The fallacy of price appreciation: an adjusted by spatio-time and quality house price index for Spain

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Abstract

Spanish housing prices rose 159.8% since 1994 and felt around 21% since the credit crunch crisis started in 2008, both until 2012. Such data is estimated on the price index which is not adjusted by quality. This paper employs a large database of houses of different Spanish regions to estimate a yearly index adjusted by quality to highlight which parts of those rates are due to the price evolution instead of growth on quality.
Hedonic models corrected by space component is used to estimate indices varying by geographical region (province level) along some of the most overvalued Spanish areas. The hedonic model includes three groups of attributes: housing, neighbourhood and socioeconomic characteristics. Conclusions suggest that most of the overvaluation is due to increase on quality at housing, physical accessibility and neighbour area. The maximum appreciation in ten years has been 50% in Valencia province.

Keywords: Price index, housing market, hedonic models, spatio-time models, Spain

JEL classification: R21, R31, D46,

Introduction

Housing market is highly heterogeneous. Price is considered to capture multiple circumstances like how each household evaluates housing attributes according to income, education, quality and household characteristics. With severe heterogeneity, housing prices use to be analysed 'adjusted of quality' that means calculate the index using hedonic models controlling by the differences given by a bundle of attributes and extracting the pure price behaviour.

Houses are priced depending on their characteristics (and cost of construction plus cost of location) as well as how the demand considers their worth. In essence, the idea that housing prices could be reflected more a human behaviuor rather than an exact (technical) market condition is inside the literature since the beginning of the analysis.
Rosen (1974) is a seminal work where a 'joint-envelope function' was defined capturing the structure of consumers' preferences and producer technologies. In essence the hedonic equation embraces a combination of attributes 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 taking account of quality changes.

Hedonic method has been broadly used to analyze housing prices. There are agreements in some results that support further analysis. For instance, single-family homes in the same neighbourhood are likely to share similar structural characteristics (Basu and Thibodeau, 1998). The weight of each attribute relative to the others reflects purchaser preference or taste at a neighbourhood level (Tsu, 2002). It is argued that weights are invariant inside a homogeneous submarket (Sun et al, 2005, Galster, 2003) but that weights change among submarkets reflecting differences in demand preferences which affect the submarket design and its boundaries. Due to the relevance of location in housing prices, space-state techniques have increasely be applied in order to avoid spatial and time autocorrelation that is usually present in the information obtained at micro level and which biases the estimated parameters.

The aim of this paper is to estimate the price index controlled by quality for houses in the Spanish market and to test differences among regions. A hedonic method is used to extract the index using asking prices, the supply side of the market, and not transactions. The use of asking or list price is supported by other studies in time on market (Knight et al, 1998, Arnold, 1999, Anglin et al, 2003), search process and its impacts on transaction prices (Genesove and Mayers, 1997, Goetzman and Peng, 2006, Hardin et al 2003) and avoiding transaction biases from non-traded units (Pryce and Mason (2006)). McGreal et al, 2010 demonstrates how asking prices tend to be close to transaction prices with asking prices lagging sale price in the up-cycle and the opposite effect in the down cycle.

The analysis seeks to add to the literature base by firstly estimating a hedonic model with spatio-temporal focus and secondly by assessing the role of socioeconomic and city characteristics as attributes in housing prices.

The paper is organized as follow. The second section reviews the literature on hedonic house price modelling and state-space models, section three explains the model and implementation. Section four provides details of the database and variables used in the analysis. In section five STAR-STM model results are explained and discussed. Section six presents the results and discussion of GLM model and section seven draws conclusions.

2. Literature review

The literature on hedonic models is well established with well known studies like Rosen, 1974, Linneman, 1980, Haurin et al, 1991, Peek and Wilcox, 1991, Geltner, 1993, Adair et al, 1996 or Clapp, 2004. Most of the papers argue that house price index estimated from 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. Due to the perceived limitations of hedonic models, the repeat sales method offers an alternative approach based on transaction data of the same properties at different periods of time. Hybrid models (a combination of hedonic and repeat sale methods) estimate the changes in price based on the housing attributes and describe how they evolve over time (Shiller, 1993, Quigley, 1995, Palmquist, 1982). Hybrid models have been developed in order to avoid underestimation of prices and errors.

The conventional linear hedonic model follows a functional form as in equation (1):

$$Ph_{it} = \alpha + X_{it}\beta + \gamma t + v_{it} \qquad (1)$$

Where:

Ph = price of the house

$X = \{x_1, x_2, x_3 \ldots x_n\}$ is a set of independent attributes

t = is a measure of time

v = a random error $\sim N(0,\sigma^2)$.

α,β, γ are parameters to be estimated. In log form, γ represents the prices evolution adjusted by quality and is used to build the price index.

Hedonic models of housing markets have produced biased results due to the existence of space dependence among housing characteristics and autocorrelation effects arising from different time periods resulting in inefficient estimated parameters with large errors (Anselin, 1999, Dubin, 1998). On the other hand, changes on attributes among locations and market segments (Maclennan and Tu, 1996; Adair et al, 1996) and correlated attributes reduce the robustness in the regression estimated parameters due to the autocorrelation and multicolinearity problems. Richness of information characteristics also creates an omitted variable problem in those models using existing databases with residual correlation (Pace et al, 1998, Basu and Thibodeau, 1998, Des Rosiers and Theriault, 1999). Space-Time models are considered to reduce such problems and provide robust estimations for house price indices.

Spatio-temporal autoregressive models -STAR (Stimson, 1985, Anselin, 1998, 1999, Florax, Pace et al, 1998) consider that both geographical and time dependences jointly affect housing attributes shadow prices and biased the true price index. Both dependences could be parametrized in the STAR weighted matrix W which is a combination of the spatial distances between each pair of observation (dij) and the time relation of each observation with their lagged values (di,i-n). The STAR model is obtained by pre-multiplying the general specification both sides of equation by (I-W), and has the following form (Pace et al, 1998):

$$(I-W)Y = (I-W)X\beta + \varepsilon, \quad (2)$$

Then.... $$Y = WY + X\beta + WX\beta + \varepsilon \quad (3)$$

As W contains the time-lag operator, this expression can be presented as:

$$Y_t = Y_{t-1} + WY_t + X\beta + WX\beta + \varepsilon \quad (4)$$

Anselin, 1999:13, defined four types of STAR models,

1st Pure Space-recursive, in which dependence happen at neighbouring location in different period:

$$y_{it} = \gamma[\mathbf{W}\boldsymbol{y}_{t-1}]_i + f(x) + \varepsilon_{it} \quad (5)$$

Where f(x) are the regressors (which could be also lagged in time and/or space), y are dependent variable (housing prices) and ε the random errors. Note that W here refers to the spatial dependence

2nd. Time-Space recursive, where the dependence relates both the same location as well as the neighbourhood location in another period.

$$y_{it} = \lambda \boldsymbol{y}_{i,t-1} + \gamma[\mathbf{W}\boldsymbol{y}_{t-1}]_i + f(x) + \varepsilon_{it} \quad (6)$$

In these two models, asymptotics are needed only in the crossectional (space) dimension.

3rd. Time-Space simultaneous model, where both spatial and time lagged dependent variables are included.

$$y_{it} = \lambda \boldsymbol{y}_{i,t-1} + \rho[\mathbf{W}\boldsymbol{y}_t]_i + f(x) + \varepsilon_{it} \quad (7)$$

the term $\rho[\mathbf{W}\boldsymbol{y}_t]_i$ is the i-th element of the spatial-lag vector WY, been W the full spatio-temporal matrix.

4th Time-Space dynamic which includes all forms of dependence considered:

$$y_{it} = \lambda \boldsymbol{y}_{i,t-1} + \rho[\mathbf{W}\boldsymbol{y}_t]_i + \gamma[\mathbf{W}\boldsymbol{y}_{t-1}]_i + f(x) + \varepsilon_{it} \quad (8)$$

Econometric method to estimate STAR model depends of the specification made due to the structure of the errors dependence is very complex and needs to be critically defined and special tool applied. Although general agreement is that OLS is an imperfect tool to be used, Anselin, 1999 support that OLS is good estimator when a pure-space recursive model is estimating due to errors are defined as independent and, then, satisfied the assumption of classical regression model. He also provides different tools as 2 stage spatial least squares (2SSLS), which achieves the consistency and asymptotic normality properties of the standard 2SLS, Generalised Method of Momentums (GMM), and non parametric as SUR or Code methodology.

Researchers use a broad bundle of techniques where OLS is still very popular.

Sun et al, 2005, Beamonte et al, 2008 use Bayesian tools to estimate STAR models. Pace et al, 1998, and Liu, 2010 use maximum likelihood, Leishman, 2009, Case et al, 1998, use OLS with dummy variables, and weighted least square - maximum likelihood to compare results obtained among the different techniques. Nappi-choulet and Maury, 2009, uses OLS in the spatial and temporal autoregressive local (LSTAR) model. Khuete et al, 2006 uses flexible least square FLSE methodology. Case et al, 1998 compare distinct methods as OLS, OLS with spatial trend, Clapp Local Regression Model and Dubin's Maximum Likelihood and develop a combine tool to estimate housing prices including a Kriging method to incorporate spatial correlation into the predicted variables. Kriging is also used in Paez et al, 2007 (Urban Studies, 2008), with a geographically weighted regression (GWR) and moving windows regression to estimate the different spatial effects in hedonic price models. Caliman and Di Bella, 2011, uses OLS in a spatio-temporal recursive model specification. Park, 2002, uses both semiparametric and parametric OLS methods to estimate hedonic price model using STAR specification, where distance variables are estimated using non parametric methods. Dubin et al. (1999) could be good reference of the spatial autoregressive techniques in real estate market analysis.

- Asking prices

Harding et al (2003) demonstrate that prices are related to the household's bargaining power. The bargaining power and the negotiation process may affect the final price modifying the implicit prices of housing characteristics. 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 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.

3. **The model**

This paper estimates the housing prices index based on hedonic models in seven Spanish provinces along an extensive period from 1995 to 2010. The database of prices observe the effect of credit crunch era in the collected asking prices and one of the aim of this paper is to capture how the shock has affected to those prices. Hedonic model is built to calculate the price index controlled by quality, then highlighting the true evolution of prices and its housing attributes.

The database used comes from the almost around than 2.362 million observations of comparables used to do valuation of subject properties by a Spanish valuation company during the mentioned period. Only the information of comparables are used here (and no from any subject property) and it contains housing characteristics as well as neighbourhood and city features summing up 32 different attributes of each property usable for this study. Spanish regulations binds to use information from at least 6 comparables for valuation purposes, being those other similar properties closer (in the space and valid within six month before the valuation) to the subject property and not sold. Then, the database does not contain transaction but information about supplied houses and the price collected is the asking price in the market. Such prices are used here as a close (although imperfect) proxy of transaction prices.

The paper extract quality adjusted price indices thanks to the richness of the database. To control properly, attributes have been classify within the three groups defined by Bowen et al, 2001, structural, neighbourhood quality and accessibility housing characteristics. Our database can distinguish also the socioeconomic characteristics of the city and the neighbourhood including income level of the area as well as population flow and density. Through such specification this paper adds evidence to the literature on hedonic analysis.

Observations are, then, at property level (microdata) with both the spatial (location) and time dimensions which should require to utilize STAR models to analyze the house price dynamic.

However the data base miss the exact location as well as the exact date of the valuation (not supplied by the company because legislation constrains), and although information available in the database is at municipality level, postal codes or georeferences are mainly missing and impede us to proceed as other researchers calculating geo-distances between each pair of houses to build the W matrix. We, in fact, cannot build the conventional spatio-temporal matrix. To build the W matrix here the spatial reference is the level of urban dependence located in an urban area. There is information about four levels of urban dependence[1]: (1) in a municipality which depends (social and economic) of other municipality; (2) autonomous city, which is a town/city concentrating economic activity and population and which could have one or more dependent municipalities; (3) county capital, which is the administrative center of a county in each province and (4) province capital. These four levels describe a kind or urban structure which is taken as space reference in this paper and used to build the spatial matrix.

The second critical information missing is the exact date of the observations was taken. Years are the only time reference appears in the database.

Model adopted here follows the time-space recursive functional form (6) proposed by Anselin, 1999 to estimate a pseudo spatio-time hedonic model. Then, the model is:

$$y_{it} = \lambda \boldsymbol{y}_{\boldsymbol{i,\, t-1}} + \rho[\mathbf{W}\boldsymbol{y}_{\boldsymbol{t-1}}]_{i} + \Gamma(\mathrm{x}_{\mathrm{ki}})_{\mathrm{t}} + \delta \mathrm{t} + \varepsilon_{it} \tag{9}$$

Where y_{it} is the element of the vector Y of dependent variable (housing asking prices) and X is a matrix of independent attributes classified in four groups (socioeconomic attributes, structural, neighbourhood and accessibility), W is the pseudo spatio-temporal matrix, λ and ρ are the time and spatial parameters, Γ is a parameters matrix containing the shadow prices of *k* housing attributes as well as the spatial effects on attributes, that is, $[\beta+W^*\beta]$ parameters. $W^*\beta$ controls for spatial similarities in the housing attributes that is, spatial correlation among housing characteristics due to similarities at neighbourhood/city level. δ captures the remaining impact of time on housing prices, that is the house price index , and ε is independent and random residuals.

[1] Here urban dependence means that population should commute to the next urban level due to the location of jobs (for instance) and also that economic and social activity is located in the closed urban area towards which it is dependent.

W matrix is not a conventional nxn distances matrix. In our case, it has 4xn dimension where the four columns contain information about the type of urban environments (variable Urbandep) where the property is located. Matrix W has one as each row and it does not need to be weighted. It does not capture the distance between pair of properties but only the fact that the property is located in a urban area with certain degree of dependence of other ‘urban-superior’.

Time dimension is yearly. We don’t have a database ordered by time due to it is not possible identify the order of observation within a year and the model specification follows a simple time treatment. That is why a triangular nxn matrix with zero diagonal is not defined here as it is common when exact date or month is available. Asking price data is assumed to follow an *AR(1)* process (as in Tse, 2002). It implies that T is used to calculate one lag dependent variable (Y_{t-1}) as containing the time effects.

There is neither information about whether the house has repeated observation which means that it is not obvious that *Yt* could be lagged one period in the traditional sense. To built Y_{t-1} successive steps have been followed: (1) Median of asking price is calculated for each year and assigned as the weighted value to each observation in a new variable. That is, we construct a new vector variable *MPht* where each element, mph_{it}, it the median of the price by square metre in the year t corresponding to all existing properties located in a done urban dependence level. To build it up, we cluster all database by province, by urban level (four cathegories as it is the variable we use as spatial reference) and by year, and calculate the medians of their asking price by square metre at each urban location. The median is used because it is the better estimation, following the Central Limit Theorem, in a database with long dispersion in the values, and the price by square metre is used in order to minimize bias on the differences between mean and median that could appears if the total asking price was used. All calculations are made in logs. Then $lMphtm^2$ = median of the log of Housing asking price (*lPht)* by square metre, for year *t* .

Second step is construction $lMPh_{t-1}$ by square metre. We proceed assigning to every observation of $lPhm^2$ in t, the value of the median of $lPhm^2$ in t-1, as the normal procedure in a lagged variable, then $LMPhm^2(t-1)_{it} = lMPhm^2_{it-1}$ for all i .

Third step is to reconstruct the total value multiplying by the square metres of each observation in time t, that is, $LMPh(t\text{-}1)_{it} = LMPhm^2(t\text{-}1)_{it} \times lSqm_{it}$

Time vector δ is represented by the pooled set of dummy variables by year with nx16 dimension. As separate time and space effects are including, it is assumed here that the effects owns isotropic autocorrelations. It is also assumed that final estimated model could suffer of some level of spatio-time autocorrelation due to the absence of combined time and space effects in W. In order to control for the existence of remaining autocorrelation, the estimation minimizing the standard errors in the model will be chosen in order to guarantee that this dependence is not severe and parameters are robust.

3. Data

The analysis is based on an extensive valuation database from the Spanish housing market over the period 1995-2010[2]. Table 1 shows the distribution of the data over the time series from 1995 to 2010. The database includes evidence from the whole of Spain but there is a strong regional presence in the provinces of Alicante, Valencia, Murcia, Castellón, and Balearic Islands, as well as significant activity in the two major provinces of Spain, Madrid and Barcelona. The net effect includes 2,362,800 observations.

Insert Table 1

Available information about attributes was divided into three groups as explained before (structural attributes, neighbourhood-environmental features and socio-economic characteristics in the city where the property was located). Housing prices are measure through the asking price and time variable reflect the moment where the information was taken in the market. The analysis utilises 30+1 variables; 9 relating to the property, 11 neighbourhood variables, 3 variables related to the accessibility facilities and 4 referreing to socio-economic characteristics. Four additional variables are used to reference the property in the space and time and the asking prices (Table 2). Time

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

variable (year) serves to estimate quality adjusted price index. 8 variables are continuous (and are transformed into logs) and 22 are cathegorical. The database is much larger than 31 variables, summing up until more than 45 usable variables, but the information for comparables is lower. We have avoided variables like number of rooms, number of bathrooms, balcony, due to the linearity among them was so strong. The representative of these characteristics is the square metres. However, to have a balcony is not necessarily correlated with good view, so we have maintained views and orientation features in order to better control by quality measured in prices.

Insert Table 2

In Spain, the asking price of the 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 asking price trend (the median price are reported here) over the period 1995-2010 for the seven provinces together is illustrated in Figure 1. However, the trend differs between the seven provinces. For example, in Madrid the asking price distribution is distinctly different from most other provinces, although Barcelona shows a similar pattern from 2002. Distinct differences are apparent in the starting point of the rise in asking prices. In Murcia, Valencia, Castellón, Balearic Islands and Alicante strong growth commenced in 1999, whereas in Madrid and Barcelona this is observed later, in 2001. Such differences suggest that the clustering effect should be examined at an individual province level. This issue is considered in greater detail later in the paper.

Insert Figure 1

The valuation database as it contains observations at different moments of time is essentially a pool of data but also has the characteristics associated with panel data. It also contains a large number of different characteristics of the property, several of which are qualitative variables assessed on a scale basis, for example from best to worst in order to capture the specific differences as part of the valuation process. Ranges are in table 2. Thus there is the potential that the database contains a degree of endogeneity in similar attributes and non-independence.

The median property in the database is a house in around 2003, offered at 117,197.0 euros, with 100 square metres and a no patio or garden, with a good quality of construction (ranged as 4/6), 5 years old, in a multi-family house with one lift. Such house has good accessibility by train and bus (not underground), and is located in a neighbourhood with good health, sport, leisure facilities, good schools and road system and acceptable shopping area and water system quality. The urban area is consolidated (urban) with high density of population, medium level income (ranged 4 over 7). It is a primary home, located in urban 'inside town' areas, with high population growth and mix (industrial as well as services) economic activities' cities. The municipality use to be non-dependent city for administrative as well as social services provision.

5. Empirical analysis and modelling

The analysis seeks to calculate the price index for properties over the period 1995-2010, assess them in different provinces and the impact of housing demand crisis on their values under the space-time framework.

Complexity arises from the size of the database, the extent of geographical coverage (seven provinces) and the time series (16 years). The analysis isolates the space and time independent effects to allow for the different provinces and to capture annual variation controlled by quality.

The model to be estimated is the Time Space Recursive model (9), using 2SLS[3] with spatial parameters as Anselin,1999, recommend and based on our pseudo W time-space matrix explained before. It is called STM in order to avoid misunderstanding with the STAR method. Some remaining space-time autocorrelation must be present in the model due to the imperfect pattern to estimate W matrix but the coherent results and robust parameters suggest that they may be small or do not affect the model stability.

Results are summarized in table 3 containing the 2SLS time-space recursive model (STM) house price index estimated for seven provinces plus the overall database.

[3] We also have estimated the model using OLS as most research do but we do not report the results here. They are available under request. In all cases, the total errors obtained in 2SLS are smaller than in OLS and the estimations provide a more robust parameter.

A number of steps have been followed in order to allow precise hedonic STM results. Some variables are transformed into dummies, like Type of building which generate one dummy of property quality capturing the existence of green areas of private use in the building. Age is also included with its squared (age and age^2) to control for the non linearity associated to this variable. Resarea is a variable capturing whether the property is located in a primary, secondary or a mix neighbourhood. It is transformed into dummies as well and its parameter capturing the effect of the primary homes relative to a secondary living area. All continuous variables are transformed into natural logs and the model estimated has a semilog functional form.

In the 2SLS estimation, the more representatives of each group statistically significant are selected to be estimated due to the strong requirements of instruments to be used. In this specification, the cathegorical instead of dummy space specification has been chosen to estimate the spatial effect on attributes as the model definition allows it[4].

For the recursive term, time effect parameter (lambda) captures the effect of the lagged price on the current house price in the model. The overall effect (lmph(t-1)) gives a coefficient with similar interpretation than the autocorrelation, that is, the share of the prices in the previous period contributing to the price today. There are also calculated the space-recursive parameter at each urban level (urb_i_lphask(t-1)), that is $\rho[\mathbf{W}\boldsymbol{y}_{t-1}]_i$.

The model includes 28 + 5+16 parameters to be estimated in the overall 2SLS model using the space description based on 4 urban levels. When it is controlled by province, the parameters are multiplied by 7 creating a very complex matrix to be estimated. There was a strong requirement of instruments non linear dependent to be used in 2SLS tool.

As at province level most of the attributes appear in homogeneous bundles, many of variables are dropped in the calculation process due to a lack on saturation at the required levels or perfect colinearity. It requires to use Z-score values of the instruments in some cases to avoid last problem. These lead us to eliminate some space attributes parameter in order to let the model to capture changes on urban location.

The more relevant results regarding the yearly coefficient representing the index, are shown in table 2 to 9 (overall as well as province results).Each table includes the

[4] It is the original definition of *f(x)* in Anselin, 1999 which suggest that some spatial effect on attributes is contained but not necessarily the full space relationships.

recursive parameter (time effect, λ) and the space-recursive parameter (time lag-space effects, ρ) and the goodness of fit tests.

Residuals of the model are small and with bell shape suggesting that they are random distributed as white noise (figure 3)

Insert figure 3 around here

Results and discussions

The model gives quite acceptable results with small standard deviation and errors at all province levels (but in Balearic Islands) and reasonable interpretation of the estimated parameters. Parameters are significant at aggregate level for the seven provinces and their results are supported by provinces' parameter values as well.

Results from the 2SLS model are *the price indices controlled* by quality and spatio-temporal interactions, calculated by province. Based on the estimated parameter, the indices normalized to 1 in 1999 are calculated for the overall database and each analyzed province. Figure 2 to provide their shapes where the impact of the 2008 credit crunch shock could be easily seen.

Insert Figure 2 around here

Using the estimated hedonic indexes, the accumulated revaluation of housing prices controlled by quality and time-space is calculated and compared to the non-adjusted by spatio-time and quality original data provided by the Ministry of Fomento[5]. An index based on 1999 is calculated with this data as well and the accumulate revaluation during 1999-2010. Results are reported in tables 2.

- It can be shown how increases on housing prices adjusted by quality and spatio-time autocorrelation in all provinces since 1999 to 2010 are around 25% in the decade. The province with higher revaluation has been Valencia (contains the third capital in Spain) with a 50.5% of accumulated revaluation in last decade and two show the lowest

[5] This data is based on housing prices by m2 values estimated using information from valuation and Registry data but the Ministry of Fomento. There is another house price index quality adjusted using hedonic models, published by INE, but time period is only available since 2007 and it does not allow us for comparison.

revaluation (around a 19.5%-19.7%) as Alicante and Balearic Island. Castellón, Madrid and Murcia have experienced a revaluation around 30-36% and Barcelona a 25.1%.

Insert Table 2 around here

- Maximum revaluation has been in 2007 for most provinces but Barcelona (in 2006) and Murcia (in 2008). Main price correction has taken place during 2009, with increase on prices during 2010 in Alicante and Balearic Is (3.5% and 17.8% respectively). Castellón, Madrid and Murcia have reduced strongly their housing prices during 2010 (between -3.5 to -5.9% in one year). Smaller correction has been in Valencia, with a total of -3.5% since 2008 and an accumulate revaluation of 50.5% since 2000, the highest in the dataset.

- Revaluation figures are substantially lower in spatio-time and quality adjusted index than those in the original data at the order of 60%-65% of less accumulate overvaluation, consistently in all regions (see table 3). Such strong difference is suggested to be due to differences in quality and spatio-time which suggest that time, space autocorrelation and changes on quality are the main reasons to explain the house overvaluation in most Spanish regions during last decade. Four regions from those analyzed shows stronger differences between the adjusted index and the original one: Alicante, Balearic Islands, Castellón and Murcia. These four have similar features: coastal areas, with secondary housing demand and high quality environment. They do not have located a relevant prime capital at Spanish level (like Madrid, Barcelona o Valencia provinces) and their capitals have similar size.

Insert Table 3 around here

- Differences among adjusted versus non adjusted overvaluation were smaller at the beginning of 2000’s increasing dramatically since 2002. Housing cycle also growth strongly since 2001. Similarities between two indexes (adjusted and non adjusted) at the beginning of the period support the previous interpretation about the changes on quality associated to new house building starting to appear after 2002 associated to the building cycle.

- Lag recursive parameter show time autocorrelation structure on the data and capture the time effect on data. It is statistically significant for most of provinces but Castellón and Valencia. In other cases, the value is around 0.17 for Barcelona, Madrid and Murcia and 0.45-0.55 for Alicante and Balearic Islands.
- Space recursive parameters (time lag-space effects) are statistically significant in all models. In all cases, results are consistent with positive differences in house prices in superior urban levels. Each model range around -1% to – 1.4% the difference between prices of a m2 of house located in a dependent urban area relative to their independent city. Balearic Island shows distinct pattern, with such difference in county capitals (and Barcelona as well) but a positive and very small difference in those smaller urban areas. In Barcelona county capitals. Premium to be located in a province capital is between 0.6-0.8% (Castellón, Alicante), 1% (Valencia, Madrid, Balearic Islands) and 2% in Murcia.
- Indices for each region are highly statistically significant but for Murcia (table 4 to 11). Goodness of fit gives low standard errors (ranged from 0.08 to 0.1) and high Adjusted R2, explaining higher than 82% of variability in dependent variables, log of asking prices. Higher explanatory power is in Murcia and Castellón with more than 92%.

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8. Conclusions

This paper calculates housing price index controlled by quality and spatio-time autocorrelation for selected Spanish provinces, using asking prices over a long-run period from 1995 to 2010. The paper utilises hedonic models to fit the pricing process allowing the parameters change with time and space.

The modelling process uses STAR methodologies to estimate an hedonic model obtaining prices indexes controlling by space and time. Such indices are precisely calculated controlled by three different dimensions of the attributes including those relating to the socio economic characteristics of the city, the neighbourhood, accessibility and structural attributes and, by observing changes over time and space.

Results support that changes on quality and controlling for spatial autocorrelation is one of the main reasons to explain house price revaluation in Spain and their differences at spatial level. In this respect the paper makes an important contribution to the literature through application to the Spanish market but more significantly adds to the knowledge base on how constant quality indexes controlled by time and space could give strong differences related to non-adjusted housing price indices. This is tested at spatially at a macro-level by province. The highest revaluation ate using controlled by quality and spatio-time index is 50.5% accumulated since 2000 to 2010 in Valencia province while the revaluation for Madrid was 35.7% and 25.1% for Barcelona. Both adjusted and non adjusted indices where very close during 1999-2001, the previous years to the housing boom (2001-2007) which suggest that house-building have been developed with different quality levels than the previous existing stock.

All these results adds evidence to the literature regarding how any large and reach database could incorporate bias in hedonic price indices if it is not controlled by time and space. Furthermore the analysis suggests that the difference between asking prices and hedonic prices could be a measure of market information and subjective perception.

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TABLE 1. Basic Statistics

Group	VARIABLE	N	Mean	Median	Mode	St.deviation	Min.	Max.	Variable	Description
	Year	2362800	2002,72	2003	2005	3,526	1995	2010	Continuous	
	Urbandep	2362800	2,49	2	2	0,949	1	4	Cathegorical	Urban dependence. 4 cathegories
	prov2	2362800	19,76	8	3	17,260	3	46	Cathegorical	province
	Phask	2362800	132770,63	117197	72121,45	89471,373	10,22	5400000	cont	Asking prices
Socioeconomic	Popdens	2362071	2,50	3	3	0,543	1	3	Cathegorical	density of population
	Ecoact	2362264	4,02	5	5	1,367	1	5	Cathegorical	economic activity in the city/neigbourhood
	Popgrow	2354552	1,71	2	2	0,512	0	2	Cathegorical	population growth
	Income	2362519	4,19	4	4	0,645	1	7	Cathegorical	income level in the neighbourhood
	Urbanenv	2362709	2,99	3	3	0,134	1	3	Cathegorical	urban area in rural, medium or urban
Neighbourhood	Resarea	2344542	1,30	1	1	0,700	1	5	Cathegorical	use of houses in the area: first residence, second or mix.
	Cons	2362800	86,18	90	90	19,012	0	990	cont	urban consolidation
	Qroad	2361553	3,90	4	4	0,401	0	5	Cathegorical	quality of construction
	Qwater	2362769	2,97	3	3	0,266	0	4	Cathegorical	quality of the roads
	Qlight	2362769	3,89	4	4	0,435	0	5	Cathegorical	quality of water system
	Qshop	2362680	3,89	3	3	1,231	0	6	Cathegorical	quality of urban lights
	Qschool	2362698	3,93	4	4	0,816	0	5	Cathegorical	quality of shopping area
	Qleisure	2362704	3,88	4	4	0,804	0	5	Cathegorical	quality of leisure facilities
	Qsport	2362616	3,88	4	4	0,812	0	5	Cathegorical	quality of sport facilities
	Qhealth	2362559	3,90	4	4	0,822	0	5	Cathegorical	quality of health facilities
Accesibility	Bus	2362644	4,12	4	4	0,808	0	6	Cathegorical	bus stop near
	Train	2362535	1,27	2	2	0,942	0	2	Cathegorical	train stop/station
	Underg	2360520	0,41	0	0	1,038	0	5	Cathegorical	undergraund station
Structural	dweel	2362800	17,06	12	0	24,058	0	2410	con	Total dweelings
	lift	2362800	0,78	1	1	0,912	0	50	cont	Number of lift
	age	2362800	8,83	5	0	11,002	0	301	cont	age
	Orient	2360630	4,30	5	6	2,391	0,1	8	Cathegorical	Orientation
	View	2361832	3,04	3	2	0,973	0	6	Cathegorical	View
	Constq	2362715	4,01	4	4	0,789	1	6	Cathegorical	Construction quality
	m2	2362800	104,33	100	90	38,217	11	1200	cont	m2
	m2 other areas	2362800	8,39	0	0	981,781	0	396668	cont	m2 other areas
	type_t3	2362350	1,4015391	1,00	1	0,68140773	1	3	Cathegorical	Private green areas, dummy

Table 2 **STAR Model Hedonic index: Revaluation of housing prices since 1999**

(Accumulative annual % of housing prices change)

	FULL MODEL	3 Alicante	07 Balearic Isl.	08 Barcelona	12 Castellón	28 Madrid	30 murcia	46 Valencia
2000	5,0	5,9	5,1	5,0	0,5	16,9	3,0	5,3
2001	10,4	4,2	17,8	12,0	3,2	20,9	6,2	17,7
2002	17,0	10,6	13,6	16,7	5,3	26,2	13,6	22,3
2003	22,9	17,0	11,9	19,1	7,3	31,2	16,9	26,3
2004	24,2	16,9	16,8	28,2	20,2	35,8	23,1	30,9
2005	29,3	19,7	19,0	33,0	37,2	35,1	32,1	46,1
2006	34,2	22,5	21,1	37,2	40,2	40,8	36,4	52,6
2007	35,4	24,1	22,4	35,7	41,7	41,8	36,4	54,0
2008	32,0	21,2	20,5	34,1	41,4	41,0	39,9	52,7
2009	26,7	18,7	16,7	25,9	33,6	41,6	37,8	51,9
2010	27,9	19,5	19,7	25,1	30,1	35,7	32,1	50,5

Table 3 **STAR Model Hedonic index vs non spatio-time adjusted data: Differences on house prices revaluation**

(Accumulative annual % of housing prices change: STM index revaluation minus original data index revaluation)

	FULL MODEL	**3 Alicante**	**07 Balearic Isl.**	**08 Barcelona**	**12 Castellón**	**28 Madrid**	**30 murcia**	**46 Valencia**
2000	-3,6	-9,7	-16,7	-9,0	-13,6	5,7	-9,5	-6,1
2001	-8,1	-27,6	-20,4	-15,1	-21,9	-4,7	-22,2	-5,7
2002	-17,2	-40,1	-33,9	-18,2	-38,5	-19,8	-31,6	-13,7
2003	-28,9	-50,8	-44,5	-27,7	-54,0	-34,7	-46,1	-23,4
2004	-45,1	-65,1	-49,6	-34,9	-59,2	-46,6	-66,1	-32,8
2005	-53,8	-77,5	-60,4	-40,4	-60,1	-59,7	-72,0	-35,9
2006	-59,3	-81,7	-69,8	-48,4	-68,7	-61,6	-77,0	-42,0
2007	-63,9	-82,6	-76,1	-55,8	-72,6	-63,7	-86,4	-47,2
2008	-68,1	-84,8	-79,8	-60,1	-72,0	-61,7	-82,6	-52,8
2009	-65,9	-76,9	-74,6	-61,8	-71,4	-52,4	-73,0	-47,3
2010	-60,8	-69,4	-67,1	-59,5	-71,1	-53,2	-75,7	-42,0

Table 4 STM 2SLS HEDONIC IN RECURSIVE SPATIO-TIME MODEL HOUSE PRICE INDEX. Overall model

Dependent Variable: lPhask		Overall database[1]				General index Spain [a)]	
Parameters[2]		δ	*t*	Index 1999=1	% acc change since 1999	Index 1999=1	% acc change since 1999
	Intercept	2,37	152,4 ***				
Price index	d1996	-0,36	-95,6 ***	,698		,854	
	d1997	-0,34	-98,9 ***	,706		,878	
	d1998	-0,25	-67,1 ***	,773		,929	
	d1999	-0,29	-103,8 ***	,743		1,000	
	d2000	-0,24	-69,6 ***	,780	5,0	1,086	8,6
	d2001	-0,19	-53,3 ***	,822	10,4	1,193	18,4
	d2002	-0,13	-46,1 ***	,877	17,0	1,380	34,2
	d2003	-0,07	-29,8 ***	,928	22,9	1,624	51,8
	d2004	-0,06	-22,8 ***	,940	24,2	1,907	69,2
	d2005	-0,013	-- --	,988	29,3	2,172	83,1
	d2006	0,036	23,4 ***	1,037	34,2	2,398	93,6
	d2007	0,048	29,6 ***	1,050	35,4	2,537	99,3
	d2008	0,013	6,5 ***	1,013	32,0	2,555	100,0
	d2009	-0,04	-15,1 ***	,959	26,7	2,365	92,6
	d2010	-0,03	-8,6 ***	,971	27,9	2,274	88,7
Time lag - autorregresive parameter		λ	t				
	lMPhask_t-1	0,261	97,3***			[a)] Source: MFOM	
Time lag-space effect		ρ	t				
	urb3_lphask_t-1	0,0005	1,5				
	urb2_lphask_t-1	-0,002	-8,3***				
	urb1_lphask_t-1	-0,008	-18,7***				
Tests	R2	0,83					
	R2adj	0,83					
	standard error	0,115					
	Resid	954,7					
	F	5457,2					
	pr	0.00					

[1] STM2SLS Hedonic Index is estimated as exp(β) and normalized to 1 in 1999

[2] Parameters for attributes and combine spatial effects could be sent under request

Table 5 STM 2SLS HEDONIC IN RECURSIVE SPATIO-TIME MODEL HOUSE PRICE INDEX. ALICANTE

Dependent Variable: lPhask		Alicante province database[1]					Alicante province H prices [a)]	
Parameters[2]		δ	*t*		Index 1999=1	% acc change since 1999	Index 1999=1	% acc change since 1999
	Intercept	1,875	20,2	***				
Price index	d1996	-,291	-22,5	***	,921		,766	
	d1997	-,237	-18,1	***	,972		,797	
	d1998	-,225	-16,9	***	,984		,879	
	d1999	-,209	-17,3	***	1,000		1,000	
	d2000	-,152	-13,2	***	1,059	5,9	1,155	15,5
	d2001	-,169	-17,7	***	1,041	4,2	1,343	31,8
	d2002	-,106	-14,3	***	1,108	10,6	1,597	50,7
	d2003	-,044	-7,6	***	1,179	17,0	1,870	67,8
	d2004	-,046	-8,6	***	1,177	16,9	2,135	82,0
	d2005	-0.02	--	--	1,210	19,7	2,459	97,1
	d2006	,009	3,2	***	1,244	22,5	2,631	104,1
	d2007	,026	7,9	***	1,264	24,1	2,701	106,8
	d2008	-,004	-0,9	***	1,227	21,2	2,679	106,0
	d2009	-,029	-7,1	***	1,197	18,7	2,402	95,6
	d2010	-,022	-4,6	***	1,206	19,5	2,240	88,9
Time lag - autorregresive parameter		λ	t					
	lMPhask_t-1	,446	15,7	***			[a)] Source: MFOM	
Time lag-space effect		ρ	t					
	Urb4_lphask_t-1	,008	11,3					
	Urb3_lphask_t-1	,009	11,0	***				
	urb1_lphask_t-1	-,016	-14,9	***				
Tests	R2	0,86						
	R2adj	0,86						
	standard error	0,09						
	Resid	158,5						
	F	1883,0						
	pr	0,00						

[1] STM2SLS Hedonic Index is estimated as exp(β) and normalized to 1 in 1999

[2] Parameters for attributes and combine spatial effects could be sent under request

Table 6 STM 2SLS HEDONIC IN RECURSIVE SPATIO-TIME MODEL HOUSE PRICE INDEX. BALEARIC ISLANDS

Dependent Variable: lPhask		Balearic I.province database[1]				Balearic I. province H prices [a)]	
Parameters[2]		δ	*t*	Index 1999=1	% acc change since 199	Index 1999=1	% acc change since 1999
	Intercept	2,50	10,0 ***				
Price index	d1996					,628	
	d1997					,642	
	d1998	1,43	7,5***			,683	
	d1999	-0,18	-7,5***	5,016		,796	
	d2000	-0,13	-5,5***	1,000		1,000	
	d2001	-0,01	-0,5	1,051	5,1	1,218	21,8
	d2002	-0,05	-4,1***	1,184	17,8	1,417	38,1
	d2003	-0,07	-5,5***	1,134	13,6	1,549	47,5
	d2004	-0,02	-3,0***	1,115	11,9	1,687	56,4
	d2005	0,00		1,170	16,8	1,857	66,5
	d2006	0,02	5,7***	1,195	19,0	2,097	79,4
	d2007	0,03	6,1***	1,221	21,1	2,339	90,9
	d2008	0,02	1,9*	1,237	22,4	2,517	98,5
	d2009	-0,02	-2,2***	1,213	20,5	2,562	100,3
	d2010	0,01	0,8	1,168	16,7	2,332	91,3
Time lag - autorregresive parameter		λ	t				
	lMPhask_t-1	0,548	6,8***			[a)] Source: MFOM	
Time lag-space effect		ρ	t				
	Urb3_lphask_t-1	-0,010	-9,7***				
	Urb2_lphask_t-1	-0,003	-3,9***				
	urb1_lphask_t-1	-0,002	-1,9*				
Tests	R2	0,85					
	R2adj	0,85					
	standard error	0,08					
	Resid	43,27					
	F	746,8					
	pr	0,00					

1 STM2SLS Hedonic Index is estimated as exp(β) and normalized to 1 in 1999

2 Parameters for attributes and combine spatial effects could be sent under request

Table 7 STM 2SLS HEDONIC IN RECURSIVE SPATIO-TIME MODEL HOUSE PRICE INDEX. BARCELONA

Dependent Variable: lPhask		Barcelona province database[1]					Barcelona province H prices [a)]	
Parameters[2]		δ	*t*		Index 1999=1	% acc change since 199	Index 1999=1	% acc change since 1999
	Intercept	2,50	10,0	***				
Price index	d1996						,786	
	d1997						,814	
	d1998						,876	
	d1999	-0,37	-10,4	***	1,000		1,000	
	d2000	-0,33	-9,2	***	1,050	5,0	1,140	14,0
	d2001	-0,26	-8,5	***	1,123	12,0	1,289	27,1
	d2002	-0,21	-7,8	***	1,176	16,7	1,390	34,9
	d2003	-0,19	-8,2	***	1,204	19,1	1,555	46,8
	d2004	-0,10	-5,5	***	1,314	28,2	1,809	63,1
	d2005	-0,05	-5,3	***	1,377	33,0	1,996	73,4
	d2006	-0,01	-2,7	***	1,435	37,2	2,240	85,7
	d2007	-0,03			1,413	35,7	2,370	91,5
	d2008	-0,04	-9,4	***	1,391	34,1	2,434	94,2
	d2009	-0,13	-17,4	***	1,277	25,9	2,277	87,7
	d2010	-0,14	-10,0	***	1,267	25,1	2,206	84,6
Time lag - autorregresive parameter		λ	t					
	lMPhask_t-1	0,17	2,4	***			[a)] Source: MFOM	
Time lag-space effect		ρ	t					
	Urb4_lphask_t-1	-0,001	-0,2					
	Urb3_lphask_t-1	-0,005	-9,0	***				
	urb1_lphask_t-1	-0,012	-4,0	***				
Tests	R2	0,82						
	R2adj	0,82						
	standard error	0,09						
	Resid	89,2						
	F	1127,2						
	pr	0,00						

1 STM2SLS Hedonic Index is estimated as exp(β) and normalized to 1 in 1999

2 Parameters for attributes and combine spatial effects could be sent under request

Table 8 STM 2SLS HEDONIC IN RECURSIVE SPATIO-TIME MODEL HOUSE PRICE INDEX. CASTELLÓN

Dependent Variable: lPhask		Castellón province database[1]					Castellón province H prices [a)]	
Parameters[2]		δ	*t*		Index 1999=1	% acc change since 199	Index 1999=1	% acc change since 1999
	Intercept	2,36	30,43	***				
Price index	d1996						,82	
	d1997						,85	
	d1998	,04	3,17		,83		,91	
	d1999	,23	11,51	***	1,00		1,00	
	d2000	,23	5,89	***	1,00	,5	1,14	14,1
	d2001	,26	10,38	***	1,03	3,2	1,27	25,1
	d2002	,28			1,05	5,3	1,50	43,8
	d2003	,30	9,66	***	1,08	7,3	1,77	61,4
	d2004	,42	19,03	***	1,21	20,2	2,09	79,4
	d2005	,58	44,82	***	1,42	37,2	2,46	97,4
	d2006	,61	49,04	***	1,46	40,2	2,75	109,0
	d2007	,62	48,43	***	1,48	41,7	2,89	114,3
	d2008	,62	39,99	***	1,48	41,4	2,87	113,3
	d2009	,54	26,31	***	1,36	33,6	2,63	105,0
	d2010	,50	15,57	***	1,32	30,1	2,53	101,2
Time lag - autorregresive parameter		λ	t					
	lMPhask_t-1	excluded					[a)] Source: MFOM	
Time lag-space effect		ρ	t					
	Urb4_lphask_t-1	0,006	4,425***					
	Urb3_lphask_t-1	-0,001	-,806					
	urb1_lphask_t-1	0,003	1,002					
Tests	R2	0,92						
	R2adj	0,92						
	standard error	0,08						
	Resid	8,19						
	F	401,49						
	pr	0,00						

[1] STM2SLS Hedonic Index is estimated as exp(β) and normalized to 1 in 1999

[2] Parameters for attributes and combine spatial effects could be sent under request

Table 9 STM 2SLS HEDONIC IN RECURSIVE SPATIO-TIME MODEL HOUSE PRICE INDEX. MADRID

Dependent Variable: lPhask		**Madrid province database[1]**					**Madrid province H prices [a)]**	
Parameters[2]		δ	*t*		Index 1999=1	% acc change since 199	Index 1999=1	% acc change since 1999
	Intercept	2,90	29,6	***				
Price index	d1996						,96	
	d1997						,94	
	d1998	-0,27	-21,6		,99		,94	
	d1999	-0,27	-26,1	***	1,00		1,00	
	d2000	-0,11	-8,6	***	1,17	16,9	1,11	11,2
	d2001	-0,07	-6,7	***	1,22	20,9	1,27	25,6
	d2002	-,02			1,28	26,2	1,53	46,0
	d2003	0,03	4,1	***	1,34	31,2	1,84	65,9
	d2004	0,07	8,5	***	1,41	35,8	2,14	82,4
	d2005	0,07	7,5	***	1,40	35,1	2,41	94,8
	d2006	0,12	13,0	***	1,48	40,8	2,59	102,5
	d2007	0,13	13,9	***	1,49	41,8	2,67	105,5
	d2008	0,12	11,1	***	1,48	41,0	2,59	102,6
	d2009	0,13	9,2	***	1,49	41,6	2,37	94,1
	d2010	0,07	2,8	***	1,40	35,7	2,25	89,0
Time lag - autorregresive parameter		λ	t					
	lMPhask_t-1	0,155	2,9	***			[a)] Source: MFOM	
Time lag-space effect		ρ	t					
	Urb4_lphask_t-1	0,011	9,9	***				
	Urb3_lphask_t-1	0,002	-0,4					
	urb1_lphask_t-1	-0,039	-3,6	***				
Tests	R2	0,84						
	R2adj	0,84						
	standard error	0,10						
	Resid	35,16						
	F	436,19						
	pr	0,00						

1 STM2SLS Hedonic Index is estimated as exp(β) and normalized to 1 in 1999

2 Parameters for attributes and combine spatial effects could be sent under request

Table 10 STM 2SLS HEDONIC IN RECURSIVE SPATIO-TIME MODEL HOUSE PRICE INDEX. MURCIA

Dependent Variable: lPhask		Murcia province database[1]					Murcia province H prices [a)]	
Parameters[2]		δ	*t*		Index 1999=1	% acc change since 199	Index 1999=1	% acc change since 1999
	Intercept	2,62	104,0	***				
Price index	d1996	-0,45	-3,0	***			,84	
	d1997	-0,44	-3,0	***	1,01		,87	
	d1998	-0,47	-3,1	***	1,02		,93	
	d1999	-0,44	-2,9	***	1,00		1,00	
	d2000	-0,40	-2,6	***	1,03	3,0	1,12	12,5
	d2001	-0,33	-2,1	***	1,06	6,2	1,30	28,3
	d2002	-0,30	-1,9	*	1,14	13,6	1,52	45,2
	d2003	-0,24	-1,5		1,18	16,9	1,79	63,0
	d2004	-0,15	-0,9		1,25	23,1	2,26	89,2
	d2005	-0,11	-0,7		1,37	32,1	2,60	104,1
	d2006	-0,11	-0,6		1,42	36,4	2,84	113,4
	d2007	-0,08	-0,4		1,42	36,4	3,11	122,8
	d2008	-0,10	-0,5		1,47	39,9	3,10	122,6
	d2009	-0,16	-0,9		1,44	37,8	2,74	110,8
	d2010	-0,15	-0,8		1,36	32,1	2,66	107,8
Time lag - autorregresive parameter		λ	t					
	lMPhask_t-1	0,172	1,9	*			[a)] Source: MFOM	
Time lag-space effect		ρ	t					
	Urb4_lphask_t-1	0,020	15,5	***				
	Urb3_lphask_t-1	-0,001	-0,4					
	Urb2_lphask_t-1	0,002	2,8	***				
Tests	R2	0,94						
	R2adj	0,94						
	standard error	0,08						
	Resid	57,9						
	F	2589,7						
	pr	0,00						

[1] STM2SLS Hedonic Index is estimated as exp(β) and normalized to 1 in 1999

[2] Parameters for attributes and combine spatial effects could be sent under request

Table 11 STM 2SLS HEDONIC IN RECURSIVE SPATIO-TIME MODEL HOUSE PRICE INDEX. VALENCIA

Dependent Variable: lPhask		Valencia province database[1]					Valencia province H prices [a)]	
Parameters[2]		δ	*t*		Index 1999=1	% acc change since 199	Index 1999=1	% acc change since 1999
	Intercept	2,95	116,5	***				
Price index	d1996						,81	
	d1997						,84	
	d1998	0,02	2,7	***	,99		,89	
	d1999	0,02	4,9	***	1,00		1,00	
	d2000	0,08	12,2	***	1,05	5,3	1,11	11,4
	d2001	0,19	26,6	***	1,18	17,7	1,25	23,4
	d2002	0,24	25,9	***	1,24	22,3	1,41	36,0
	d2003	0,28	44,8	***	1,29	26,3	1,60	49,7
	d2004	0,32	53,3	***	1,35	30,9	1,82	63,8
	d2005	0,46	92,2	***	1,55	46,1	2,15	82,0
	d2006	0,53	99,4	***	1,65	52,6	2,43	94,6
	d2007	0,54	97,0	***	1,67	54,0	2,58	101,1
	d2008	0,53	87,7	***	1,65	52,7	2,70	105,5
	d2009	0,52	74,1	***	1,64	51,9	2,53	99,2
	d2010	0,50	68,8	***	1,62	50,5	2,36	92,4
Time lag - autorregresive parameter		λ	t					
	lMPhask_t-1	-0,060	-1,3				a) Source: MFOM	
Time lag-space effect		ρ	t					
	Urb4_lphask_t-1	0,007	12,8	***				
	Urb3_lphask_t-1	-0,004	-8,7	***				
	Urb1_lphask_t-1	-0,001	-0,8					
Tests	R2	0,86						
	R2adj	0,86						
	standard error	0,08						
	Resid	105,36						
	F	1953,5						
	pr	0,00						

[1] STM2SLS Hedonic Index is estimated as exp(β) and normalized to 1 in 1999

[2] Parameters for attributes and combine spatial effects could be sent under request

Figure 1. Asking prices average by year in euros

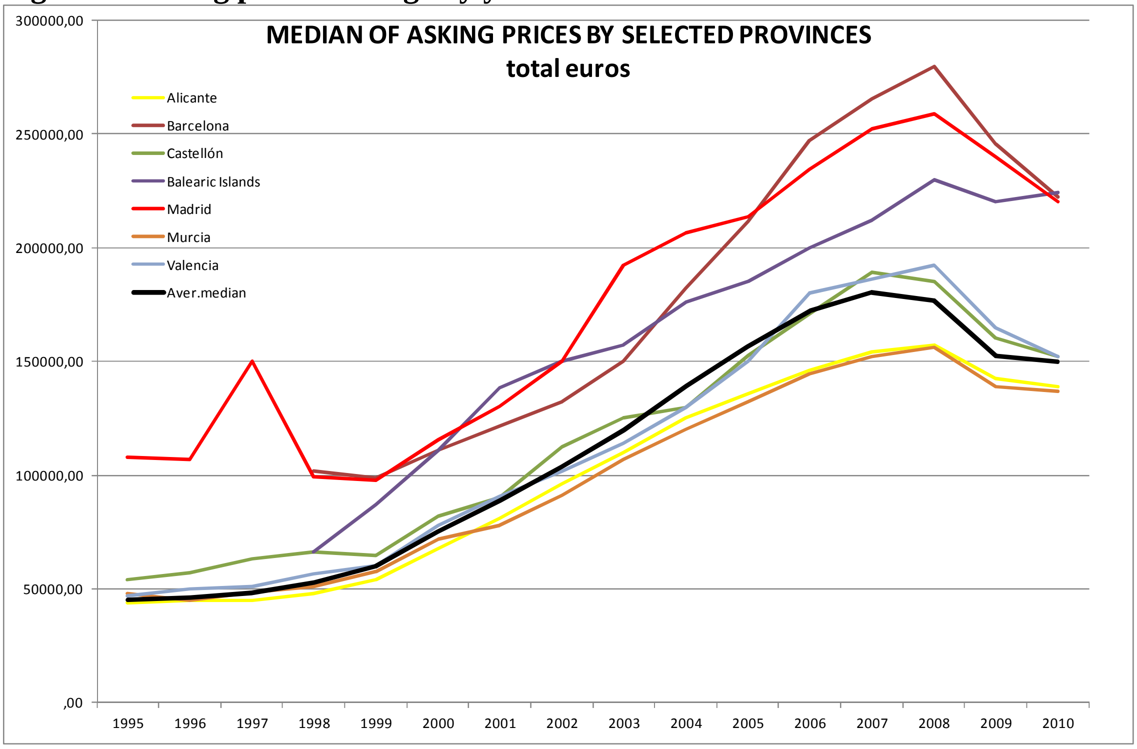

Figure 2- Hedonic price indexes by provinces estimated from hedonic STM recursive model

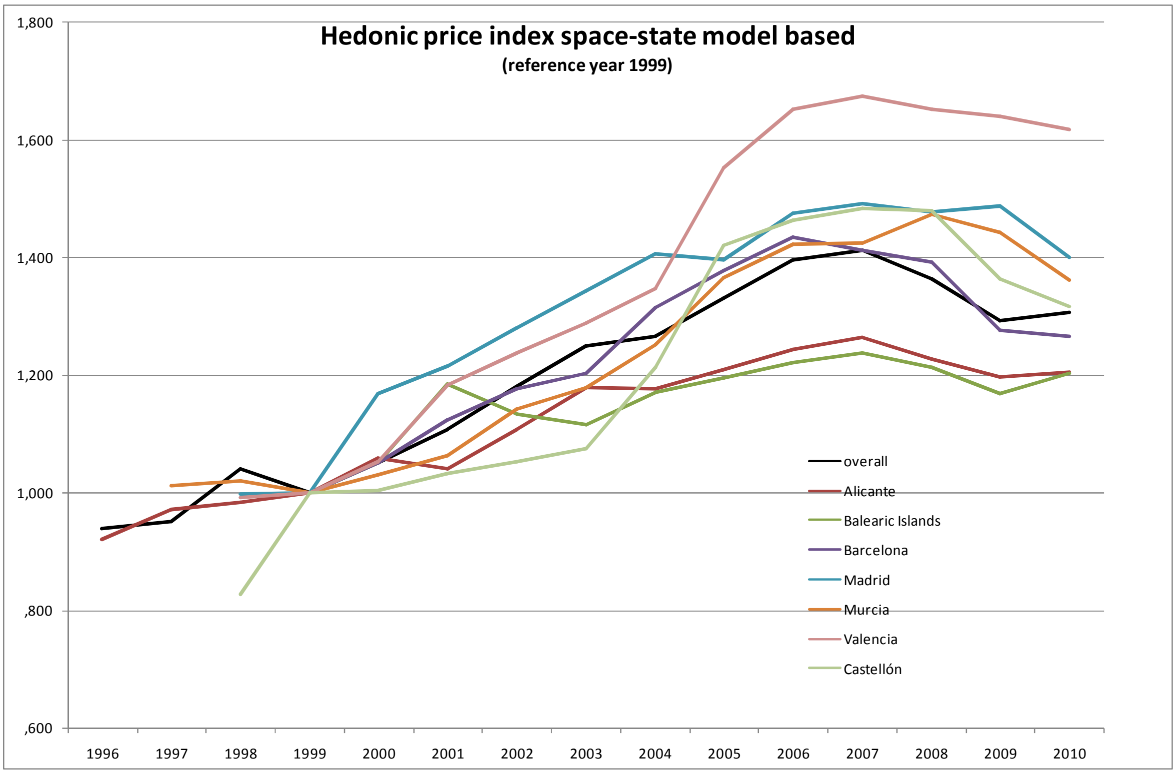

Figure 3: Residual distribution of STM recursive model

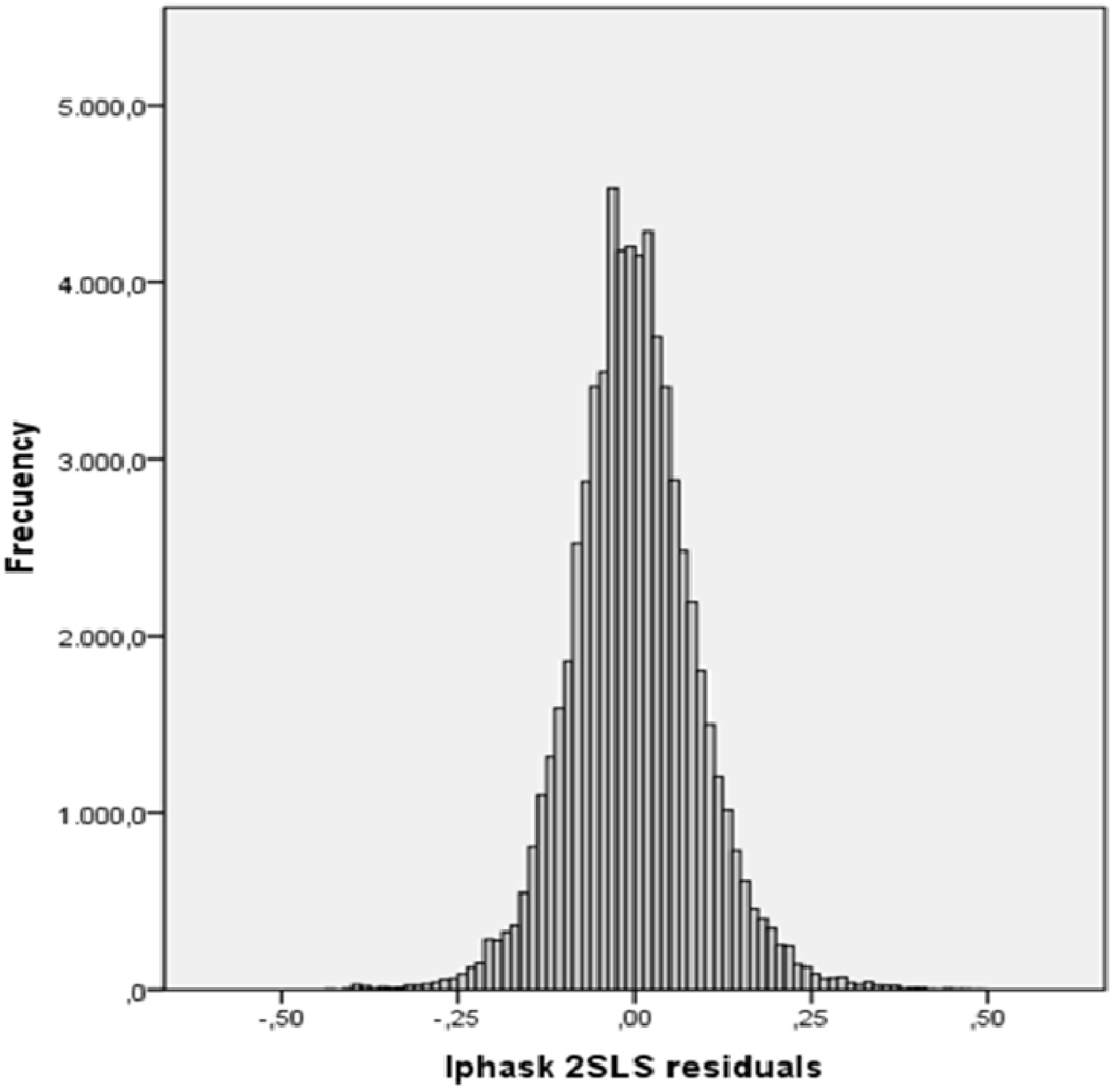

Figure 4: Revaluation 1999-2010: STM hedonic index versus non spatial-time adjusted data. Overall database vs Spanish average

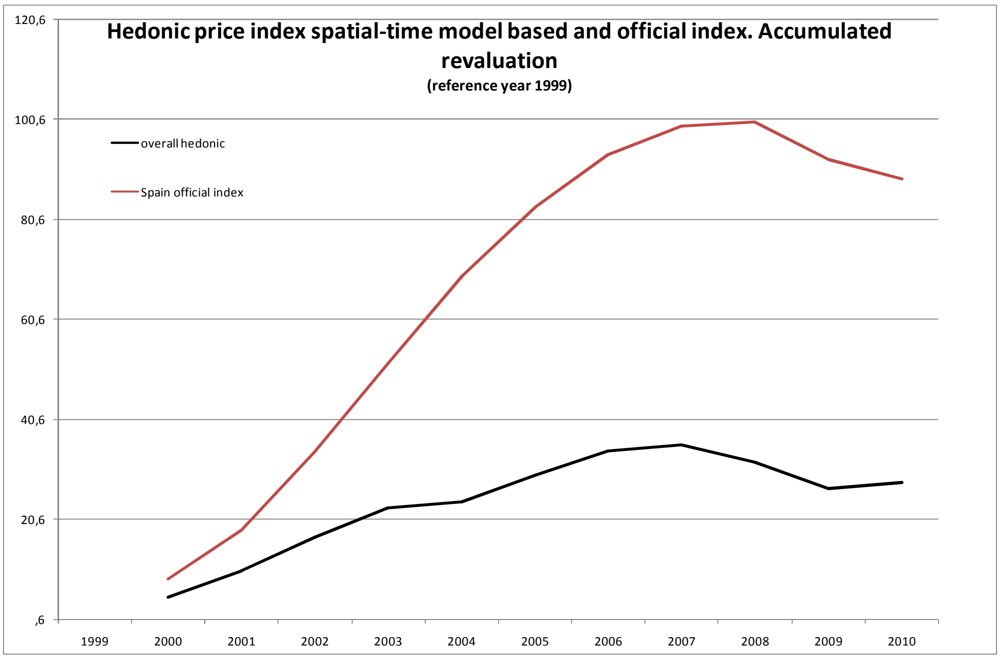

Figure 5: Revaluation 1999-2010: STM hedonic index versus non spatial-time adjusted data. Murcia province and Balearic Islands

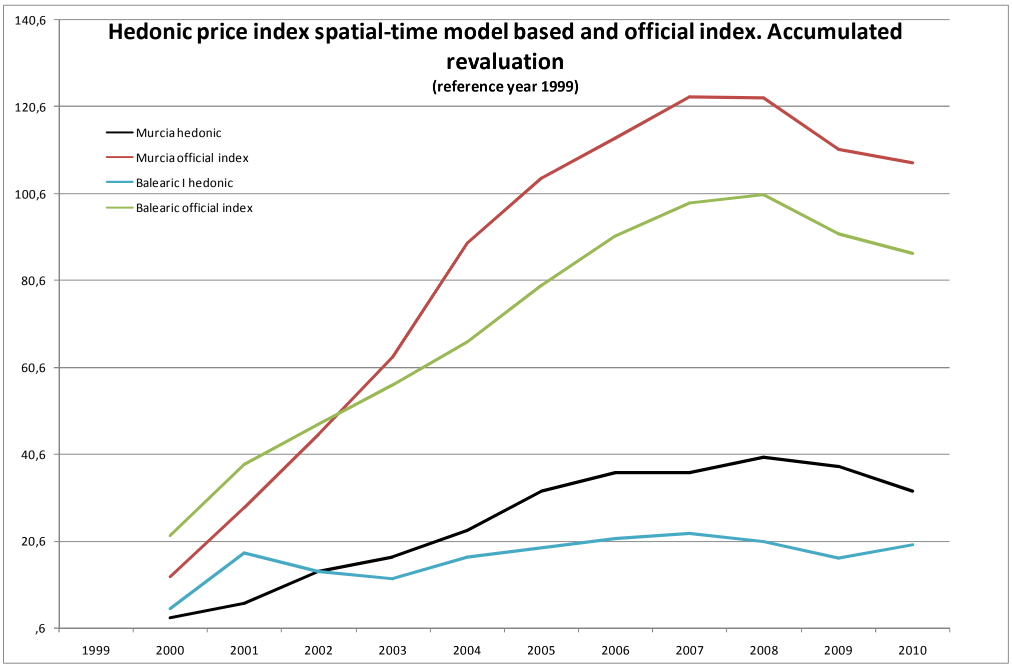

Figure 6: Revaluation 1999-2010: STM hedonic index versus non spatial-time adjusted data. Barcelona and Madrid provinces

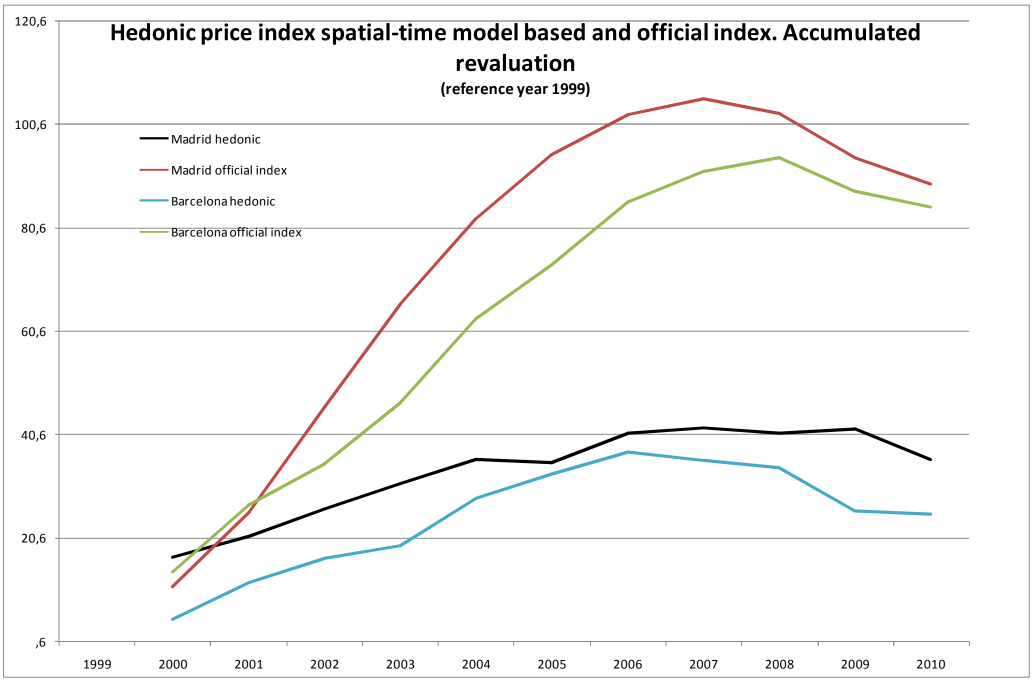

Figure 7: Revaluation 1999-2010: STM hedonic index versus non spatial-time adjusted data. Valencia, Alicante and Castellón provinces