both variables, we do not observe this effect, variations in temporary employment in the short-run do not significantly affect the variable of nominal rental prices, however, when we observe the long-run relationship, both in the VAR model with the variables in levels and the Bayesian VAR model, a causal relationship between the amount of temporary employment and rental prices does appear: in the long run, a shock in employment does lead to an increase in rents. Therefore, it can be considered that the effect of the shock in temporary employment does not have an effect in the short run, that is, at the immediate level, but over time it can be seen to push nominal rental prices up.

The relationship between the level of concentration of economic activity and nominal rental prices was expected to be positive, in other words, it was expected that an increase in the level of concentration of economic activity in certain regions or cities would generate areas where many job and academic opportunities appear. Therefore, many people should migrate to the most economically active areas and regions to seek employment or training, the arrival of new citizens in these areas should significantly increase the demand for rental housing and therefore increase market rental prices.

Having performed the analysis with the VAR model in first differences, it can be confirmed that there is no causal relationship from the level of concentration of economic activity to rental prices in the short run, this could be considered normal, as we would expect that it should take some time from the moment when the level of concentration of business activity increases until a significant migratory movement takes place. However, when looking at the long-run relationship using the VAR model with the variable in levels and the Bayesian VAR, it can be seen that there is also no significant long-run relationship between the two variables. Therefore, it can be considered that the influence of the concentration of economic activity in a region is not sufficiently important to cause variations in rental prices, neither in the short term nor in the long term.

The expected relationship between the number of mortgages granted and the nominal price of rental housing was that an increase in the number of mortgages granted, due to, for example, a reduction in the warranty required for the granting of mortgages, would make it easier to buy a house. So that the demand for rental housing should fall considerably, as should the price of rental housing, since many of the potential tenants of such rental housing would opt to buy their own home. Moreover, this reduction in rental prices in the long run should carry more weight, since, assuming that more loans are granted, part of these loans should go to real estate projects, where new buildings and houses are constructed. Some of this housing should be used for rental housing, so that the supply would increase, causing prices to fall even more sharply over time.

When the results of the VAR model are analysed in first differences, it can be seen that there is a relationship as expected, since a shock in the number of mortgages granted is reflected in a fall in rental prices in the short term. As for the VAR model in levels and the Bayesian VAR model, they show a completely unexpected long-run relationship, since the effect generated by an increase in the level of mortgages granted is transmitted as a long-run increase in the nominal prices of rental housing. Thus, a shock that increases the ease of access to mortgages generates in the short run a decline but in the long run causes a rise in prices.

The growth of rental prices in the long term when the amount of loans granted increases seems totally counter-intuitive and contrary to expectations about this variable. One of the possible explanations is that, as already explained, as the amount of money lent increases, real estate projects are generated and part of the construction and housing created is leased. The point is that these new constructions have much better characteristics than the houses that already existed in the rental market, probably the new residential areas are located in strategic places, where there are good connections with public transport, are areas with better neighbourhoods or simply, are larger houses, with more rooms and with more updated services, therefore, the new rental houses that are offered in the market have much better characteristics than the existing ones and therefore this are offered at a much higher price, which with the passage of time increases the nominal average price of the rental houses. This is only a hypothesis, so further research will be required to go deeper into the subject and to better understand how the mortgage sector is related to the rental housing market.

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