

Implicit house prices: variation over time and space

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Abstract

This paper is concerned with implicit prices of housing characteristics based on asking price. The paper employs a large database from the Spanish housing market with models generated to explain how the pricing of attributes varies by region and how variation over time impacts on explanatory power. Attribute values are shown to be stable among regions but weights change with time suggesting that the perception of attribute values in asking price formation varies across the housing market cycle. It is shown that clustering by time tends to give higher parameter values and places more relevance on neighbourhood values.

Keywords: Asking Price, housing market, hedonic models

JEL classification: R21, R31, D46,

1. Introduction

House prices are characterized by heterogeneity arising from observational issues. Much of the research in the field, both from the perspective of theory and empirical analysis, has been centred on the application of hedonic techniques which consider that price is obtained from a combination of attributes reflecting household preferences. In this respect, price captures how each household evaluates attributes with respect to income, education and household circumstances. According to Rosen (1974) a 'joint-envelope function' captures the structure of consumers' preferences and producer technologies. In essence the hedonic embraces a combination of attributes which are common to demand and supply with estimation possible from both demand or supply price observations dependent on model specification. Muellbauer (1974) for example adopted a demand-side approach in the application of hedonic theory to a constant utility price index. .

This paper utilises the hedonic method to define implicit prices of characteristics using asking prices, the supply side of the market, and not transactions. Asking prices encapsulate a set of housing characteristics that refer to both supplier features and buyers' features with the residuals considered to capture information about sellers' preferences. The use of asking or list price is not unusual in the housing literature, for example time on the market is often based on list price (Knight et al, 1998, Arnold, 1999, Anglin et al, 2003). Indeed, **analyses based on list price avoid the** transaction biases associated with indices based on sale prices (Pryce and Mason, 2006).

This paper utilising a major valuation database from the Spanish housing market assesses how implicit prices vary over time and space and seeks to identify which of these is the more important. The former captures the dynamics of change whereas the latter embraces different market and economic structures, household variation and sentiment. In this respect, the paper extends the existing literature base by examining whether and how parameters change. In essence the paper tests the null hypothesis that time and space effects do not modify the value of hedonic parameters and that they are constant over time and space. The particular research question tested is whether parameter weights are stable or change over time according to position in the cycle; Rosen's hypothesis was that any change is related to change in quality. The paper is organized as follow. The second section reviews the literature on hedonic house price modelling, section three provides details of the database and variables used in the analysis. In section four the analytical models are outlined. Section five presents the results of clustering by province and by time draws. In Section six clustering effects by both space and time are discussed. In Section seven shocks in estimated parameters are considered and section eight draws conclusions to the paper.

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2. Literature review

The literature on hedonic models is well established and used, in the main, to estimate quality adjusted house price indices (Rosen, 1974, Linneman, 1980, Haurin et al, 1991, Peek and Wilcox, 1991, Geltner, 1993, Adair et al, 1996, Clapp, 2003) or to test the impact of different characteristics on the level of prices and their evolution (Goodman and Thibodeau, 1995, Clapp and Giaccotto, 2002, Bourassa et al, 2005). However,

some authors argue that hedonic models are characterised by econometric problems and thus provide limited accuracy in the estimation of house prices (Goodman and Thibodeau, 1995, 2003). This has raised questions concerning the ability of hedonic methods to capture the full behaviour of house prices with authors such as Case and Wachter (2005) arguing that hedonic models focus on internalising the dynamic evolution of the market.

The majority of hedonic-based papers are based on the seminal work of Rosen (1974) adopting the view that the coefficients reflect the market's valuation of housing attributes, derived from the interaction of supply with demand. Most papers use demand variables (income, taste) in hedonic models to estimate implicit prices. Rosen distinguishes between hedonic and implicit prices stating that *“Buyer and seller perfectly match when their respective value and offer functions kiss each other, with the common gradient at that point given by the gradient of the market clearing implicit price function $p(z)$. Observations of $p(z)$ represent a joint envelop of a family of value functions and another family of offer functions”* (Rosen, 1974, pp 44).

Rosen's arguments are summarised by Equations 1 and 2

$$p_i(z) = F_i(z_1 \dots z_n, Y_1) \dots \text{demand equation} \quad (1)$$

$$p_i(z) = G_i(z_1 \dots z_n, Y_2) \dots \text{supply equation} \quad (2)$$

Y_1 denotes the empirical counterparts of α^1 , including income and taste variables such as age, education

¹ α is defined by Rosen as the parameter that differs from person to person.

Y_2 denotes the empirical counterparts of β^2 , characteristics of the sellers and factor price and specific technological differences among them (if developers).

$F_i(z, Y_1)$ represents the marginal demand price for z_i

$G_i(z, Y_2)$ represents the marginal supply price.

Y_1 and Y_2 are exogenous demand and supply shift variables

The implicit marginal prices are $\delta p(z)/\delta z = \pi_i(z)$ for each buyer and seller.

Y_1 and Y_2 represent the suppliers and buyers features and are the bases of the differentiation of the product suggesting that the impact of implicit characteristics on housing prices depends on the demand and supply characteristics, separately. However, Rosen (pp54) clearly argues that the estimated hedonic price-characteristics functions typically identify neither demand nor supply but are described by a joint-envelope function.

Harding et al (2003) demonstrate that prices are related to the household's bargaining power. The bargaining power and the negotiation process may also affect the implicit prices of housing characteristics (Harding et al, 2003). In expanding these relationships Capozza et al (2005) highlight how the economic environment influences the negotiation process and ultimately the selling price, thus any variation in economic circumstances across the cycle will in turn impact on price and bargaining positions. Chen and Rosenthal (1996) place emphasis on the importance of the asking price in influencing bargaining power and is the initial signal in the negotiation between buyer, seller and agent. Yavas and Yang (1995), suggest that a higher asking price leads to

² β reflects underlying variables like factor prices and production function parameters

longer time on the market and Arnold (1999) considers that asking price influences the rate at which offers arrive as well as acting as an initial offer in the bargaining game.

The approach adopted in this paper explores attributes from the perspective of asking prices. Essentially, the hedonic model expresses housing prices as the combination of attributes (Z)

$$phf_t = \alpha_{1t} + \Psi(Z)_t + \mu_t \quad (3)$$

where $Z_t = \{x_1, x_2, x_3 \dots x_n\}$ is the matrix of n housing attributes evaluated from the owners' perspective, α and Ψ are vectors of parameters and μ is the error term.

3. Data

The analysis underpinning this paper is based on an extensive valuation database from the Spanish housing market over the period 1995-2008³. Table 1 shows the distribution of the data over the time series from 1995 to 2008. The database includes evidence from the whole of Spain but there is a strong regional presence in the provinces of Alicante, Valencia and Murcia and significant activity in the two major provinces of Spain, Madrid and Barcelona. Due to the size of the database and the expanding geographical remit of the valuation company from which the data were sourced during the observed period, the total available database was reduced in order to provide homogeneity and avoid outliers. More specifically, for the purpose of the analysis, only data from seven provinces were included: Alicante, Valencia, Murcia, Madrid,

³ The data was supplied by TABIMED, one of the largest valuation companies in Spain.

Barcelona, Castellón and Balearic Islands, each of these provinces having a large representation across each year of the data set. The net effect was to reduce the number of properties considered for the analysis to 2,183,089 observations.

Insert Table 1

The variables in the database were sub-divided into three groups. The first sub-set consists of housing and building characteristics, the second neighbourhood and environmental features and the third is the asking price of each property plus other valuation information. The analysis utilises 35 variables; 12 relating to the property, 21 neighbourhood variables, the year and the asking price (Table 2).

Insert Table 2

In Spain, the asking price of properties is used in the valuation process as comparable evidence. It is important to stress that these comparables (or testigos) were at the time of entry in the database non transacted properties. The price trend (mean price) over the period 1995-2008 demonstrates differences between each of the seven provinces (Figure 1). For example, in Madrid the distribution is distinctly different from most other provinces, although Barcelona shows a similar pattern from 2002. [Asing](#) prices started to rise strongly in Murcia, Valencia and Alicante 1999, whereas in Madrid and Barcelona this effect was observed two years later, in 2001. Such differences suggest that the clustering effect should be examined at an individual province level.

Insert Figure 1

The valuation database is essentially a pool of data but also has features associated with panel data. It contains a large number of different characteristics of the property, several of which are qualitative variables assessed on a scale basis. Thus there is the potential that the database contains a degree of endogeneity in similar attributes and non-independence. Hence the adoption of a non-linear method of estimation to avoid potential biases from the endogenous and/or correlated independent variables. Econometric theory recommends that when there is large panel data with time and space basis, a two step non parametric methods should be used to estimate the model (Wooldridge, 2001).

4. Model theory and development

The analysis seeks to identify the role of attributes in explaining the asking prices for properties over the period 1995-2008 and assesses how exogenous changes affect residential pricing prior to noise introduced at the start of the bargaining process between the buyer, the seller and the agent. Complexity arises from the size of the database, the extent of geographical coverage (seven provinces) and the time series (14 years). The analysis isolates the space effect to allow for the different provinces and time effects to capture annual variation. The hedonic coefficients are compared to assess the impact of bias in the estimation.

4.1 Defining the statistical problem

This involved formulating a hedonic model to obtain the implicit prices of the characteristics. The model at this stage included data for all seven provinces and all fourteen years of the time series. The equation follows a general form of the hedonic model as expressed in Equation 2 and fitted using the 2SLS method⁴.

The result from the general hedonic equation has a low goodness of fit ($\text{Adj } R^2=0.463$) and a high value of standard error ($\epsilon>67,080$). All variables apart from Qschool are significant at a 0.01 of confidence. Those variables which have positive impact on asking price include the floor area of the property; not an unexpected outcome as most other studies in the literature have found similar relationships. Amongst those other variables having strong positive impact are transport accessibility in terms of proximity to a metro station, economic activity, income and building type. These variables are consistent with the wider literature on hedonic modelling (Theriault et al, 2003). Similarly, those variables that have a strong negative impact are reflective of the literature, and in this study include age of building, quality of the road network in the neighbourhood, and construction quality of the building. Overall, the specification of the model, as checked by correlations among variables and residuals, is appropriate ($\text{Corr}(X_t, \epsilon_t)=0$). However, the high errors suggest the possibility of non independence and the existence of cross correlation. The distribution of the residuals confirms

^{4 4} The Two Stage Least Squared method used here is the standard non linear method one with a constant, including the independent variables both as predictors and instruments and with a 100 maximum number of iterations. The 2SLS estimate in two stages. The first is the OLS regression where each variable is regressed against the set of instruments, and the second is the regression of the original equation where all variables are replaced by the fitted values obtained from the first stage regression. In this procedure, both stages are simultaneously estimated to obtain the reported 2SLS estimates. All estimated equations include also an ANOVA analysis with results rejecting the evidence of equality of means in all equations.

autocorrelation. It is also probable that the overall model incorporates a firm (space) effect (Figure 2), a form of dependence among the residuals in panel data set estimations, the presence of which generates estimation bias (Petersen, 2007, Skoulakis, 2006, Primo et al, 2007).

Insert Figure 2

There are two general forms of dependence. The residuals of a given firm/cluster/group may be correlated across years (time series dependence); this is the time effect (Wooldridge, 2003). The second form is when the residuals of a given year may be correlated across different firms/clusters/groups (cross-sectional dependence); this is termed the firm or space effect.

In a linear model, both could be expressed as in Equation 4:

$$Y_{it} = \alpha + X_{it}\beta + v_{it} \quad (4)$$

Y = dependent variable

X= set of independent variables

v = error term

With the observations belonging to different groups (i) across years (t), the model is robust when X and v are assumed to be independent with zero mean and finite variance: that is $\text{Corr}(X_{it}, v_{it})=0$ and $\text{Cov}(X_{it}, v_{it})=0$.

In fitting the traditional model the existence of correlation within the residuals and variations of parameters among the firms/groups means that $\text{Cov}(X_{it} v_{it}, X_{it-k} v_{it-k}) \neq 0$. This condition gives residuals which are not independent and produces biased estimated

parameters. Under such circumstances, the residual contains a firm specific component (γ_i) and the idiosyncratic error component (ε_{it}) (Petersen, 2007) expressed as:

$$v_{it} = \gamma_i + \varepsilon_{it} \quad (5)$$

X may also contain a firm specific component (μ_i) and a time varying component (η_{it}), such that

$$X_{it} = \mu_i + \eta_{it} \quad (6)$$

with γ , ε , μ and η independent of each other, with zero mean and finite variance.

It is also possible to find the presence of time effects in a panel. The bias produced by time effects, cross-correlation bias, assumes that errors are not independent due to the existence of autocorrelation among residuals, that is $\text{Cov}(X_{it} v_{it}, X_{kt} v_{kt}) \neq 0$. Considering only time effects, the residuals from the general model contain a time specific component (δ_t) and the idiosyncratic error component (ε_{it}):

$$v_{it} = \delta_t + \varepsilon_{it} \quad (7)$$

X also contains a time specific component (ζ_t) and a time varying component (η_{it}):

$$X_{it} = \zeta_t + \eta_{it} \quad (8)$$

Petersen (2007) considers that when only a firm effect exists standard errors are unbiased, however there is a need to estimate the effect of clustering by time when the

source of the bias is the time correlation⁵. The requirement is for residuals to be uncorrelated across clusters. Errors and variables related with firm and time effects are as expressed by Equations 9 and 10.

$$v_{it} = \gamma_i + \delta_t + \varepsilon_{it} \quad (9)$$

$$X_{it} = \mu_i + \zeta_t + \eta_{it} \quad (10)$$

Parametric methods of decomposition may be used when dependence is correctly specified allowing the effects of firm or time dependence to be removed and errors to be unbiased. This occurs when the firm or time effect are constant, although this type of dependence is not usually clearly identified⁶. Non-parametric methods are adopted when the dependence form is not precisely known, in this case the solution recommended by the econometric literature is to cluster by the two dimensions (firm and time) combining the standard errors and isolating much of the bias.

5. The evidence of clustering effects

This section of the paper utilizing the theory and the initial overall analysis specifically tests for the clustering effect by generating models for each of the seven provinces and time effects by generating models for each of the fourteen years. In total 98 models were estimated (7x14) with the specification shown in Equation 4 obtaining the different parameters showed in Equations 5 to 8.

⁵ Using time dummies is a common approach to remove the correlation between observations due to time, when the time effect is fixed. Only the firm effect is left in the data. When time effect is not fixed, dummies cannot remove the dependence and standard errors obtained are biased.

⁶ A parametric method to isolate the biases have been estimated here finding that the firm and time effects are not constant. Results could be sent by request.

5.1 The clustering effect by space

For each of the models generated at a province level (Table 3), the goodness of fit is better than the overall model and ranges between 0.534 for Murcia to 0.635 for Barcelona. The value of standard errors ranges from 40,216 (Murcia) to 82,759 (Madrid). For five of the provinces (Alicante, Murcia, Valencia, Castellón and Balearic Islands) the standard errors are lower than the overall model, but for Barcelona and Madrid they are larger⁷. The standard error estimates by province are either lower or in the case of Madrid and Barcelona not sufficiently larger than the White Standard Error obtained from the overall model suggesting that the firm effect is present in the database, although not appearing to introduce any strong bias in the model. It seems that clustering by province gives better results in explaining asking prices than the overall model. This outcome is consistent with housing theory which frequently refers to location as a key variable in explaining housing price main differences.

Insert Table 3

The analysis by province highlights similar influences with parameters showing considerable consistency in explaining asking price. Economic activity and total population has a positive effect in all regions, though is stronger in Alicante, Valencia

⁷ For all models, the specification has been checked using the same procedure described in the overall model ($\text{Corr}(X_t, \epsilon_t) = 0$). It should also be stressed that all models estimated have large sample size avoiding the biases on hedonic coefficient that could exist due to a reduction of the sample.

and Castellón than in Murcia, Madrid and Barcelona. Resident population has a strong impact on Valencia, Madrid and Castellón, but not in Alicante, Murcia or Barcelona. A similar perspective is apparent with population growth having a strong impact in Alicante, Murcia, Valencia and the Balears, but not in Barcelona or Castellón and negative impact is evident for Madrid.

Insert Table 4

Similar results are obtained for neighbourhood characteristics (Table 4). Income and density of population are positively related to asking prices, but with differing effect. For instance in Alicante, Valencia, Madrid and Castellón asking prices discount strongly by income level rather than population density but in Murcia, Barcelona and the Balears population density explains the increase in asking prices better than income. The character of the residential area encapsulates the impact of second homes and the importance of mixed residential areas in increasing asking prices in the provinces, but not in Madrid and Barcelona.

An unexpected outcome is the negative impact of the quality of roads; seemingly the closer the property is to major highways the less value is added to asking price. This observation is apparent in all regions, though Madrid, Barcelona and the Balears have a lower estimated parameter value, and could be interpreted as the asking prices assigning more value to isolated houses. The impact of underground stops is relevant in the main cities notably Madrid and Barcelona, and also Valencia province. The presence of a bus stop has similar effect in the provinces, but in Madrid, Barcelona and the Balears this variable is discounted negatively when close to the property. Table 6

also considers the impact of different facilities. For example, proximity to retail facilities and the quality of the water system have positive impacts; however schools and the health system appear to be evaluated in different ways depending of the provinces. For instance, to be close to a hospital is positive (and reflected in an increased asking price) in Madrid, the Balears and Castellón, but negative in Alicante, Murcia, Valencia and Barcelona. Proximity to churches increases asking prices in Murcia, Valencia and Madrid, but not in the other provinces. Schools positively impact on asking price in Alicante, Valencia, Murcia, the Balears and Castellón, but not in Madrid and Barcelona.

Regarding property characteristics, the most relevant, as frequently articulated in the literature, is the size of the house (square metres) which positively affects the asking price. This relationship is strongest for Madrid, Barcelona and the Balearic Islands⁸. Asking prices also react negatively to the age of property, reducing the perceived price although in Madrid and Barcelona this variable has a very low impact.

The parameters obtained for the full sample differ from the value observed in each province suggesting bias in the aggregate data. Also, different dynamic behaviour is apparent between the provinces suggesting that information about asking prices contained within the residuals differs amongst the regions. This infers that the housing markets may be subject to different shocks.

5.2 The clustering effect by time

⁸ This seems to neglect some results from the literature which sustain that the larger houses produce decreasing prices (in terms of the price by unit metre).

This aspect of the analysis includes data for all provinces collectively, analysed by each individual year (Table 5)..⁹ The goodness of fit for each year exceeds the overall model (0.46) and ranges between 0.48 (2004) and 0.71 (1996-1997) (Table 5). The higher adjusted R^2 values suggest that those models fitted on an annual basis show greater accuracy due to the elimination of cross correlation among the residuals. The standard errors are much lower than the overall model. For example, at the start of the time series (1995-1999) the respective values of the standard errors are very low, circa 1/5 of that of the overall model indicating a much better fit of the hedonic model to asking prices. In the middle part of the time series the standard errors increase, though standard error is still appreciably lower than the overall model. At the end of the time series, 2007-2008, standard errors exceed that for the overall model.

Insert Table 5

Autocorrelation effects among the residuals appear to be eliminated and no time-trend component is apparent when the data are clustered by time. The distribution of the residuals seems to reflect white noise, around zero, and finite standard deviation (Figure 3).

Insert Figure 3

⁹ The models clustered by time have large sample size and hence avoid the potential bias on hedonic coefficients arising from small samples

Table 6 shows the estimated parameters for the models, clustered by time. In particular, these results demonstrate how the parameters' values change depending on the time period for which the models are estimated. Most of the parameters remain relatively consistent around the same values until late 1990s but have experienced change (rising and falling) in the subsequent years. For city parameters, asking prices become more sensitive to economic activity from 2000, while urban dependence and population increase their influence from 2004 (Figure 4a) and is seemingly capturing the effect of population growth close to the major cities of Madrid, Barcelona and Valencia where infrastructure development has increased the accessibility of locations close to these cities. The influence of second homes locations increases from 2000 as does the role of income from 2004; whereas density of population plays a negative role in the perception of the house prices from 2004. Accessibility attributes have more stable values until 2005, though underground stop becomes more important from 2006 and the quality of roads from 2004. In the neighbourhood parameters, the strongest influence is the quality of retail area which became negative from 2004, the existence of a good system of water supply (relevant from 2005) and school areas from 2004.

Regarding property characteristics the most relevant determinant of asking price is the size (Sqm_t) (Figure 4b) though there has been a reduction in the influence of this variable from 2004. Other variables which are important are the view, construction quality, the existence of lifts and the availability of extra surface in non-covered areas. However, all of these have reduced influence from 2004 onwards, in contrast neighbourhood income level increases its influence on the asking price. In relation to physical characteristics, a number of attributes have negative impact namely age and density of dwellings ($Ndwe_t$).

Insert Figures 4a and 4b

Figure 5 compares the average weights of the parameters of the models clustered separately by time and space. A high element of commonalities exists with similar values and signs for the parameters. The main differences are in some neighbourhood variables namely school quality, health quality, accessibility to bus stop and proximity to a church. The size of the property is the most important parameter in both models but lower impact on asking prices when clustered by province relative to clustering by time.

Insert Figure 5

6. Clustering by time and space

Clustering by both time and space together produces a substantially better fit to the model for all provinces compared to clustering by time alone (Figure 6). In all cases the goodness of fit follows a similar time pattern with higher estimation at the start of the time series (1995-1997) and thereafter the explanatory power reduces until 2004 and subsequently increases over 2005-2008. For example, the hedonic analysis for Madrid explains over 90% of the asking prices in 1995 reducing to 69% in 2003 and raising to 84% in 2008.

Insert Figure 6

This aspect of the analysis shows that parameter signs are consistent with the results obtained from the clustering by time and space separately. A number of attributes have a positive relation with asking price; for example the level of income, the quality of construction, lift, views and the character of the neighbourhood. However, the values of the parameters differ by province reflecting varying levels of importance placed on them and in arriving at asking price. For example, views are highly valued in Alicante, Murcia, Valencia, Castellón and Balearic Island but are not of the same importance in Barcelona or Madrid. Income level of the city shows similar parameter values but there is variation at a neighbourhood level; the latter being of greater importance in fixing the prices in Alicante, Murcia and Valencia. The presence of lifts in apartment buildings has a higher importance in Madrid and lower in the Balearic Islands. Negative coefficients characterise age in most provinces but not in Barcelona and Madrid while density (number of dwelling units in the building) has a negative affect mostly in Alicante, Murcia and Castellón, but not elsewhere. The character of the area is of particular relevance in the most tourist-orientated provinces, (Castellón, Murcia and Alicante) with the effect of increasing asking prices where there is the greatest concentration of second homes.

Attributes that characterise urban areas, such as the type of the city, size of population, population density, the extent of urban consolidation and income level, have similar weights across the provinces and all have a positive effect, though some attributes relating to the quality of the neighbourhood and facilities differ by province. For instance, the quality of the water system is negative in Alicante (a province with water shortages), placing constraints on the development process. The analysis shows that the quality of schools is positively perceived in Barcelona, Valencia and Murcia, while the

quality of shopping areas is more valued in Alicante and Murcia. Accessibility is perceived favourably when transport facilities (train station or underground) is in close proximity to the property and has greatest relevance in Madrid, Barcelona and Valencia.

Figure 7 is an example of one parameter, age of the building, obtained by clustering by time and space.

Insert Figure 7

7. Shocks in estimated parameters

The results from each of the exercises: clustering by time, clustering by space and clustering by both time and space, suggest that clustering does not affect the role (sign) of the parameters rather influence the scale (parameter value) of the attribute in pricing the house supporting econometric theory. The pattern of the results suggests that a shock has affected asking price formation, changing the role of the attributes during the period of the analysis. These changes are accompanied by a reduction in the explanatory power of the models and have the appearance of a shock hitting the previous model equilibrium, supporting the contention that those attributes explaining housing prices change with time.

In order to identify whether attributes have been submitted to a permanent or transitory change (which could impact on the explanatory power of the model), the attributes

parameters clustered by time and space are used to test the existence of a structural change (equation 11)¹⁰.

$$\varphi_{\text{int}} = \Psi(\text{dumm})_t + \mu_{\text{int}} \quad 11$$

φ_{it} is the vector of estimated coefficient for attribute i in the year t and province n
 dumm_t is a matrix of yearly dummies being $t=1995 \dots 2007$
 μ the random component.

The analysis (Table 6) indicates that six attributes change parameter value according to exogenous changes namely: Popgrowth, Qshop (quality of shopping area), Qhealth (quality of health equipment), Lift (existence of lift in the building), Ndvwe (number of units in the complex (apartment building or condominium) and Popdens_t (population density in the building). The relationship is statistically significant and positive suggesting that these parameters have experienced changes due to an exogenous shock. A number of these parameters as highlighted in Table 6 are characterised by a permanent shock¹¹ consistent with changes in population and also with changes in building quality.

Insert Table 6

A second group of attributes have experienced either a short term or temporary shock on their values namely: Qwater (quality of water) for which a significant parameter for the external shock is estimated from 1998 onwards but this loses significance in 2006;

¹⁰ This test is similar to estimate a chow test to find the effect of an exogenous structural change

¹¹ Permanent shock is considered to take place when all parameters are statistically significant (table 6).

Qschool (quality of schools) which shows statistically significant changes on the parameter for all years until 2004, and Train (proximity to train station). Statistically significant estimation for View means an improvement in a property's location on the observed properties. The positive significance of these attributes suggests that improvements in quality have led to changes in their hedonic prices which have increased marginally until 2005-2006. Other related transport variables, the availability of buses received a short term shock being statistically significant (negative) during 1999-2000 and 2002-2003. Three attributes usually relevant to the explanation of hedonic prices are shown to have evolved in different ways. Age of the house has a statistically significant shock (negative) during all years until 2004 suggesting that the hedonic readjusts the implicit price over the time series up to the year 2004, beyond which age appears to stop affecting prices. Similar interpretation might be advanced for the quality of construction, although the significance of shocks affecting the changes on this hedonic parameter is less clear.

Other variables do not seem to be submitted to external changes; these include income, economic activity of the town, urban dependence, road quality, leisure and quality of sport facilities, and quality of the shopping area close to the property. This suggests that these variables do not change due to a shock and are stable during the period. The latter infers correlation among the components affecting the individual who fixes the price (Y_2 in the Rosen nomenclature) and the (theoretically) fixed hedonic parameters.

8. Conclusions

This paper evaluates the role of housing and related attributes in explaining asking prices in the Spanish market over a long-run period from 1995 to 2008. The paper utilises hedonic models to fit the pricing process and observe how the parameters change with time and space. In this respect the paper makes an important contribution to the literature through application to the Spanish market for which there has been little previous analysis in the international literature but, more significantly, the paper adds to the knowledge base on how parameters can change over the property market cycle and spatially at a macro-level by province. The former reflects the dynamics of the market and the latter captures the effect of different perceptions of the value of housing and housing-related parameters by region arising from different economic, social, cultural and household structure issues.

The modelling process estimates the bias due to the firm (space) effect and seeks to isolate this in order to obtain robust attribute parameters. The results illustrate that the structure of attribute values is stable among regions but weights change with time suggesting that the perception of attribute values in asking price formation varies depending on the position in the housing cycle. It is shown that clustering by time tends to give higher parameter values to city and house attributes rather than clustering by space, which places more relevance on neighbourhood values.

The study adds evidence to the literature regarding how a large database with observations split across space could incorporate bias in hedonic models if not controlled by time and which is not necessarily eliminated if controlled by location. The results infer that models which use a constant weight for attribute parameters in valuations produce bias and the risk of mis-estimation of price. This highlights the

difficulty of accurately valuing a property depending on position in the cycle with the variation between a traditional valuation and the owner's estimated price a function of housing expectations.

The paper shows that changes in attributes parameters could be due to a permanent shock related to population growth, increased density, improvement to the infrastructure and other factors. However, for this dataset changes in the attributes stopped in 2005 with a stabilization of the value of the parameters. These results offer a new perspective as to how hedonic models capture existing shocks on housing markets through the perception of value and how this relates to the asking price; a key step in the price formation process in housing markets. Furthermore the analysis suggests that the difference between asking prices and hedonic prices could be a measure of market information and subjective perception, and that the information about asking prices contained within the residuals infers that housing markets may be subject to different pricing patterns.

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Table 1. FINAL SAMPLE USED INTO THE MODELS FROM THE VALUATION DATABASE

	Nº properties	% of TOTAL OBSERVATIONS included in the DB	Provinces						
		%	Alicante	Murcia	Valencia	Madrid	Barcelona	Castellón	Baleares
1995	45381	99.7	23406	10545	9612	376	0	164	1278
1996	88233	99.7	41326	25822	17801	372	12	0	2900
1997	105074	99.8	49688	32040	20476	97	0	0	2773
1998	120746	98.4	56554	27825	25899	3150	1624	2435	3259
1999	149150	95.8	63691	30138	29650	9923	5300	6823	3625
2000	140495	94.5	63231	27128	26944	9581	5942	4925	2744
2001	168548	94.1	70928	32515	32557	14253	9261	5819	3215
2002	220997	94.5	88120	39123	41810	22696	15634	8190	5424
2003	251229	94.2	91981	49084	53415	24173	17803	8905	5868
2004	98082	91.6	35660	17241	22212	8090	7587	4274	3018
2005	429661	84.4	133713	76868	98598	39073	39972	27725	13712
2006	377548	80.8	120429	75812	76414	29604	33107	28958	13224
2007	289191	81.1	94567	62774	51890	23619	25652	21447	9242
2008	122735	81.9	47085	29268	19637	7980	5738	9505	3522
Total	2607079	88.8	980379	536189	526915	192990	167632	129170	73804

Table 2		VARIABLES INCLUDED IN THE ANALYSIS	
Property variables		Range	
1	Year	age- number	Year when the testigo was observed
2	Sqm_t	surface- m2	Testigo's surface (m2)
3	Lift_t	lift - number	Number of lifts
4	Constq_t	0= very low, 6= superior plus extras	Quality of construction
5	Inc_t	1=very low, 7= very high	Income level in the testigo property building
6	Type_t	1= flat building, 2= detached homes and 3=house with green area	Type of building
7	Ndwe_t	number of dwellings	Number of dwellings in the testigo's building
8	Age_t	age, number	Current age of the testigo
9	View_t	0= degraded area or interior house, 1=narrow street, 2= avenue or street, 3= 2nd line to the see or significant element in the city, 4= facing the see, sea or square/garden see, 5= sea/significant location front see (first line), 6= exceptional	Quality of the views from the testigo
10	Qshop_t	0= do not exists, 1=very deficiency, 2= deficiency, 3= basic, 4= acceptable, 5= good, 6= very good	Quality of the shopping areas
11	Popdens_t	1= low, 2= medium, 3= high	Population density in the building where testigo is located
12	Orient_t	0,1= north, 1= northwest, 2= west, 3= southwest, 4= northeast, 5= East, 6=south, 7= southeast	Subject property orientation (north, south...)
13	Sqmnoc_t	surface- m2	Surface in non-cover areas in the testigo property
14	Ph	price, number	Asking price
Neighbourhood variables			
15	Popdens	1= low, 2= medium, 3= high	Population density in the neighbourhood
16	Qshop	0= do not exists, 1=very deficiency, 2= deficiency, 3= basic, 4= acceptable, 5= good, 6= very good	Quality of trade and shoping facilities
17	Income	1=very low, 7= very high	Income level in the testigo area
18	Cons	ranged from 1 to 100	Area consolidation
19	Qlight	0= does not exists, 1=very deficiency, 2= deficiency, 3= acceptable, 4= good, 5= very good	Quality of light network in the neighbourhood
20	Qsport	0= does not exists, 1=only in city area, 2= deficiency, 3= limited, 4= acceptable, 5= all type of sport equipment	Quality of the sport facilities
21	Bus	0= does not exists, 1=only in city area, 2= insufficient and scarce, 3= sufficient, 4= Urban network, 5= inter-urban network	Number of buses lines
22	Qrelig	0= does not exists, 1=only in city area, 2= scarce, 3= limited, 4= sufficient, 5= all type of religious centers	Level of religious facilities
23	Resarea	1= firs residence, 2= mix between 1st and 2nd residence, 3= 2nd residence, 4= business and shoping area, 5= industrial	If only first residencial, mixed between first and second residence area, only second residence area, industrial, business or shoping area.
24	Popgrow	0= negative, 1= slow or stable, 2= positive	Population dynamism
25	Ecoact	1= agricultural, 2= industry, 3= tourism, 4= services, 5= multiple	Economic activity in the area: Agricultural, industry, services, tourism
26	Train	0= does not exist, 1= it exists on proximity, 2= it exists in the municipality	Train stop available
27	Qroad	0= do not exists, 1=very deficiency, 2= deficiency, 3= acceptable, 4= good, 5= very good	Quality of the roads
28	Qhealth	0= does not exists, 1=only in city area, 2= scarce, 3= limited, 4= sufficient, 5= all type of health centers	Level of health assistance facilities
29	Urbanenv	1= rural, 2= suburban, 3=urban	Type of urban area
30	Qwater	0= does not exists, 1= deficiency, 2= acceptable, 3= good, 4= very good	Quality of water network supply
31	Qschool	0= does not exists, 1=only in city area, 2= scarce, 3= limited, 4= sufficient, 5= all type of school centers	Quality of School facilities

32	Urbandep	1= urban area dependent of other municipality, 2= autonomous municipality, 3= county capital, 4= province capital and national capital	Urban dependence:
33	Qleisure	0= does not exists, 1=only in city area, 2= scarce, 3= limited, 4= sufficient, 5= all type of leisure centers	Quality of leisure facilities
34	Underg	0= does not exist, 1= it exists on proximity, 2= it exists in the municipality	Underground stop
35	Regpop	number of persons	Total population registered

Table 3 Non parametric general cluster model results

Table 3 2SLS MODEL: RESULTS OF THE HEDONIC MODEL OF ASKING PRICE clustered by firm								
Dependent variable: asking price of testigo i								
Years	1995-2008							
TOTAL	TOTAL SAMPLE	Alicante	Murcia	Valencia	Madrid	Barcelona	Castellón	Baleares
Multiple R	0.6804	0.7890	0.7404	0.7756	0.7803	0.7970	0.7841	0.7865
R Square	0.4630	0.6225	0.5481	0.6015	0.6088	0.6352	0.6148	0.6185
Adjusted R Square	0.4630	0.6224	0.5345	0.6015	0.6087	0.6351	0.6145	0.6184
Std. Error of the Estimate	67081	40794	40216	47303	82759	75295	44551	57322

Table 4 Estimated parameters, model cluster by province

Table 4.- Estimated parameters 1995-2008		Variable category	All provinces	Alicante	Murcia	Valencia	Madrid	Barcelona	Baleares	Castellón
			β	β	β	β	β	β	β	β
Urbandep	1		0.017	0.048	0.057	-0.064	0.052	0.101	-0.012	0.045
Regpop	1		0.103	0.014	0.023	0.075	0.059	0.025	0.045	0.127
Ecoact	1		0.159	0.069	0.038	0.074	0.033	0.035	0.007	0.063
Popgrow	1		-0.002	0.105	0.135	0.068	-0.027	0.035	0.132	0.028
Urbanenv	2		-0.010	0.014	0.025	0.030	0.019	-0.021	0.042	0.031
Resarea	2		0.089	0.177	0.110	0.054	-0.013	-0.008	0.056	0.092
Income	2		0.079	0.118	0.055	0.103	0.081	0.075	0.060	0.083
Popdens	2		0.068	0.004	0.104	0.032	0.029	0.087	0.103	0.021
Cons	2		0.030	0.031	0.043	0.018	-0.005	0.026	-0.038	0.069
Qroad	4		-0.165	-0.216	-0.189	-0.169	-0.075	-0.096	-0.042	-0.229
Qwater	5		0.079	0.040	0.074	0.058	0.052	0.051	0.007	0.081
Qlight	5		-0.045	-0.114	-0.043	-0.061	-0.039	-0.084	-0.110	-0.087
Qshop	5		0.033	0.131	0.101	0.085	0.061	0.068	0.125	0.058
Qschool	5		0.000	0.021	0.004	0.030	-0.037	-0.044	0.025	0.049
Qrelig	5		-0.008	-0.059	0.137	0.075	0.041	-0.004	-0.011	-0.005
Qleisure	5		0.116	0.128	0.000	0.053	0.056	0.078	-0.083	0.071
Qsport	5		0.038	-0.054	0.097	0.023	0.054	0.045	0.087	-0.038
Qhealth	5		-0.055	-0.025	-0.096	-0.151	0.010	-0.037	0.007	0.006
Bus	4		0.026	0.037	0.145	0.029	-0.013	-0.039	-0.038	0.004
Train	4		0.019	0.013	0.083	0.013	0.012	-0.004	-0.032	0.022
Underg	4		0.187	0.002	0.000	0.130	0.118	0.224	0.026	-0.002
Type_t	3		0.040	0.092	-0.013	0.000	-0.012	0.063	0.052	0.177
Ndwe_t	3		-0.024	-0.069	-0.004	-0.026	-0.024	-0.003	-0.017	0.004
Lift_t	3		0.025	0.087	0.091	0.088	0.114	0.085	0.005	0.036
Age_t	3		-0.138	-0.147	-0.141	-0.159	-0.040	-0.031	-0.154	-0.249
Qshop_t	6		0.068	0.206	0.067	0.222	0.104	0.017	0.137	0.200
Inc_t	6		0.145	0.185	0.176	0.151	0.154	0.121	0.116	0.052
Popdens_t	6		0.044	0.012	0.082	-0.051	0.037	0.080	0.046	0.008
Orient_t	3		0.046	0.047	0.047	0.029	-0.002	0.057	0.018	0.055
View_t	3		-0.004	0.018	-0.034	-0.014	0.002	-0.035	0.129	0.038
Constq_t	3		-0.035	-0.044	-0.071	-0.055	0.027	-0.040	-0.004	-0.130
Sqm_t	3		0.335	0.370	0.378	0.390	0.566	0.509	0.568	0.410
Sqmnoc_t	3		0.005	0.081	0.006	0.011	0.001	0.095	0.133	0.037
Numbers in shade means they are not statistically significant										
Variables category										
1	City characteristics						4	Accessibility		
2	Neighbourhood characteristics						5	Facilities		
3	Housing characteristics						6	Social characteristics on housing		

Table 5 Hedonic models by time

Table 5 2SLS MODEL: RESULTS OF THE HEDONIC MODEL OF ASKING PRICE clustered by time															
Dependent variable: asking price of testigo i															
Years	1995-2008	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
TOTAL															
Multiple R	0.680	0.826	0.841	0.84	0.781	0.75	0.749	0.74	0.7167	0.704	0.692	0.724	0.715	0.725	0.749
R Square	0.463	0.682	0.707	0.705	0.61	0.562	0.561	0.548	0.5137	0.495	0.479	0.525	0.512	0.525	0.561
Adjusted R Square	0.463	0.681	0.706	0.705	0.61	0.562	0.561	0.548	0.5136	0.495	0.479	0.525	0.512	0.525	0.561
Std. Error of the Estimate	67081	18216	17478	16634	21706	29991	33405	36456	43333	51057	59046	58082	68320	70628	76174

Table 6 .- Time shocks affecting attributes parameters

95-2008	dummies												
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Urbandep	0,029	0,047	0,026	0,036	-0,007	0,102	-0,001	-0,027	0,001	-0,060	0,080	0,136	0,104
Regpop	0,119	0,050	0,044	-0,047	-0,007	-0,148	0,009	0,002	0,013	0,102	0,049	0,010	0,165
Ecoact	0,047	0,051	0,033	0,026	0,016	0,045	0,062	0,094	0,115	0,145	0,168	0,125	0,228
Popgrow	0,143***	0,141***	0,148***	0,140***	0,133***	0,028***	0,063***	0,060***	0,085***	0,092***	0,164***	0,133***	-0,004
Urbanenv	-0,071	0,040	0,019	0,001	0,011	0,007	0,014	0,020	0,015	0,001	-0,003	-0,007	-0,057
Resarea	0,040	0,044	0,042	0,025	0,044	0,079	0,212	0,262**	0,260**	0,237*	0,194	0,182	0,105
Income	0,029	0,026	0,047	0,037	0,047	0,037	0,014	0,040	0,051	0,033	0,165*	0,189**	0,104
Popdens	0,011	-0,004	0,015	0,081**	0,053	-0,001	0,015	0,000	0,012	0,023	-0,056	-0,025	0,041
Cons	0,021	0,017	0,038*	0,029	0,035	0,039*	0,026	0,011	0,023	0,033	0,014	0,012	0,023
Qroad	-0,018	-0,009	-0,014	-0,009	-0,017	-0,046	-0,014	-0,024	-0,018	-0,033	0,023	0,009	0,008
Qwater	-0,085***	0,011	-0,051**	-0,094***	-0,118***	-0,132***	-0,083***	-0,073***	-0,078***	-0,074***	-0,081***	0,026	0,009
Qlight	0,042	-0,102***	-0,061**	-0,042	-0,017	-0,012	-0,021	-0,022	-0,005	0,004	-0,041	-0,09***	0,000
Qshop	0,09***	0,114***	0,111***	0,087***	0,122***	0,115***	0,108***	0,121***	0,116***	0,111***	0,021***	0,018***	-0,075***
Qschool	-0,036***	-0,037***	-0,047***	-0,108***	-0,090***	-0,131***	-0,15***	-0,062***	-0,044***	-0,026**	-0,001	-0,008	0,044***
Qrelig	0,030	0,028	0,015	0,080*	0,007	-0,001	-0,086**	-0,111	-0,131***	-0,117***	-0,060	-0,039	0,022
Qleisure													
Qsport	-0,020	-0,018	0,004	-0,029	-0,035	-0,027	0,048*	-0,029	-0,005	0,003	0,018	-0,007	0,056*
Qhealth	0,028***	0,024***	0,073***	0,034***	0,045***	0,013***	0,053***	0,058***	0,057***	0,085***	0,039***	0,034***	-0,006***
Bus	-0,020	-0,017	-0,012	-0,038**	-0,086***	-0,058***	-0,030	-0,039**	-0,048**	-0,028	-0,003	-0,021	0,002
Train	0,018	0,045***	0,055***	0,047***	0,060***	0,082***	0,066***	0,097***	0,051***	0,037**	0,041***	0,021	0,064***
Underg	-0,007	-0,003	0,007	0,013	0,004	0,018	0,007	-0,002	0,000	-0,006	-0,004	-0,001	0,178
Type_t	0,122***	0,066***	0,056***	0,078***	0,10***	0,036***	-0,001	-0,010*	-0,023***	0,006	0,085***	0,023***	0,052***
Ndwe_t	-0,045***	-0,075***	-0,062***	-0,089***	-0,059***	-0,033***	-0,120***	-0,143***	-0,133***	-0,137***	-0,072***	-0,049***	-0,007
Lift_t	0,082***	0,104***	0,076***	0,095***	0,074***	0,036***	0,127***	0,135***	0,141***	0,117***	0,072***	0,059***	0,007
Age_t	-0,221***	-0,215***	-0,243***	-0,257***	-0,239***	-0,217***	-0,136**	-0,121**	-0,116*	-0,146**	-0,059	-0,050	-0,074
Qshop_t	0,007	-0,024	0,038	0,085	0,084	0,014	0,046	0,000	-0,008	0,000	0,033	0,055	-0,067
Inc_t	0,152	0,182	0,149	0,147	0,139	0,139	0,211	0,147	0,155	0,153	0,225	0,206	0,142
Popdens_t	0,005***	0,016***	0,019***	0,030***	0,019***	0,074***	-0,018***	-0,035***	-0,043***	-0,081***	0,035***	0,023***	0,005***
Orient_t	0,030	0,052	0,042	0,068	0,047	0,050	0,053	0,052	0,041	0,062	0,010	0,019	0,040
View_t	0,107***	0,114***	0,150***	0,179***	0,156***	0,222***	0,208***	0,240***	0,204***	0,193***	0,072**	0,094**	0,044
Constq_t	0,159***	0,099**	0,125**	0,128**	0,097*	0,168***	0,132***	0,139***	0,107**	0,093*	0,039	0,062	0,064
Sqm_t	0,646	0,560	0,602	0,600	0,620	0,610	0,666	0,655	0,618	0,625	0,575	0,529	0,520
Sqmnoc_t	0,117	0,048	0,045	0,032	0,036	0,038	0,068	0,061	0,087	0,094	0,108	0,108	0,003

*** sign al 1% p<1%
 ** sign al 5% p<5%
 * sign al 10% p<10%
 Not significant

List of figures

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Figure 1a. Asking prices average by year in euros

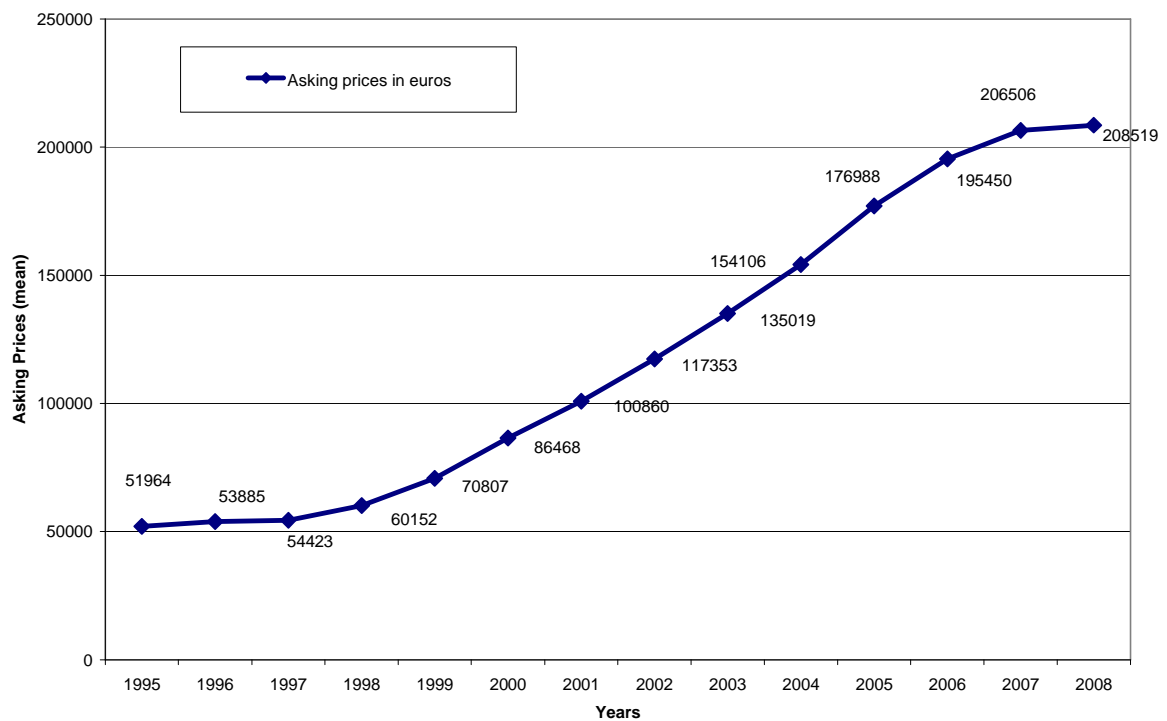


Figure 1b- Asking prices in selected provinces

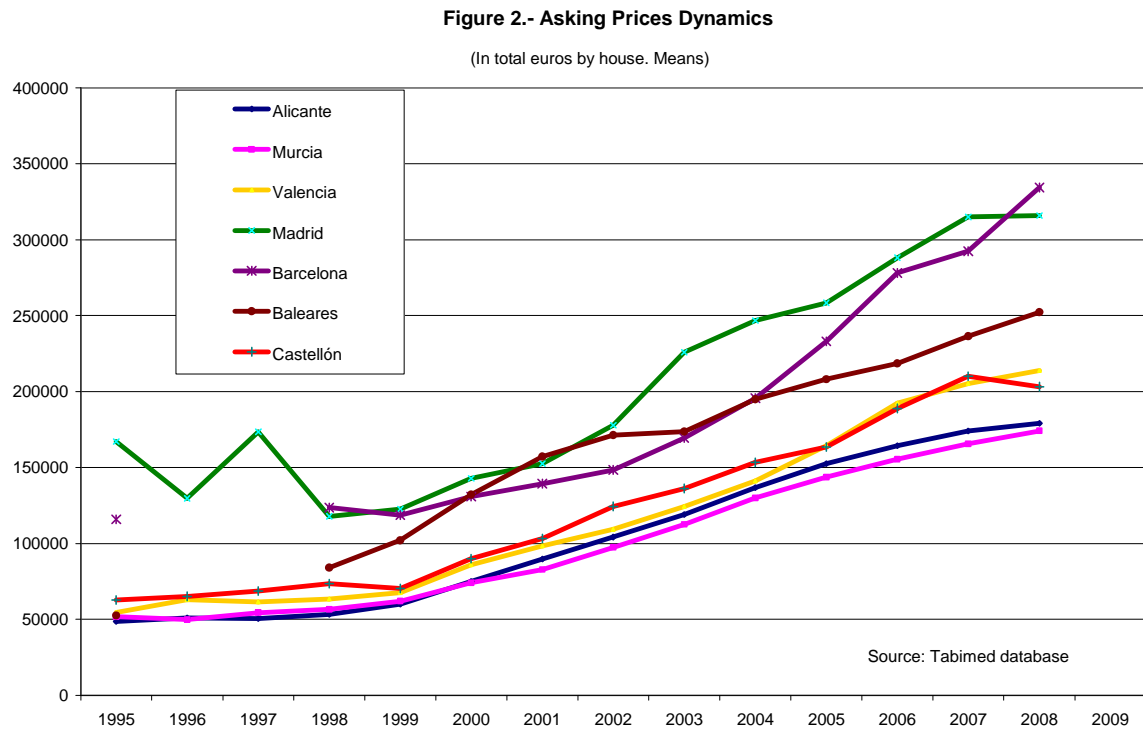
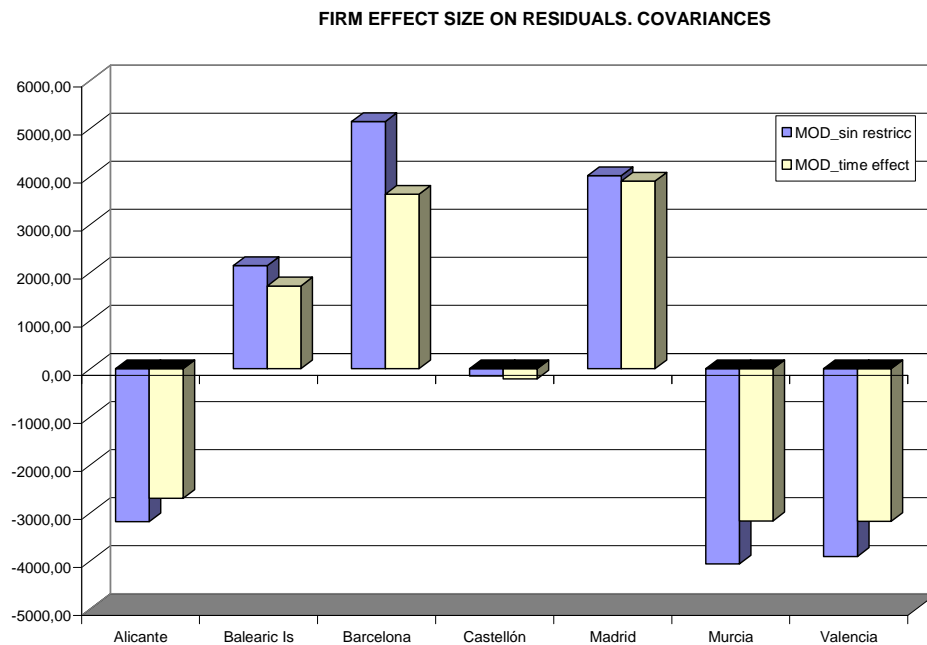
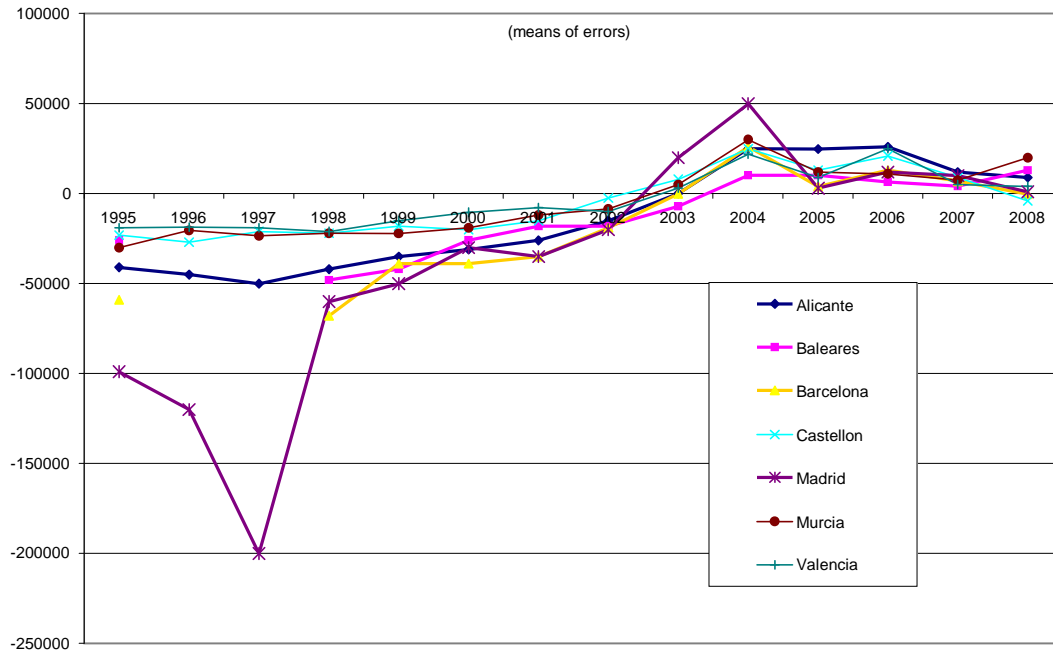


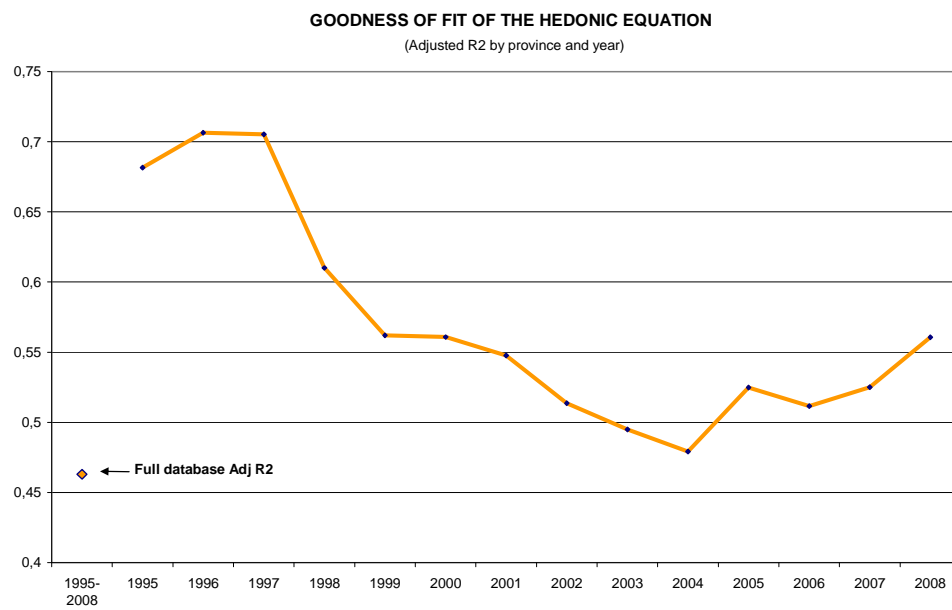
Figure 2: Space effect on residuals - covariances



. DISTRIBUTION OF RESIDUALS PROFILE FROM HEDONIC ESTIMATION CLUSTERED BY PROVINCE



Bias evidence in panel clustered by time



Residuals by time (all provinces)

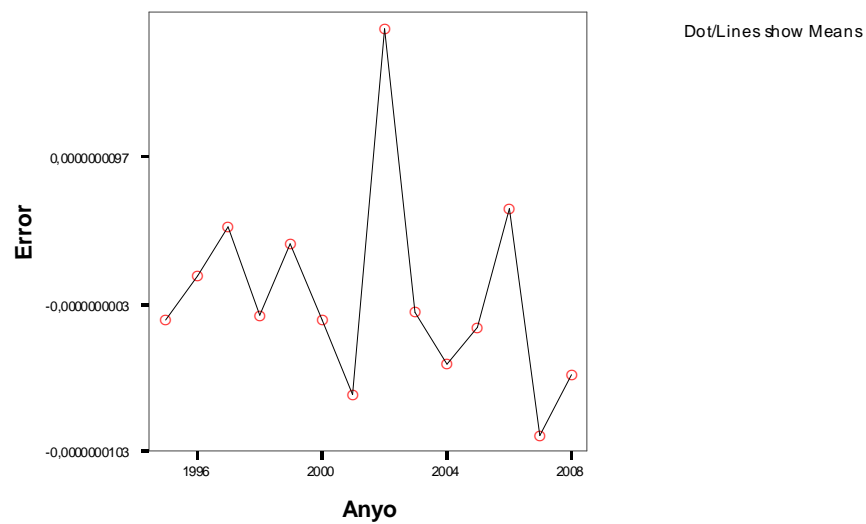


Figure 3 Distribution of residuals

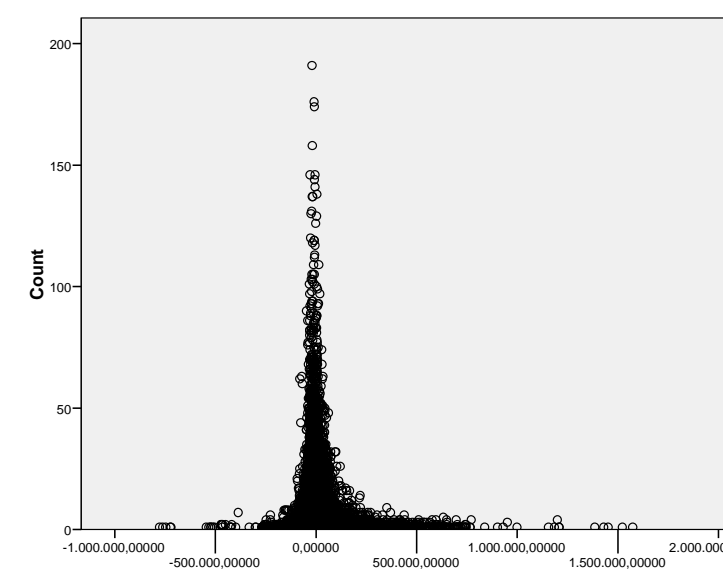
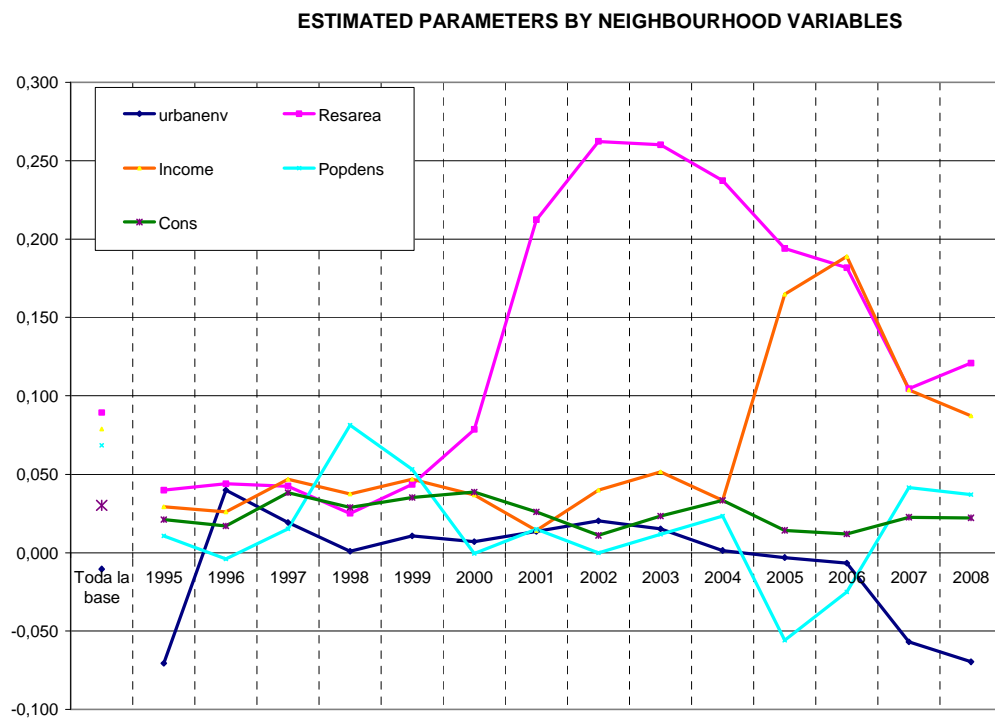
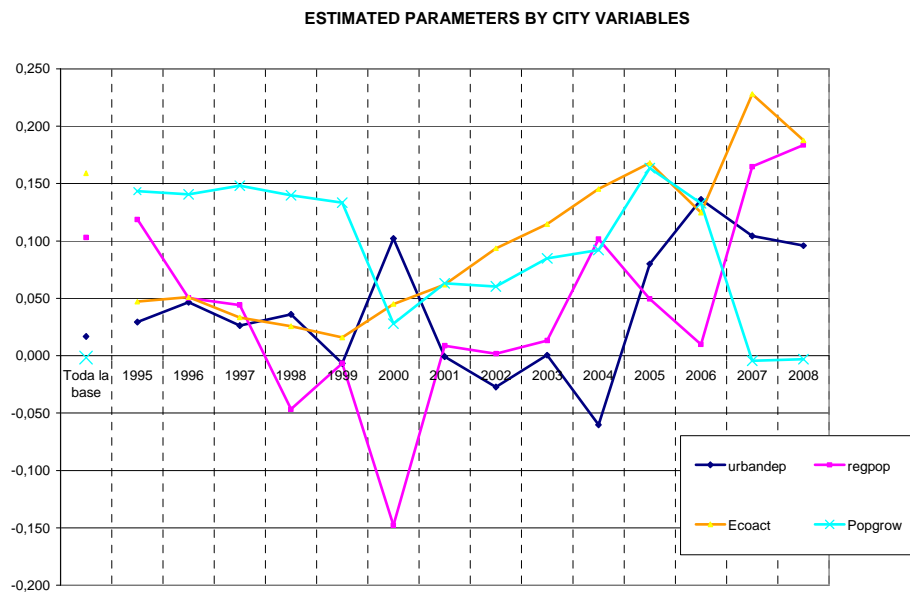
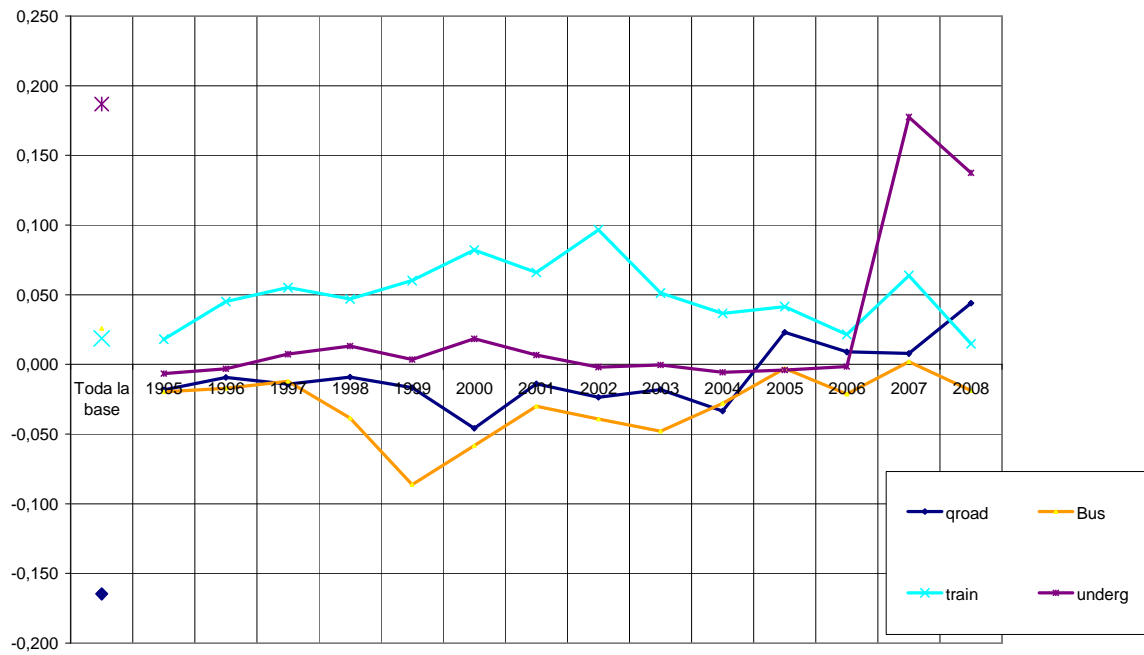


Figure 4a to 4d Hedonic parameters time varying

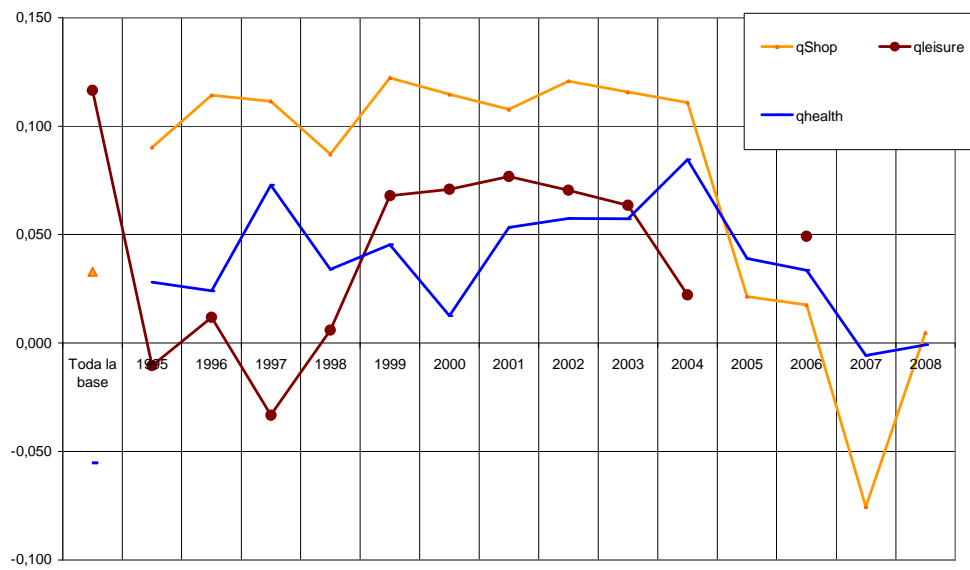
Figure 8a



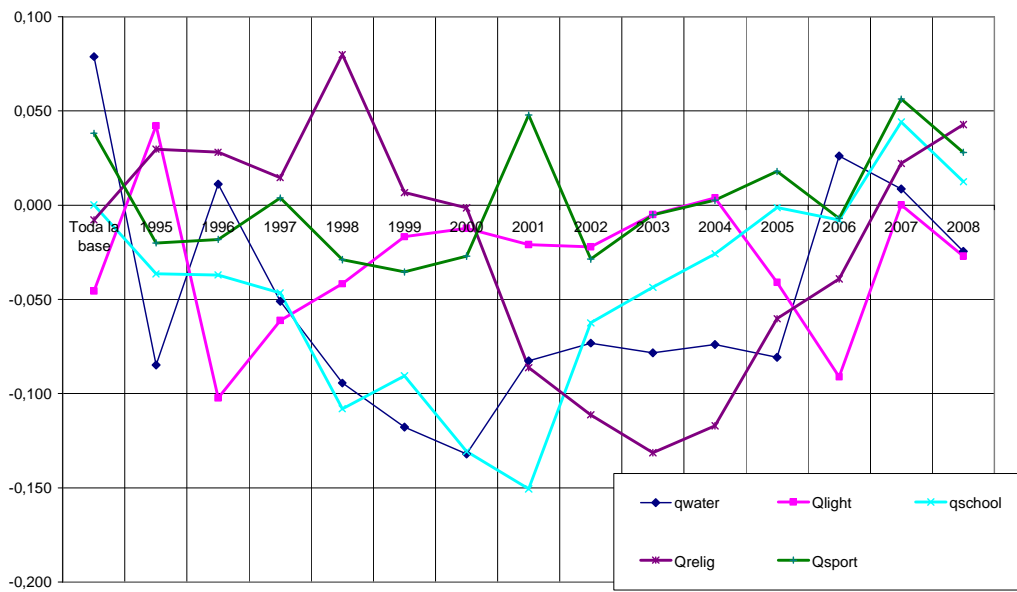
ESTIMATED PARAMETERS BY ACCESIBILITY VARIABLES



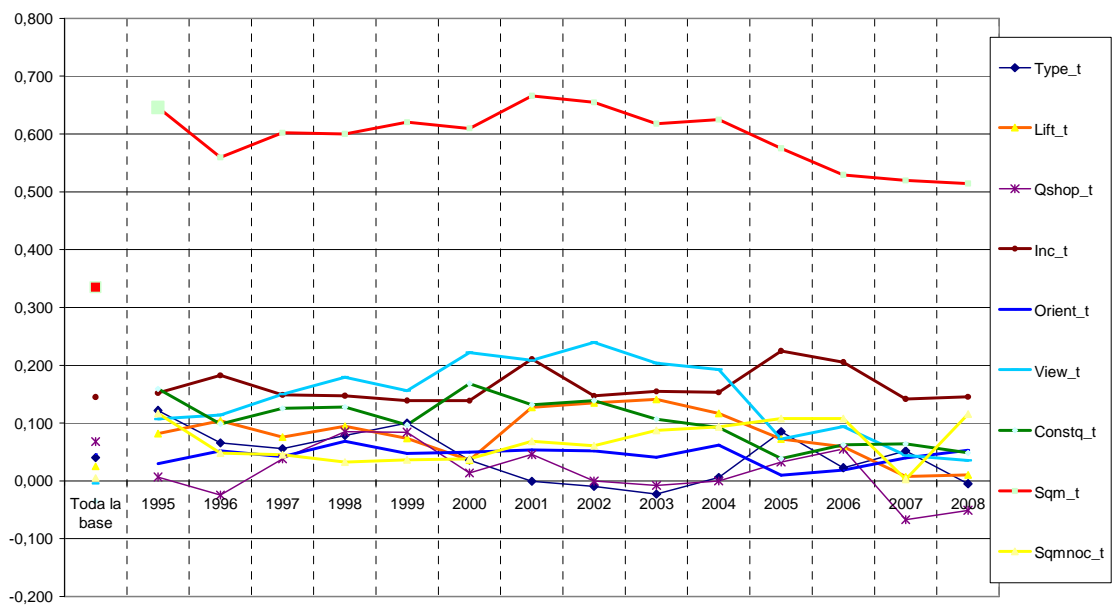
ESTIMATED PARAMETERS BY NEIGHBOURHOOD FACILITIES. Positive impact



ESTIMATED PARAMETERS BY NEIGHBOURHOOD FACILITIES. Negative o neutral impact



ESTIMATED PARAMETERS FOR THE HOUSING FEATURES. Positive impact



ESTIMATED PARAMETERS FOR THE HOUSING FEATURES

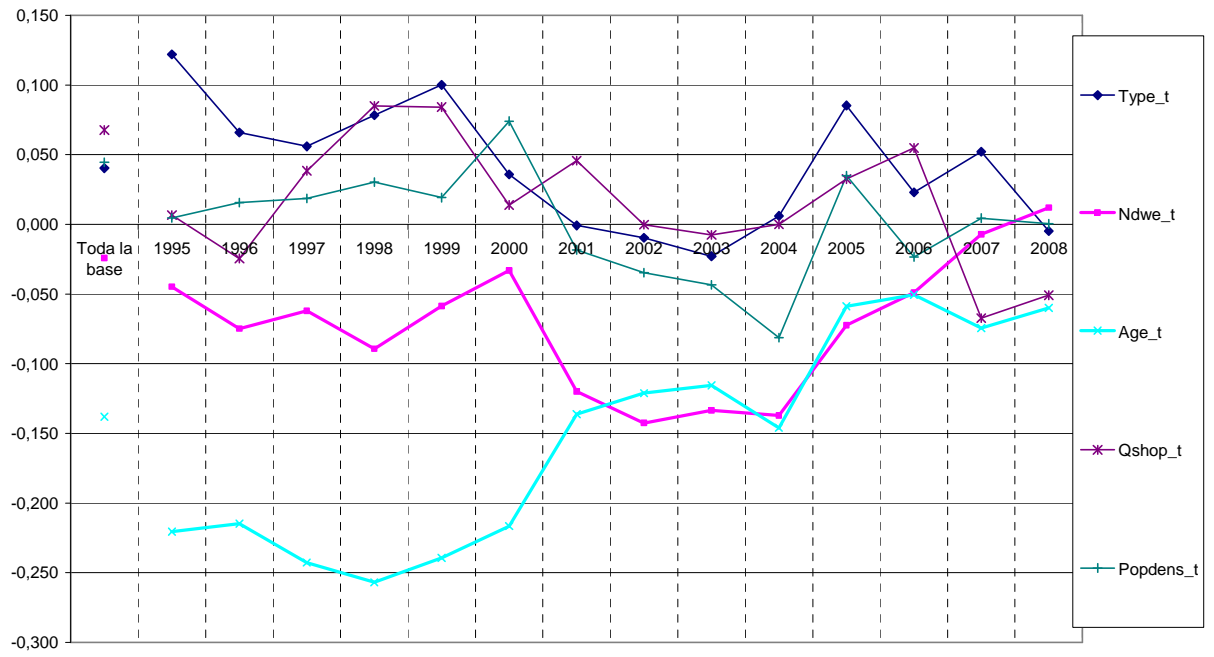


Figure 5

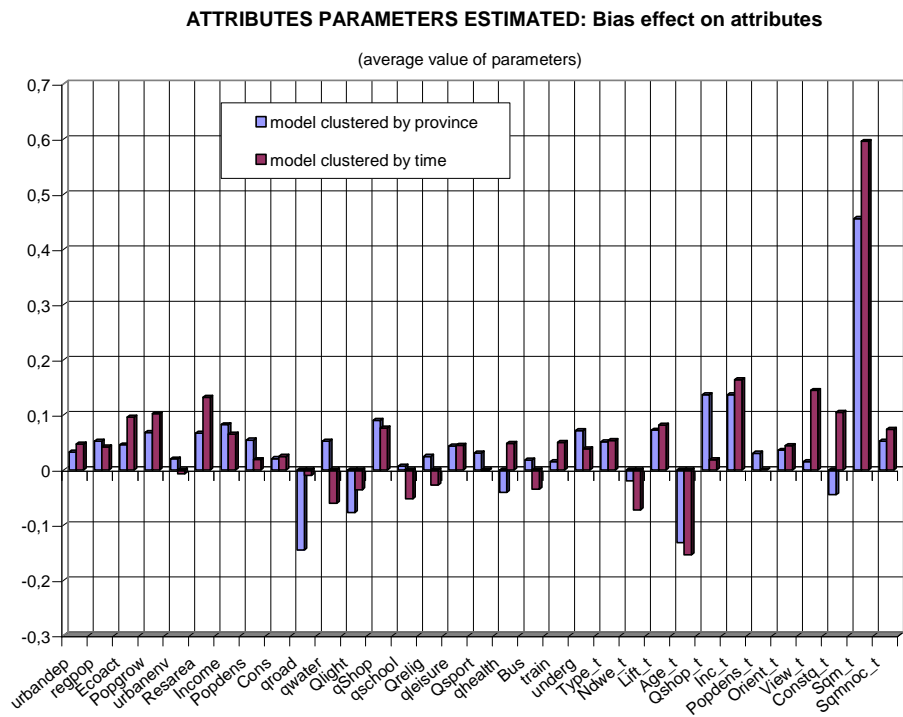


Figure 6. Goodness of fit of the hedonic equation

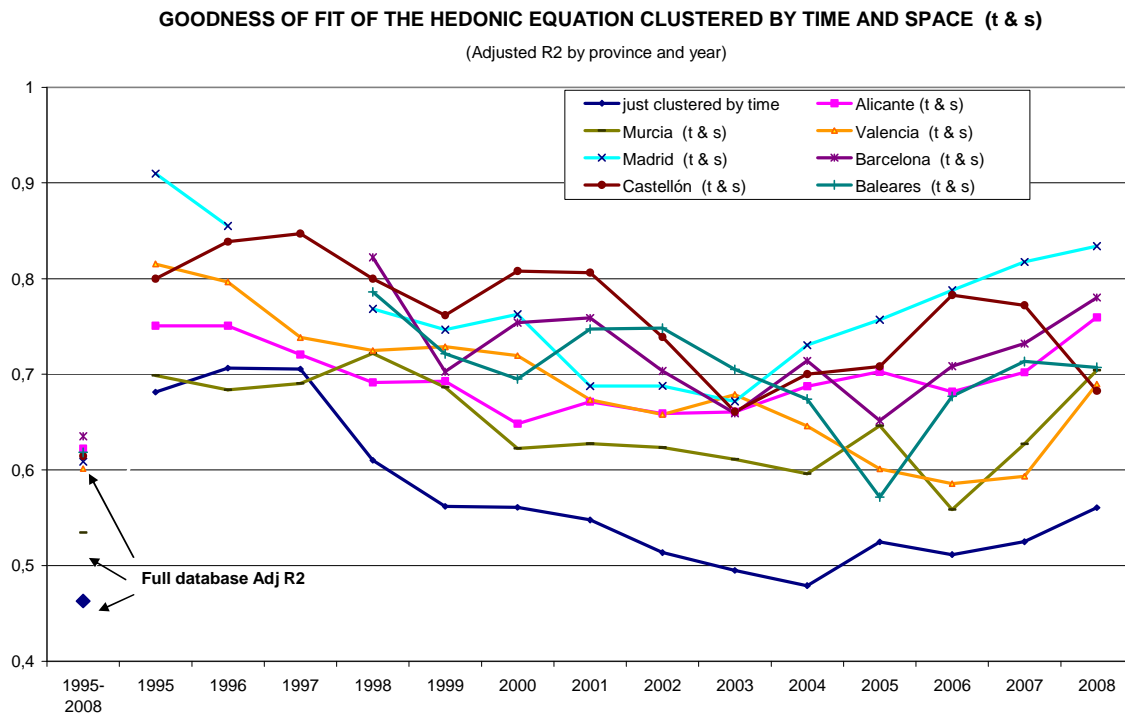


Figure 7 a.

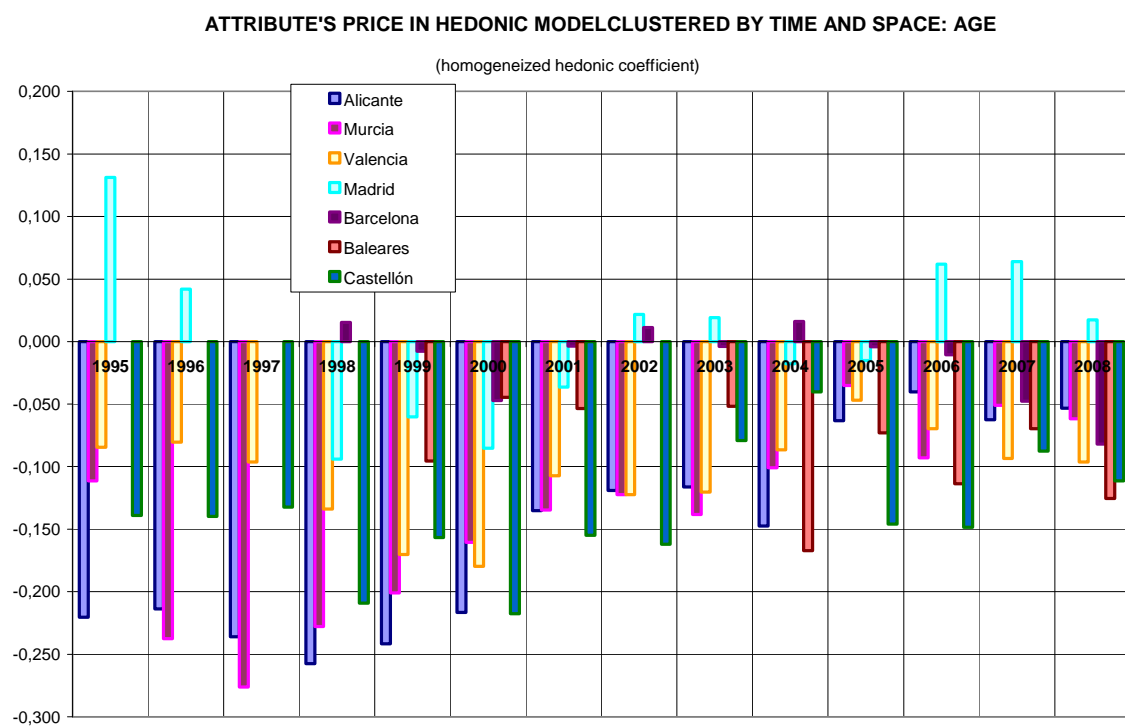


Figure 7 b

