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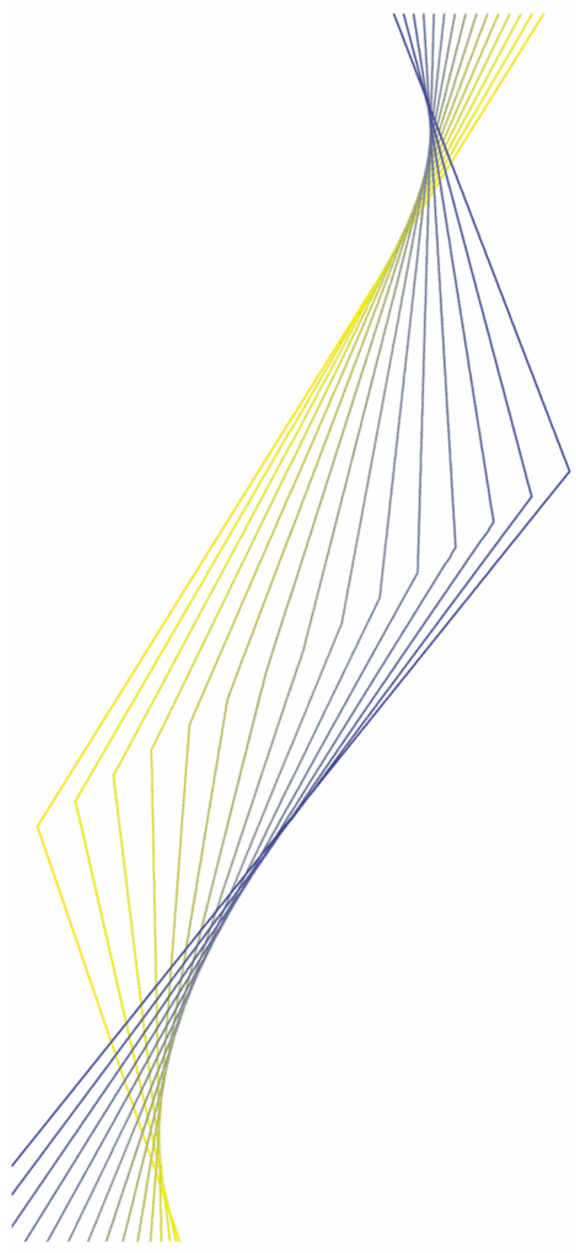

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This paper was presented at the CEPR/ECB Workshop on "Issues in the Measurement of Price Indices", held at the European Central Bank on 16/17 November 2001.

We are grateful to M. Arellano, J.J. Camio, S. Cecchetti, V. Gaspar, M. Izquierdo, Ll. Matea, J. Muellbauer, F. Restoy, E. Sentana and M. Silver for comments and suggestions and to the Ministerio de Fomento, Tecnigrama, and the regional authorities for providing the data. Special thanks are due to Teresa Carbajo and Carmen Marcos for their help in obtaining the data.

The views expressed in this paper are those of the authors and do not necessarily reflect those of the European Central Bank.

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ISSN 1561-0810

Contents

Abstract

In this paper we propose an alternative to traditional hedonics for estimating new multiunit housing inflation, adjusting for quality changes. By relying on the within-site variation we control in a very general way for unobserved housing characteristics using site-specific effects. Precise location, transport, traffic, closeness to services, or construction quality are some of the unobserved but typically relevant housing characteristics that may bias estimated house price inflation, even when using hedonic methods. We also estimate standard hedonic equations and compare the results to those obtained with the alternative hedonic equations with site dummies. Our dataset is fairly rich in observable housing characteristics but, nevertheless, the quality-adjusted house price evolution is quite different in some cases. The data cover the construction of new housing in some of the large Spanish cities and in the smaller towns on the outskirts of the capital during part of the 1990s.

JEL Classification System: C43, E31, O47, R31

Key words: House Prices, Quality Adjustment, Hedonic Price Indices, Unobservable Characteristics, Site Specific Effects

Non-technical Summary

The drawbacks and the consequences of using traditional methods for measuring prices when there are substantial quality changes have recently been highlighted again by the rapid development of information technologies. One of the problems of traditional price measurements is that it is difficult to distinguish which part of the observed price variation of a given product is due to a change in its characteristics (i.e., a change in its quality) and which is due to pure price variation. This has important implications for the measurement of real economic magnitudes since using biased prices when deflating nominal magnitudes will lead to biased real figures. Lately these measurement problems have been most acute in the IT industries. However, there are other areas where the proper measurement of quality-adjusted prices has substantial implications. In this paper we focus on the measurement of new house prices.

New housing is a significant component of real investment and output in all countries. The crucial role of the new housing construction deflator used in the National Accounts is therefore obvious. In fact, the U.S. Bureau of Economic Analysis first adopted hedonic techniques in 1963, precisely for the new housing National Accounts deflator, in order to take into account the slow but steady increases in quality that occur in construction. Moreover, there is a growing consensus that owner-occupied housing should be considered in the European Harmonised Index of Consumer Prices (HICP) and that the way to do this is by constructing an appropriate quality-adjusted index for the price of new dwellings (see Eurostat (2000)).

As an alternative to the traditional (and unsatisfactory) methods of quality adjustment, the literature and practitioners in statistics offices have been using the hedonic method since it was first popularised in the early seventies by Zvi Griliches and co-authors. Hedonic methods use information on the changes in product characteristics to break down price variations into those attributable to changes in characteristics and those that take place for given characteristics. However, if there are unobservable characteristics that are correlated with those included, hedonic regression estimates could be severely biased. This weakness of the standard hedonic method may be more of a problem for certain goods like housing given the importance of construction quality, precise location, traffic, or closeness to services which are usually unobserved. Furthermore, and related to the previous point, the adoption of hedonic methods requires a considerable data-collection effort as information is needed not only on product prices but also on their related characteristics.

In this paper we propose an alternative to traditional hedonics for estimating new multiunit housing inflation, adjusting for quality changes. We do so by relying on the changes in prices of housing units belonging to the same housing development (or site). Indeed, a site takes the form of one (or various) blocks of apartments or various houses with similar quality standards built together on the same site. They may share certain facilities and a site is usually on the market over an extended period of time, between 18 and 24 months on average. Therefore, the method proposed is based on the price variation within a given site over time to capture the price changes net of changes in the characteristics of the site. Furthermore, in contrast to the usual hedonic model, the data requirements are very modest since all site-specific features are accounted for.

We use a large micro data set with information on new dwellings on the market for various cities in Spain over the period 1993 to 1997. When comparing our hedonic index with site specific effects to an average per square meter index constructed with the same data, the difference is sizeable and we estimate the upward bias due to quality increases to be between 0.75% and 1.2% per year over our sample period. We also estimate standard hedonic equations and compare the results to those obtained with the alternative hedonic equations with site dummies. Our dataset is fairly rich in observable housing characteristics but, nevertheless, the quality-adjusted house price evolution is quite different in some cases. Finally, a comparison with the National Accounts residential construction deflator highlights the additional biases that may result from the use of input cost based indices, a problem originally stated in the Stigler report in 1961.

1. INTRODUCTION

Price measurement problems are back on the agenda. The drawbacks and the consequences of using traditional methods for measuring prices when there are substantial quality changes have recently been highlighted again by the rapid development of information technologies. However, there are other areas where the proper measurement of quality-adjusted prices has substantial implications. In this paper we focus on the measurement of new house prices. Hedonic methods have often been used as an alternative in an effort to capture quality improvements adequately. Nevertheless, there is no consensus about the methods that should be adopted and there is a need for broader debate on the advantages, drawbacks, and uses of alternative methods suited to the particularities of different goods or sectors. We hope in this paper to provide some basis for new discussion about alternatives when estimating quality-adjusted prices for new housing.

The significant weight in all countries of new housing when measuring real investment and output can be seen in columns 1 and 2 of Table A.1. Residential construction is a substantial part of Gross Fixed Capital Formation (GFKF) and its importance in overall GDP is not negligible either. The crucial role of the new housing construction deflator used in the National Accounts is therefore obvious. In fact, the U.S. Bureau of Economic Analysis first adopted hedonic techniques in 1963, precisely for the new housing National Accounts deflator, in order to take into account the slow but steady increases in quality that occur in construction. Moreover, there is a growing consensus that owner-occupied housing should be considered in the European Harmonised Index of Consumer Prices (HICP) and that the way to do this is by constructing an appropriate quality-adjusted index for the price of new dwellings (see Eurostat (2000)).

As an alternative to the traditional (and unsatisfactory) methods of quality adjustment, the literature and practitioners in statistics offices have been using the hedonic method since it was first popularised in the early seventies by Zvi Griliches (see, for example, Griliches (1964, 1971), and Berndt, Griliches, and Rappaport (1995)). In the case of housing, hedonic price indices are officially being used in the Netherlands, Norway, Sweden, and the U.S. (see OECD (1997)). In the U.K., mix-adjustment is used (see Department of the Environment (1982)). This procedure can be seen as a non-parametric method similar to (but more general than) an hedonic regression based on the same characteristics[1]. Despite its quite widespread use, there is some uneasiness about fully adopting the hedonic method. First, it is often argued that hedonic estimates of the shadow prices of the characteristics are unstable and do not always make economic sense. Imprecise estimates of individual slope coefficients, however, do not necessarily invalidate the estimated quality-adjusted inflation derived from these estimates. Second, omitted unobserved characteristics correlated with those included could severely bias the hedonic estimates. This may be more of a problem for certain goods like housing given the importance of, for example, construction quality or precise location, which are usually unobserved. Third, and related to the previous point, the adoption of hedonic methods requires a considerable data-collection effort as information is needed not only on product prices but also on their related characteristics.

Another procedure that has been used to control for quality changes in house prices is the repeated sales regression method first proposed by Bailey, Muth, and Nourse (1963) and further developed and implemented by Case and Shiller (1987). The idea is to use observations on houses that have been sold more than once to estimate a quality corrected index. This technique has been criticised (see, for example, Mark and Goldberg (1984), Haurin and Hendershott (1991), and Clapp, Giacotto, and Tirtiroglu (1991)) because of the small sample sizes involved after throwing away all the information on houses sold only once. Other caveats are the lack of representativeness of the often-sold houses and the possible changes that occur between sales, both in the structure of the house itself and in the neighbourhood characteristics. Some hybrid models that share features of both the hedonic and the repeated sales methods have also been estimated (see Palmquist (1980), Case, Pollakowski, and Wachter (1991), and Case and Quigley (1991)).

In this paper we aim to construct a quality-adjusted price index for new housing controlling for unobservable characteristics. We use a large micro data set with information on new dwellings on the market for various cities in Spain. The data are collected twice a year over the period 1993 to 1997. The database contains a large number of characteristics about the dwellings aside from price. The large number of characteristics allows us to present fairly rich estimated hedonic equations. In addition, we also present a new estimation method of housing inflation exploiting the fact that new housing is grouped by sites. By relying on the within-site cross-sectional and time series variation we can control

[1] For mix-adjustment to be feasible in practice, very few characteristics can be considered.

for unobserved characteristics in a very general way using multiple site-specific effects. We believe this method has the potential to be more widely aplicable to other countries.

In Section 2 we first comment briefly on some features of the Spanish housing market relevant to the paper and then we describe the data. In Section 3 the econometric models are presented. The results are discussed in Section 4. First, we present the city estimates of the different price indices we have obtained (average house prices, hedonic, and with site-specific effects); and second, the aggregate indices we have constructed from them. Finally, our aggregate quality-adjusted new house price index is compared to the deflator for residential construction used in the National Accounts. Section 5 contains the conclusions.

2. SOME CHARACTERISTICS OF THE HOUSING MARKET IN SPAIN AND DATA USED

2.1. Some characteristics of the housing market

As is well known, Spain has one of the highest owner-occupancy rates (85% approximately) among the European countries. This is probably the result of various housing policies taken since the 1960s when the authorities had to cope with the large number of migrants moving from rural to urban Spain (before 1960 less than half of the population lived in owned accommodation). The Spanish governments of the 1960s decided to subsidise housing through subsidies to interest rates on loans for buying a house, rather than subsidised rents, and this policy has continued without fundamental change until the present. Nowadays there is no real alternative to purchase when looking for medium or long-term accommodation.

Another distinctive feature that is probably less well known is the enormous proportion of new housing. First, to accommodate migrants, the construction sector was very active throughout the sixties and seventies. Currently, the weight of new housing is still most notable. The share in total construction of residential construction is the highest among OECD countries (see Table A.1, column 3). In turn, new dwellings (and improvements) account for most of residential construction, in a way unseen in the other countries for which we have information (see Table A.1 columns 4 and 5). Indeed, accommodation is needed for the baby-boom generation, the children of the above-mentioned migrants. The migrations of the 1960s and early 1970s, coupled with the very high fertility rates at the time, have produced a high demand for new extra housing in the cities or on their outskirts. Moreover, the number of secondary residences has increased considerably (by 39% between 1981 and 1991). Understandably, Spaniards have somehow become accustomed to this continuous production of new dwellings (and have even developed a preference for new housing).

New housing in Spain is produced by builders or developers who buy the land, build (or sub-contract) dwellings, and offer the finished product for sale. A property development takes the form of one (or various) blocks of apartments or various houses with similar quality standards built together on the same site. They may share certain facilities such as a garage area or a garden. The sale of dwellings starts on the site often before construction work begins (it has been a usual practice to buy on the basis of plans) and continues until all dwellings are sold. A site is therefore on the market over an extended period of time, from 18-24 months on average (but see Figure 1 for the distribution of site duration in our sample). There are usually dwellings of different sizes at each site (see Figure 2 for the distribution of the number of sizes of dwellings by site in our sample). Buyers-to-be visit sites and collect information directly rather than going through estate agents.

2.2. The data

The database, provided by the *Ministerio de Fomento,* contains information on newly constructed housing (apartments and houses) available in the main Spanish cities. To that end, interviewers aim to visit twice a year all private new housing developments as if they were potential buyers. The amount of information gathered is large. For each site there are details on the types of dwellings available, where the difference between types lies in the number of bedrooms and the floor surface area. Furthermore, aside from price and floor area, there is information about the following characteristics: municipal district, total number of dwellings on the site, total number of dwellings on offer, number of bedrooms, number of bathrooms, availability of garage space, central heating, air conditioning, fitted wardrobes, kitchen fittings, utility space, lift, garden, swimming pool, and sports facilities among others. The wide range of the characteristics collected is one of the main advantages of this data set. It makes it possible to estimate hedonic equations and to compare them with alternative methods of obtaining housing price indices. However, before the data on the characteristics could be used, intense work filtering and cross-checking the raw information over time was necessary.

An important variable for the methods we use is the site identifier. We have constructed a unique site identifier using the indicators of province, city, and municipal district, the original site number, and the total number of dwellings built on the site. We also allowed for the possibility, after a site was completely sold, of the same number being assigned in the original database to a different site within the district[2].

The data began to be collected in Madrid and Barcelona in 1990 (first and second semester, respectively), with other towns incorporated into the sample in successive periods. However, in 1993 the methodology of the survey changed quite substantially. For example, we have detected that there are differences in the definition of some characteristics, municipal districts for some cities are not available before 1993, and, until

[2] If information on a given site is missing for two (or more) consecutive periods (semesters) we consider that the same original site number corresponds in fact to different sites.

1993, the number originally assigned to a given site was not the same over time. Furthermore, as we shall see below, disaggregated information about the distribution of types of dwellings by site is not available for any of the cities before 1993. Therefore, our sample period starts in 1993 and ends in 1997 (the first semester for all cities except Madrid and Barcelona for which we have information for the second semester as well), the latest period for which we have data.

One initial limitation of the data is that the price information reflects list as opposed to actual transaction prices. However, discounts are much less frequent for new housing sales than for second-hand ones.

Second, we have reliable information on the number of dwellings on each site that are on the market, but no information about the actual number of dwellings sold. We have tried unsuccessfully to derive the number of dwellings sold from the number of dwellings on offer over time. The main problem is that sometimes the number of dwellings on the market from one period to the next increases. Possible explanations for this fact are that buyers may back down, builders may keep some of the dwellings for a late sale, and also a given development may be built in different phases.

Finally, for some of the cities and/or for some periods, we know the different types of dwellings on offer for each property development site and the total number of dwellings on offer at each site, but we do not know how many of each type are on offer, by site. Therefore, in our empirical analysis we study first the cities (and the period) for which the distribution of dwelling types disaggregated by site is available, i.e. Cádiz and two municipalities on its outskirts[3], fifteen municipalities on the outskirts of Madrid[4], Málaga, Valencia, Valladolid, and Zaragoza, from 1993 to 1997 (our sample of 6 cities). Second, in order to construct an aggregate index that is as representative as possible, we consider a larger sample including as well Barcelona, Bilbao, Madrid and Sevilla (our sample of 10 cities). To be able to study these cities for which a disaggregated distribution of dwelling types by site is not available, we assume that the aggregate city distribution of dwellings (by number of bedrooms) holds within each site. Therefore, using the total number of dwellings on offer at each site and the types of dwellings available at each site, we derive an imputed number of dwellings available of each type, by site.

[3] Puerto de Santa María and San Fernando.

[4] Alcalá de Henares, Alcobendas, Alcorcón, Coslada, Fuenlabrada, Getafe, Leganés, Majadahonda, Móstoles, Parla, Pozuelo de Alarcón, Las Rozas de Madrid, San Fernando de Henares, San Sebastián de los Reyes, and Torrejón de Ardoz.

Tables A.2 and A.3 (one for each sample) report descriptive statistics on the evolution over our sample period of the variables used in our analysis. It is interesting to note how the large drop in the absolute price level in 1994 is accompanied by a significant reduction in the average size of dwellings. Further reductions in quality in 1994 can also be seen from the sharp drop in the proportion of dwellings with a fully equipped kitchen, air conditioning, or sports facilities. However, by 1997 the presence of most of the desirable characteristics (except floor area, sports facilities, and air conditioning) has significantly increased as compared to 1993.

The econometric models will be estimated separately for each city (or group of neighbouring municipalities). To aggregate the different indices obtained we use the weights derived from our sample. We check for the validity of our sample weights by further using the annual data on building permits ('*licitaciones*') provided at the municipality level by the *Ministerio de Fomento*.

3. ECONOMETRIC MODELS

In this section we present the different econometric models we estimate to correct for changes in the quality of housing. First, a standard hedonic model based on observed characteristics, and then the hedonic models with site effects that we propose to control for relevant unobserved housing characteristics.

3.1. Hedonic model with observed characteristics

We estimate standard hedonic equations of the form:

$$p_{it} = g_0 + d_t + b\ m_{it} + \sum_k a_k c_{kit} + e_{it} \qquad (t = 1,...,T) \qquad (1)$$

where $p = \log P$ and P is the price of the dwelling, $m = \log M$ and M is its area*, c* are a set of dummy variables for the presence of certain characteristics such as garden, garage space, fitted cupboards, air conditioning, swimming pool, location as captured for example by district, etc…, *t* and *i* denote the period and the dwelling, respectively. The terms d_t are time dummy coefficients defined as changes with respect to the base year intercept g_0, so that $d_t = \sum_{s=1}^{T} d_s d_{sit}$ where d_{sit} takes the value 1 when *s*=*t* and 0 otherwise. In total $(T+1)$ periods are observed.

Instead of defining our dependent variable in terms of price per square metre and therefore assuming that price is strictly proportional to floor area (holding constant the other characteristics), we estimate the price-to-size elasticity *b.* Furthermore, in the empirical analysis we shall allow for the price-to-size elasticity to vary depending on some of the characteristics of the dwelling, in particular site facilities shared with other neighbours, such as a garden. Indeed, we would expect the price to be less than strictly proportional to size when substantial shared facilities are available.

For our equations we specify a double log form that captures the non-linear relationship between price and area in square metres and allows a straightforward interpretation of the estimated coefficients. In particular, the time dummies (which are annual in our empirical specification) defined with respect to the constant of the equation reflect (after a simple transformation) the price changes with respect to the base year that are not due to changes in the characteristics included in the equation. This is so because we take the shadow prices of the different characteristics (b, a_k) to remain constant over our sample period. Indeed, we do not think that house price changes arise because of changes in the price of the characteristics over a period of the length of ours[5]. Nevertheless, we try and estimate annual equations to allow for the shadow prices of the characteristics to vary annually. The estimated coefficients of the characteristics are far too unstable over time probably due to collinearity problems, so often encountered in traditional hedonic equations. However, this does not necessarily invalidate the estimated quality-adjusted price changes from these hedonic regressions. It just makes any economic interpretation of the evolution of the estimated shadow prices difficult.

Given our functional form, we measure house price changes with respect to the base year by the rate of growth of mean prices, i.e. $[E(P_t) - E(P_0)]/E(P_0)$. Since $d_t = E(p_{it} - p_{i0} \mid m = m_{i0}, c = c_{i0})$, the rate of growth of the mean prices with respect to the base year is approximately given by $\exp(d_t) - 1$. The approximation is exact when prices are log-normally distributed with constant variance over time[6].

To assess the extent of the quality adjustment of our different estimated models we also estimate the equation:

$$(p_{it} - m_{it}) = g_o + d_t + u_{it} \qquad (2)$$

The estimated d_t in (2) is our non-quality adjusted measure of house price inflation, which is equivalent to the usually available mean house price statistics defined in terms of price per square metre.

3.2. Hedonic model with site dummies: additive effects

One important limitation of using standard hedonic equations to adjust for quality of housing is that some of the variables one would consider as relevant determinants of the price of a house or flat are not observed by the researcher. Precise location (usually not

[5] In contrast, one would expect this to be the case for computers, for example.

[6] An alternative measure is the mean of the growth rates: $E[(P_t - P_0)/P_0] = E(P_t/P_0) - 1$. However, this measure depends on the conditional variance of $(p_{it} - p_{i0})$.

well captured by postal code or other available classifications), transport facilities, traffic, closeness to services, or construction quality can be cited as some of these unobserved but typically relevant characteristics. Since these unobserved characteristics are likely to be correlated with time dummies and m, their omission may bias estimated house price inflation even when using hedonic methods.

In this paper we propose to take advantage of the multiunit property development feature of the Spanish housing market to allow for these unobservables. As we have seen in Section 2, a new property development typically takes the form of many dwellings erected together at the same time, in the form of one or various blocks of flats, or various houses. A property development can be observed over an extended period of time (see Figure 1) since information on the site is publicly available from the very early stages of the building work up to the time all dwellings are sold. The flats or houses belonging to the same property development (or site) are built to similar quality standards and may share facilities like a garage, a garden or a swimming pool. Furthermore, aside from observed characteristics, dwellings belonging to the same site also share unobserved features like the ones we have mentioned earlier. Therefore, the idea is to allow for a site-specific effect, z_j, which is identified through repeated observations over time and the availability of different types of dwellings (as defined by floor area) at each site[7].

The equation with additive site-specific effects is of the form:

$$p_{ijt} = d_t + b\ m_{ijt} + z_j + e_{ijt} \qquad (3)$$

where j represents the property development. Note that since all the observable characteristics of the dwelling (except floor area) are constant for a given site they are now subsumed in the site effect z_j. The site effect also subsumes the price of the land except for short term variations, over the life of the site, which are difficult to account for in any case. For a given site z_j does not change with t, but since the existing sites vary over time, site effects do capture time series variation.

[7] Housing developments with only one type of dwelling and observed only once have to be excluded from the sample to estimate this model.

If the z_j capture between-site time series variation in the price of land, and one is interested in measuring house price inflation net of land price inflation, the intercepts d_t will be the quantities of interest. If on the other hand the z_j capture time series variation in the shadow prices of other characteristics, the intercepts d_t may not provide an appropriate measure of house price inflation.

We estimate (3) by OLS after transforming the variables in their deviations from site means i.e.

$$\left(p_{ijt} - \overline{p}_j\right) = \sum_{s=1}^{T} d_s (d_{sijt} - \overline{d}_{sj}) + b\left(m_{ijt} - \overline{m}_j\right) + \left(e_{ijt} - \overline{e}_j\right) \tag{4}$$

where $\overline{p}_j$ is the site mean of p_{ijt}, and similarly for the other variables. Note that we also introduce the time dummy variables in deviations from site means.

3.3. Hedonic model with site dummies: additive and multiplicative effects

More generally, as we have already mentioned, some site facilities may be thought to influence the price-to-floor area elasticity. Therefore we generalise the previous additive site-effects model and allow for unobservable characteristics acting in a multiplicative form as well.

The additive and multiplicative site-effects model is:

$$p_{ijt} = d_t + b_j m_{ijt} + z_j + v_{ijt} \tag{5}$$

We estimate the coefficients d_t in (5) by OLS in the following transformed equation:

$$\left(p_{ijt} - \overline{p}_j\right) - \hat{q}_j\left(m_{ijt} - \overline{m}_j\right) = \sum_{s=1}^{T} d_s \left[(d_{sijt} - \overline{d}_{sj}) - \hat{f}_{sj}\left(m_{ijt} - \overline{m}_j\right)\right] + \textit{transformed error} \tag{6}$$

where $\hat{q}_j$ is the site-specific slope coefficient in the OLS regression of p_{ijt} on m_{ijt}:

$$\hat{q}_j = \frac{\sum_i \sum_t \left(p_{ijt} - \overline{p}_j\right)\left(m_{ijt} - \overline{m}_j\right)}{\sum_i \sum_t \left(m_{ijt} - \overline{m}_j\right)^2} \tag{7.1}$$

and $\hat{f}_{sj}$ is the site-specific slope coefficient in the OLS regression of d_{sijt} on m_{ijt}:

$$\hat{f}_{sj} = \frac{\sum_i \sum_t \left(d_{sijt} - \overline{d}_{sj}\right)\left(m_{ijt} - \overline{m}_j\right)}{\sum_i \sum_t \left(m_{ijt} - \overline{m}_j\right)^2} \tag{7.2}$$

Note that for this model we need sites with more than one type of dwelling in order to have variation in floor area within sites[8]. This was not the case in the previous model when only additive site effects were allowed for.

Since $b_j = q_j - \sum_{s=1}^{T} d_s f_{sj}$, once we have estimated $\hat{d}_s$ the b_j can be estimated as

$$\hat{b}_j = \hat{q}_j - \sum_{s=1}^{T} \hat{d}_s \hat{f}_{sj}$$

Similarly z_j can be estimated as

$$\hat{z}_j = \overline{p}_j - \sum_{s=1}^{T} \hat{d}_s \overline{d}_{sj} - \hat{b}_j \overline{m}_j$$

From those quantities we can obtain their average and median across sites.

The site-specific effects models we have presented are attractive because they produce, in a computationally easy way, house price indices robust to omitted unobservable characteristics that are thought to be very relevant for determining the price of a dwelling. Furthermore, in contrast to the usual hedonic model, the data requirements are very modest (simply price, site identifier and floor area[9]) since all site-specific features are accounted for.

[8] In this case, all housing developments with only one type of dwelling have to be dropped from the sample.

[9] Aside from floor area, one may chose to include information on any other dwelling characteristic not common to the site that may be thought relevant according to the particular features of the country's housing market under study.

Obtaining repeated observations over time does not seem problematic given the lengthy period dwellings of any particular new property development site are on offer on the market.

Of course, with these models we do not obtain direct estimates of the shadow price of the characteristics and quality-adjusted house price changes are defined as the residual price variation, i.e. not attributable to changes in the price of the characteristics. However, under the assumption that observed and unobserved site characteristics are uncorrelated, estimates of shadow prices of the former can be obtained in a second stage by regressing the estimated site effects on their observed characteristics.

The previous method relies on within-site price variation over time to capture inflation net of changes in unobserved site characteristics. A potential source of bias of our estimates is the existence of systematic differences between dwellings sold at the beginning and at the end of the life of a site. Our method will take account of these differences as long as they are captured by the square metre or other observable variables, but not if there were unobserved within-site changes in characteristics.

In common with the repeated sales technique mentioned in the introduction, our method relies on a certain within-group variation to measure quality-adjusted inflation. In our case groups are defined by sites, whereas in the repeated sale method the groups correspond to houses sold more than once. However, we are comparing the sale price of very similar dwellings sold over short periods during which changes in characteristics are unlikely. Furthermore, although we also throw away some cross-sectional information between sites, given that almost all new housing in Spain is grouped in sites, we do not really have a problem of lack of representativeness.

3.4. Calculation of standard errors

Our data consist of observations on individual dwellings belonging to different sites. For each site we have several dwelling types observed for a certain number of periods. For the sample of 6 cities we observe the number of dwellings of each type in a given site and time period (whereas for the remaining 4 cities in the sample of 10 these figures are imputed). The observed prices for all dwellings of a given type, site, and period are the same.

Let n be the total number of individual observations in the sample, and let q be the number of type-site-period groups of observations with the same observed price. OLS in the original n-sample and grouped GLS in the q-sample provide the same estimates, but conventional standard errors from the latter are $(n/q)^{1/2}$ times larger than those obtained from the former.

The n-sample OLS standard errors are appropriate if we think that observed and actual prices coincide, so that there is no variation in prices within type-site-period groups. On the other hand, the q-sample GLS standard errors would be appropriate if we treated observed prices as group averages of underlying actual prices with as much variation within groups as there is between groups.

Clearly, the latter is not a reasonable assumption. Thus we rely on the n-sample for inference, while using heteroskedasticity-robust standard errors. An intermediate possibility would be to assume a certain non-zero within-group variance, but we do not pursue it since such a choice would be arbitrary and we believe that the variation in transaction prices of a certain type and site in a given period is small.

4. RESULTS

4.1. Estimates

In Tables 1 and 2 we report the parameter estimates for the 6 cities for which we have all the disaggregated information at the level of the site. In Table 3 the results correspond to the four cities where the distribution of dwellings by type is imputed for each site.

Given that the focus of the paper is on obtaining quality-adjusted price indices and that we estimate the equations for many cities, in general we report basically the time dummy coefficient estimates. However, to comment briefly on the estimates for the shadow prices of the characteristics obtained from the hedonic model, we present them in Table 1 for the 15 municipalities on the outskirts of Madrid but we omit them for the rest of the cities in Tables 2 and 3.

For each city (or group of municipalities) we present the estimation of the different models and specifications, from the more restrictive to the more general in terms of quality adjustment. The first column corresponds to the estimation of equation (2), i.e. our measure of what is usually reported as housing inflation (measured by the average price per square metre). In the second column we relax the assumption of strict proportionality of price to floor area. In the third, we introduce location dummies. As a general rule for all cities, we use the most disaggregated information on location that the data provide. This is typically at the municipal district level except for Cadiz and the outskirts of Madrid where the disaggregation is up to the municipality level. In column 4 we report the results of estimating a standard hedonic equation with observed characteristics (of the form in equation (1)) where the characteristics included are the same for all cities. Finally, columns 5 and 6 contain the results of our site-specific effects models, with additive effects only, and with additive and multiplicative effects, respectively.

Our data set contains other measures of size of the dwelling aside from floor area; in particular, the number of bedrooms and number of bathrooms. However, including too many size variables made it difficult to interpret the parameter estimates. Therefore, we chose to include the floor area only because we think it is a more accurate and reliable measure of size. For example, there may be differences (both cross-sectionally and over time) in floor area across dwellings with the same number of bedrooms. In our conventional hedonic equation, as well as including additively the various characteristics at our disposal[10] we allow for various interactions which seemed important to us a priori. In particular, certain shared facilities like a garden or a swimming pool may be less valuable the larger the number of dwellings they are shared with. Moreover, shared facilities can be expected to affect the elasticity of price-to-size. Indeed, this elasticity is probably smaller the more facilities one is paying for besides the dwelling itself. It is interesting to see that the estimations confirm the significance of these effects. Furthermore, we find that the number of dwellings on the site influences not only the 'additive' value of a swimming pool but also its impact on the price-to-size elasticity. In general, most of the estimated shadow prices are reasonable, except those for the presence of a garage or a utility space. For the other cities (not shown) we also usually obtain negative shadow prices for a couple or so of the desired characteristics.

Significantly, however, compared with the model that only includes the observed location dummies (as we do in column 3), the rich set of observed (non-location) characteristics of the dwellings included in our hedonic equation (in column 4) contributes little to the R^2. And this is true for all cities.

The importance of location takes us naturally to the models estimated in columns 5 and 6. Precise location[11] is one of the relevant, but often unobserved, factors that we control for in the more robust models with site-specific effects. Moreover, among these models, the model that allows for both additive and multiplicative heterogeneity (column 6) may be significantly more robust than the one with additive heterogeneity only (column 5). For example, we have seen in the estimation of the conventional hedonic equation (column 4) that some of the characteristics do play a role not only additively but also multiplicatively. Of course, to be able to estimate this more robust model one needs variation in floor area between dwellings of the same site, as in our case. Furthermore, the estimates and the standard errors obtained for both site-specific models show that there is enough variation in the data, both in sites over time and in dwellings of the same type within sites over time, to determine the coefficients on the time dummies with sufficient precision. Note that the estimates in columns 4, 5, and 6 are obtained using different numbers of observations. We present each estimated model using the largest possible sample in each case. However, we

[10] We observe whether a dwelling is an apartment or a house. Notably, the corresponding dummy is not significant when all the other characteristics are included.

[11] On the importance of neighbourhood site characteristics in the determination of site valuations see, for example, Linneman (1989), and Peña and Ruiz-Castillo (1984).

also check the sensitivity of the estimates to using the smaller samples used in columns 6 (and 5) and there is no significant difference. Therefore, the hedonic model with additive and multiplicative site-specific effects, which controls for the dwelling characteristics in a very general way, is our preferred model for obtaining a quality-adjusted housing price index.

As we explained in Section 3, we define the time dummies so that their coefficients reflect price changes with respect to the base year 1993 and by a straightforward transformation we obtain the various house price indices (base 1993=100). In Figure 3 we can see, for the different cities, the traditional average per square metre index (our non-quality adjusted benchmark), and our preferred index for adjusting for housing quality, namely the hedonic index with additive and multiplicative site effects. For more information, in Table A.4 we report the time series for all the 6 indices we have estimated, city by city. For most of the cities we can see that the average per square metre index grows on average above the quality-adjusted index. However this is not true for all the cities over the sample period. This has been found as well in other countries over short periods (see Bureau of the Census (1997) or Fleming and Nellis (1985)) and has been attributed to shifts in the short run to lower quality houses. Nevertheless, it is interesting in our case to note from Table A.4 that this happens more often with the standard hedonic index than with the site-effects index. This is probably because we observe an insufficient number of the characteristics that are relevant for assessing the quality of a dwelling. The estimated difference between the traditional price per square metre index and the index we propose to adjust for quality is significant for most of the cities, as we can see in Figure 3.1 where the confidence intervals[12] for these two indices are plotted.

Furthermore, it is interesting to point out that the differences we have estimated between the standard hedonic index and the index with general site specific effects are economically and statistically significant for all cities (except the outskirts of Madrid) and for most periods (see Figure 3.2). These discrepancies can be taken as an indication of the presence of unobserved house characteristics which are taken into account by our site effect indices but not by the standard hedonic indices.

[12] Defined as ± 2 times the corresponding standard error. The standard error of the estimated indices is straightforwardly obtained by multiplying the estimated index itself by the corresponding standard error of the estimated time dummy coefficients in Tables 1 to 3.

In what follows we use the city indices to construct aggregate indices. This allows us to give a more general assessment of the extent of the bias incurred in house prices when differences in quality are not appropriately controlled for.

4.2. Aggregate index

In order to obtain an aggregate index from our six (or ten) city indices we could adopt geographic weights that are either fixed at their base-year values or that vary over time. When fixed base-year weights are considered, the city is assumed to represent a quality characteristic. That is, an increase in average prices due to an increase in the proportion of dwellings sold in cities where housing inflation is higher is taken as a difference in quality in the same way as an increase in average prices due to having more dwellings with garage space. This is the approach taken, for example, by the U.S. Census, and it seems more natural for a quality-adjusted index. However, following Pieper (1989), one could argue that differences in the index across cities reflect price differences between them rather than quality differences (although in utility terms this seems difficult to justify).

Naturally, to obtain the traditional average per square metre index, which is our benchmark measure of a non-quality adjusted index, we use current-year weights. For the quality-adjusted indices we use base-year weights. Nevertheless, we also calculate our aggregate quality-adjusted indices with current-year city weights to see whether this would lead to very different conclusions, but these were practically unchanged.

One obvious choice of city weights is to use the city shares of dwellings in our sample. However, for robustness we also try weights derived from other sources. In particular we use weights derived from the number of building permits issued at the municipality level, provided by the *Ministerio de Fomento*[13]. The results are reassuringly similar.

In Figure 4 we represent, for our two samples, the two main aggregate indices: the average per square metre index, and the hedonic index with site-specific effects. The difference is sizeable and we estimate the upward bias due to quality increases to be between 0.75% and 1.2% per year over our sample period. It is interesting to stress that the evolution of our index with site specific effects is not very different whether we use the six cities or the ten cities sample. The difference in the biases obtained from the two samples is due to the difference in the non-adjusted index. Note furthermore (Table A.5) that the standard hedonic index obtained also shows greater variability according to the data used than our preferred quality adjusted index.

In Table A.5 we report some of the other estimated aggregate indices. It is interesting to note that, for the two samples, the two aggregate hedonic indices with site dummies are almost identical. This is also the case for most of the cities when comparing both indices at the city level (see Table A.4).

4.3. Comparison with the National Accounts deflator

So far we have compared the different house prices we obtain from a traditional average per square metre index and the quality-adjusted index we propose. However, we are also interested in comparing the quality-adjusted index with the index used for deflating residential construction in the National Accounts. This deflator in Spain is mostly a factor-cost based index, which may overstate price changes when productivity increases. This problem with input cost indices was originally highlighted in the Stigler report (see Price Statistics and Review Committee (1961)). As a consequence, the U.S. Census started to construct a quality-adjusted price index for new housing which it has since used to deflate residential construction and the construction of small non-residential buildings (see Bureau of Economic Analysis (1974)).

The deflator currently used in Spain is reported in Figure A.2. Unfortunately, there is a slight change in the definition of residential construction in 1995 (construction services are no longer included) and there is a break in the index. The average cumulative growth of the official deflator was 3.7% per year for the period 1991-1994 and 2.5% for 1995-1998, 3% on average say for our sample period. In contrast, we estimate an annual cumulative decrease of between 0.36% and 0.56% for our quality-adjusted index.

The upward bias in the residential construction deflator is therefore estimated to be around 3.5% per year for our period. This is quite a large discrepancy that merits further investigation. It is probably not only due to the fact that the housing deflator currently used in the Spanish National Accounts is not adjusted for quality improvements in residential buildings, but also because it is an index mostly based on the cost of the construction

[13] For the sample of six cities only, because building permits for Bilbao are not available.

inputs. Indeed, the difference in annual growth rates between the input cost index and the non-quality adjusted average per square metre index is over 2%. Obviously our estimated indices are based on a sample of cities which are not necessarily representative of the whole country. Nevertheless, for this to be responsible for the large discrepancy with the national deflator, housing inflation in the part of Spain we do not study would have to be implausibly high.

5. CONCLUSIONS

In this paper we estimate a quality-adjusted price index for new multiunit housing. To this end, we propose a new method that controls in a very general way for unobserved housing characteristics that are a potential source of bias in the standard hedonic equations. This is achieved by relying on the within-site variation (both cross-sectional and over time) that allows site-specific effects to be estimated. We estimate standard hedonic equations as well. Our dataset is rich in observed characteristics but, nevertheless, the quality-adjusted price evolution is quite different in some cases. Aside from the earlier mentioned robustness to omitted unobservable characteristics, an attractive feature of the hedonic model with site dummies is that the data requirements for characteristics are very small. Indeed, all we need for each dwelling is price and floor area, and a unique site identifier number.

We also compare our chosen quality-adjusted index with non-quality adjusted indices. In particular, first with the average per square metre price index obtained from the same data, and second with the deflator for residential construction (based on input costs). The estimated upward bias of these non-adjusted indices for our sample is 0.75 to 1.2% and around 3.5% per year, respectively.

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TABLE 1

QUALITY ADJUSTMENTS AND HOUSE PRICE INFLATION (LOG CHANGE APPROXIMATION) WITH RESPECT TO BASE YEAR: OUTSKIRTS OF MADRID

	Log(P/M) on time dummies	Log(P) on log(M) and time dummies	Log(P) on log(M), time and location dummies [(a)]	Hedonic with observed characteristics [(a)]	Hedonic with site dummies: additive effects	Hedonic with site dummies: additive and multiplicative effects
Log(M)	—	0.7837	0.7223	0.7464	0.7603	0.7623
		(223.41) [(b)]	(317.92)	(229.98)	(255.81)	0.7730 [(c)]
Log(M)*swim. pool	—	—	—	-0.3242	—	—
				(25.42)		
Log(M)*swim. pool*log(dwe.)	—	—	—	0.0640	—	—
				(24.88)		
Garage included	—	—	—	-0.0106	—	—
				(6.49)		
Air cond.	—	—	—	0.0286	—	—
				(7.45)		
Fitted kitchen	—	—	—	0.0904	—	—
				(39.35)		
Fitt.+equipped kitchen	—	—	—	0.1018	—	—
				(37.56)		
Garden	—	—	—	0.1176	—	—
				(21.07)		
Garden*log(no. dwellings)	—	—	—	-0.0441	—	—
				(38.27)		
Swimming pool	—	—	—	1.5875	—	—
				(26.22)		
Swim.pool*log (no. dwellings)	—	—	—	-0.3002	—	—
				(24.62)		
Sports facilities	—	—	—	0.0242	—	—
				(15.24)		
Fitted cupboards	—	—	—	0.1131	—	—
				(22.94)		
Utility space	—	—	—	-0.0162	—	—
				(10.97)		
Constant	4.9559	5.9994	6.6156	6.2726	6.0412	6.0875
	(2163.67)	(349.79)	(537.03)	(374.01)	6.0521 [(d)]	6.0322 [(d)]
Dummy 1994	0.0013	-0.0372	-0.0212	0.0173	0.0539	0.0177
	(0.37)	(11.35)	(9.48)	(8.00)	(15.53)	(5.45)
Dummy 1995	-0.0272	-0.0544	-0.0211	0.0096	0.0546	0.0197
	(7.98)	(17.14)	(9.49)	(4.41)	(15.32)	(6.01)
Dummy 1996	-0.0116	-0.0238	-0.0002	0.0145	0.0518	0.0207
	(3.61)	(8.20)	(0.11)	(6.65)	(13.87)	(6.15)
Dummy 1997	0.0260	0.0216	0.0147	0.0237	0.0529	0.0192
	(6.53)	(6.05)	(6.08)	(9.16)	(13.77)	(5.40)
No. observ.	46,558	46,558	46,558	46,558	45,007	36,536
R^2	—	0.57	0.84	0.87	—	—

Notes:
(a) 14 municipality dummies were also included.
(b) t-ratios in brackets.
(c) Mean and median of estimated site-specific elasticities.
(d) Mean and median of estimated site-specific additive effects.

TABLE 2.1

QUALITY ADJUSTMENTS AND HOUSE PRICE INFLATION (LOG CHANGE APPROXIMATION) WITH RESPECT TO BASE YEAR: VALENCIA

	Log(P/M) on time dummies	Log(P) on log(M) and time dummies	Log(P) on log(M), time and location dummies (a)	Hedonic with observed characteristics (a)	Hedonic with site dummies: additive effects	Hedonic with site dummies: additive and multiplicative effects
Log(M)	—	1.1138	1.0755	1.0346	0.9249	0.9536
		(152.51) (b)	(197.93)	(201.75)	(208.64)	0.9170 (c)
Dummy 1994	-0.0617	-0.0622	-0.0696	-0.0511	-0.0715	-0.0574
	(16.38)	(16.60)	(22.18)	(17.35)	(29.59)	(19.67)
Dummy 1995	-0.0276	-0.0268	-0.0434	-0.0537	-0.0710	-0.0607
	(6.63)	(6.52)	(13.94)	(17.61)	(24.21)	(17.81)
Dummy 1996	0.0118	0.0130	0.0381	-0.0255	-0.0665	-0.0593
	(2.85)	(3.16)	(10.80)	(6.27)	(20.78)	(15.86)
Dummy 1997	0.0026	0.0060	0.0175	-0.0509	-0.0742	-0.0618
	(0.62)	(1.47)	(4.98)	(11.23)	(19.65)	(13.93)
No. observ.	28,185	28,185	28,185	28,185	26,970	23,895
R^2	—	0.62	0.75	0.80	—	—

Notes:
(a) 17 district dummies were also included.
(b) as for Table 1.
(c) as for Table 1.

TABLE 2.2

ZARAGOZA

	Log(P/M) on time dummies	Log(P) on log(M) and time dummies	Log(P) on log(M), time and location dummies (a)	Hedonic with observed characteristics (a)	Hedonic with site dummies: additive effects	Hedonic with site dummies: additive and multiplicative effects
Log(M)	—	0.8086	0.7466	0.7232	0.7759	0.8475
		(132.01) (b)	(154.31)	(127.13)	(118.12)	0.8339 (c)
Dummy 1994	-0.0144	-0.0090	-0.0579	-0.0482	-0.0731	-0.0735
	(2.86)	(1.76)	(19.06)	(16.53)	(24.12)	(22.07)
Dummy 1995	-0.0190	-0.0203	-0.0132	-0.0032	-0.0335	-0.0247
	(4.10)	(4.60)	(4.88)	(1.26)	(8.52)	(5.76)
Dummy 1996	0.0043	0.0031	-0.0274	-0.0293	-0.0320	-0.0230
	(0.94)	(0.69)	(9.61)	(10.94)	(8.03)	(5.39)
Dummy 1997	0.0558	0.0553	0.0234	0.0100	-0.0263	-0.0186
	(9.57)	(9.96)	(5.58)	(2.60)	(6.27)	(4.10)
No. observ.	26,644	26,644	26,644	26,644	25,996	19,995
R^2	—	0.49	0.81	0.85	—	—

Notes:
(a) 11 district dummies were also included.
(b) as for Table 1.
(c) as for Table 1.

TABLE 2.3

MALAGA

	Log(P/M) on time dummies	Log(P) on log(M) and time dummies	Log(P) on log(M), time and location dummies [a]	Hedonic with observed characteristics [a]	Hedonic with site dummies: additive effects	additive and multiplicative effects
Log(M)	—	0.8293	0.8149	0.7865	0.8376	0.8702
		(116.93) [b]	(106.22)	(106.24)	(108.82)	0.8486 [c]
Dummy 1994	-0.0415	-0.0530	-0.0510	-0.0332	-0.0139	-0.0227
	(7.16)	(10.04)	(10.48)	(6.49)	(1.88)	(2.78)
Dummy 1995	0.0143	-0.0116	-0.0019	0.0215	0.0344	-0.0067
	(2.71)	(2.51)	(0.43)	(4.55)	(4.04)	(0.81)
Dummy 1996	0.0519	0.0337	0.0508	0.0859	0.0389	-0.0016
	(8.51)	(5.71)	(8.89)	(15.25)	(4.59)	(0.19)
Dummy 1997	0.0307	0.0055	0.0358	0.0456	0.0205	-0.0197
	(5.15)	(0.99)	(6.57)	(7.79)	(2.27)	(2.17)
No. observ.	10,093	10,093	10,093	10,093	9,831	8,452
R^2	—	0.69	0.75	0.79	—	—

Notes:
(a) 5 district dummies were also included.
(b) as for Table 1.
(c) as for Table 1.

TABLE 2.4

VALLADOLID

	Log(P/M) on time dummies	Log(P) on log(M) and time dummies	Log(P) on log(M), time and location dummies [a]	Hedonic with observed characteristics [a]	Hedonic with site dummies: additive effects	additive and multiplicative effects
Log(M)	—	0.8035	0.7874	0.6867	0.7621	0.7830
		(83.46) [b]	(84.75)	(55.91)	(70.10)	0.8367 [c]
Dummy 1994	0.0501	0.0465	0.0407	0.0260	-0.0231	0.0124
	(6.33)	(6.12)	(6.53)	(4.30)	(3.56)	(1.16)
Dummy 1995	0.0713	0.0556	0.0523	0.0515	-0.0326	0.0085
	(9.30)	(7.72)	(9.01)	(8.67)	(4.44)	(0.77)
Dummy 1996	0.0950	0.0732	0.0682	0.0720	-0.0514	0.0008
	(12.06)	(9.85)	(10.81)	(11.36)	(5.91)	(0.07)
Dummy 1997	0.1147	0.0969	0.0972	0.0594	-0.0679	-0.0011
	(12.71)	(11.99)	(13.20)	(8.26)	(6.75)	(0.10)
No. observ.	6,122	6,122	6,122	6,122	5,891	5,355
R^2	—	0.65	0.70	0.79	—	—

Notes:
(a) 11 district dummies were also included.
(b) as for Table 1.
(c) as for Table 1.

TABLE 2.5

CADIZ

	Log(P/M) on time dummies	Log(P) on log(M) and time dummies	Log(P) on log(M), time and location dummies (a)	Hedonic with observed characteristics (a)	Hedonic with site dummies: additive effects	Hedonic with site dummies: additive and multiplicative effects
Log(M)	—	0.9688	0.9848	0.9000	0.8906	0.8899
		(90.49) (b)	(114.14)	(85.57)	(95.93)	0.9341 (c)
Dummy 1994	-0.0949	-0.0971	-0.0879	-0.1354	-0.3527	-0.0869
	(8.65)	(8.65)	(8.98)	(12.73)	(11.86)	(6.14)
Dummy 1995	-0.0795	-0.0807	-0.0779	-0.1267	-0.3442	-0.0801
	(7.40)	(7.43)	(8.25)	(11.78)	(11.67)	(5.69)
Dummy 1996	-0.0462	-0.0455	-0.0460	-0.1068	-0.3451	-0.0793
	(4.36)	(4.34)	(5.04)	(9.62)	(11.73)	(5.65)
Dummy 1997	-0.0843	-0.0840	-0.0576	-0.0869	-0.3456	-0.0829
	(7.42)	(7.41)	(5.80)	(7.66)	(11.66)	(5.56)
No. observ.	5,527	5,527	5,527	5,527	5,397	4,480
R^2	—	0.63	0.71	0.79	—	—

Notes:

(a) 2 municipality dummies were also included.

(b) as for Table 1.

(c) as for Table 1.

TABLE 3.1

QUALITY ADJUSTMENTS AND HOUSE PRICE INFLATION (LOG CHANGE APPROXIMATION) WITH RESPECT TO BASE YEAR: MADRID

	Log(P/M) on time dummies	Log(P) on log(M) and time dummies	Log(P) on log(M), time and location dummies [(a)]	Hedonic with observed characteristics [(a)]	Hedonic with site dummies: additive effects	additive and multiplicative effects
Log(M)	—	0.9412	0.9615	0.9298	0.9030	0.9155
		(289.91) [(b)]	(400.32)	(296.40)	(504.01)	0.9283 [(c)]
Dummy 1994	-0.0580	-0.0589	-0.0086	-0.0050	-0.0036	-0.0076
	(15.95)	(16.33)	(4.12)	(2.50)	(3.24)	(7.39)
Dummy 1995	-0.0066	-0.0039	0.0278	0.0257	-0.0047	-0.0116
	(2.03)	(1.21)	(14.06)	(13.85)	(3.37)	(8.68)
Dummy 1996	0.0019	0.0042	0.0119	0.0151	-0.0153	-0.0214
	(0.62)	(1.39)	(6.08)	(8.19)	(9.73)	(14.06)
Dummy 1997	-0.0383	-0.0337	0.0070	0.0045	-0.0244	-0.0314
	(12.70)	(11.07)	(3.61)	(2.37)	(14.38)	(19.30)
No. observ.	63,159	63,159	63,159	63,159	61,688	57,937
R^2	—	0.64	0.87	0.89	—	—

Notes:
(a) 19 district dummies were also included.
(b) as for Table 1.
(c) as for Table 1.

TABLE 3.2

BARCELONA

	Log(P/M) on time dummies	Log(P) on log(M) and time dummies	Log(P) on log(M), time and location dummies [(a)]	Hedonic with observed characteristics [(a)]	Hedonic with site dummies: additive effects	additive and multiplicative effects
Log(M)	—	1.1893	1.0261	0.9504	0.8329	0.8532
		(120.65) [(b)]	(147.51)	(125.89)	(91.86)	0.8253 [(c)]
Dummy 1994	-0.0189	-0.0232	-0.0151	-0.0042	0.0083	0.0260
	(3.10)	(3.91)	(2.94)	(0.84)	(1.99)	(5.90)
Dummy 1995	0.0609	0.0663	-0.0177	0.0002	0.0257	0.0426
	(8.72)	(9.77)	(3.48)	(0.04)	(6.43)	(8.71)
Dummy 1996	0.0004	0.0161	-0.0201	0.0090	0.0242	0.0413
	(0.07)	(2.69)	(4.29)	(1.81)	(6.01)	(8.81)
Dummy 1997	0.0161	0.0333	0.0038	0.0278	0.0223	0.0413
	(2.65)	(5.47)	(0.82)	(6.02)	(5.38)	(8.68)
No. observ.	16,289	16,289	16,289	16,289	15,365	11,799
R^2	—	0.58	0.76	0.78	—	—

Notes:
(a) 9 district dummies were also included.
(b) as for Table 1.
(c) as for Table 1.

TABLE 3.3

SEVILLA

	Log(P/M) on time dummies	Log(P) on log(M) and time dummies	Log(P) on log(M), time and location dummies [(a)]	Hedonic with observed characteristics [(a)]	Hedonic with site dummies: additive effects	Hedonic with site dummies: additive and multiplicative effects
Log(M)	—	1.2222	1.0766	0.9900	0.8716	0.9326
		(131.33) [(b)]	(172.09)	(154.62)	(214.37)	0.9633 [(c)]
Dummy 1994	0.0591	0.0529	0.0692	0.1045	-0.0162	-0.0226
	(9.56)	(8.49)	(14.81)	(27.94)	(9.37)	(14.29)
Dummy 1995	0.0601	0.0492	0.1193	0.1340	-0.0058	0.0012
	(9.73)	(8.06)	(26.24)	(34.97)	(2.67)	(0.58)
Dummy 1996	0.0833	0.0782	0.1134	0.1379	-0.0089	-0.0020
	(13.17)	(12.64)	(24.57)	(35.86)	(3.63)	(0.85)
Dummy 1997	0.1013	0.0947	0.1233	0.1377	-0.0014	0.0055
	(13.22)	(12.74)	(22.13)	(26.17)	(0.43)	(1.78)
No. observ.	22,878	22,878	22,878	22,878	21,261	19,953
R^2	—	0.54	0.81	0.86	—	—

Notes:
(a) 11 district dummies were also included.
(b) as for Table 1.
(c) as for Table 1.

TABLE 3.4

BILBAO

	Log(P/M) on time dummies	Log(P) on log(M) and time dummies	Log(P) on log(M), time and location dummies [(a)]	Hedonic with observed characteristics [(a)]	Hedonic with site dummies: additive effects	Hedonic with site dummies: additive and multiplicative effects
Log(M)	—	1.0102	0.8253	0.8654	0.8814	1.0772
		(32.81) [(b)]	(43.85)	(47.45)	(60.15)	0.9160 [(c)]
Dummy 1994	0.0135	0.0137	0.0022	-0.0014	-0.0099	0.0010
	(0.95)	(0.95)	(0.25)	(0.16)	(2.28)	(0.33)
Dummy 1995	0.0016	0.0020	0.1039	0.0261	-0.0093	0.0083
	(0.12)	(0.15)	(11.28)	(2.95)	(1.88)	(2.13)
Dummy 1996	0.0011	0.0020	0.1190	0.0620	-0.0111	-0.0020
	(0.10)	(0.16)	(15.65)	(7.30)	(1.95)	(0.41)
Dummy 1997	0.1427	0.1435	0.1347	0.0690	-0.0255	-0.0038
	(11.50)	(11.21)	(17.40)	(7.08)	(3.48)	(0.56)
No. observ.	3,175	3,175	3,175	3,175	3,132	2,795
R^2	—	0.33	0.77	0.85	—	—

Notes:
(a) 6 district dummies were also included.
(b) as for Table 1.
(c) as for Table 1.

FIGURE 1

LIFE OF SITES: NUMBER OF SEMESTERS ON THE MARKET

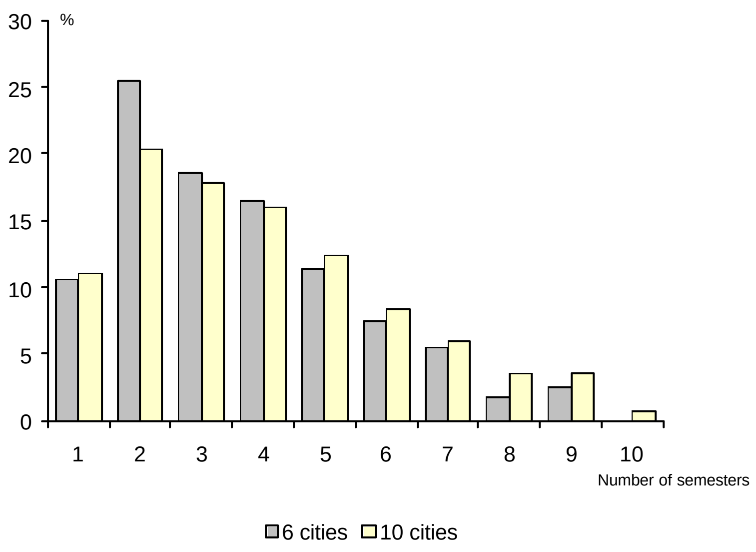


FIGURE 2

NUMBER OF DIFFERENT SIZES OF DWELLINGS PER SITE

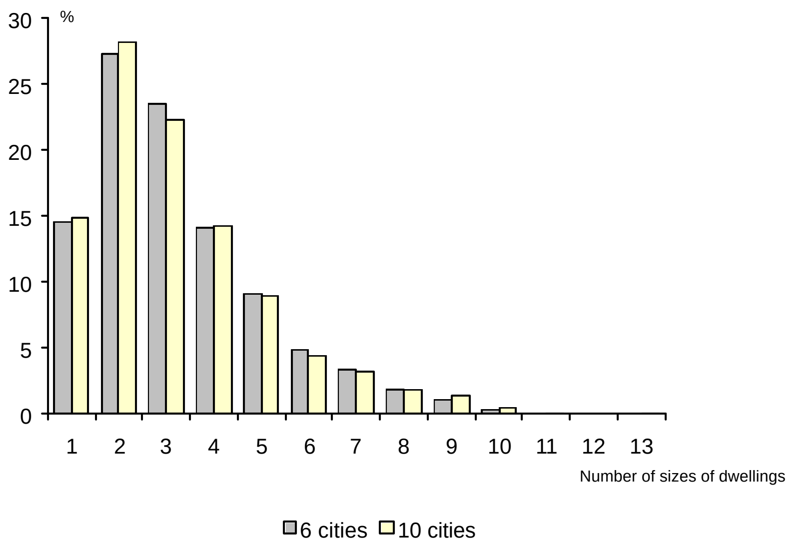


FIGURE 3.1

COMPARISON OF SITE SPECIFIC AND UNADJUSTED PRICE INDICES

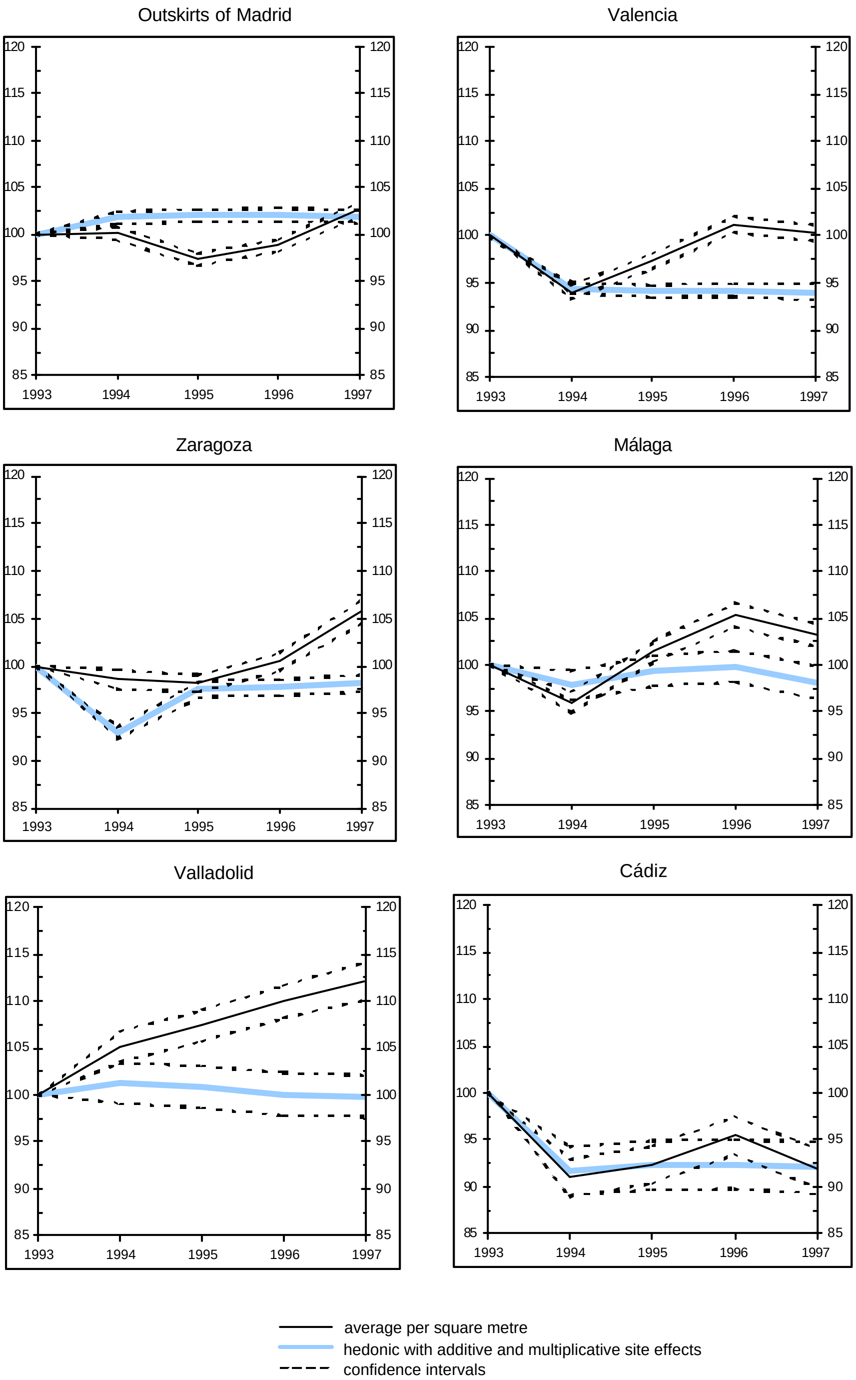


FIGURE 3.1 (contd.)

COMPARISON OF SITE SPECIFIC AND UNADJUSTED PRICE INDICES

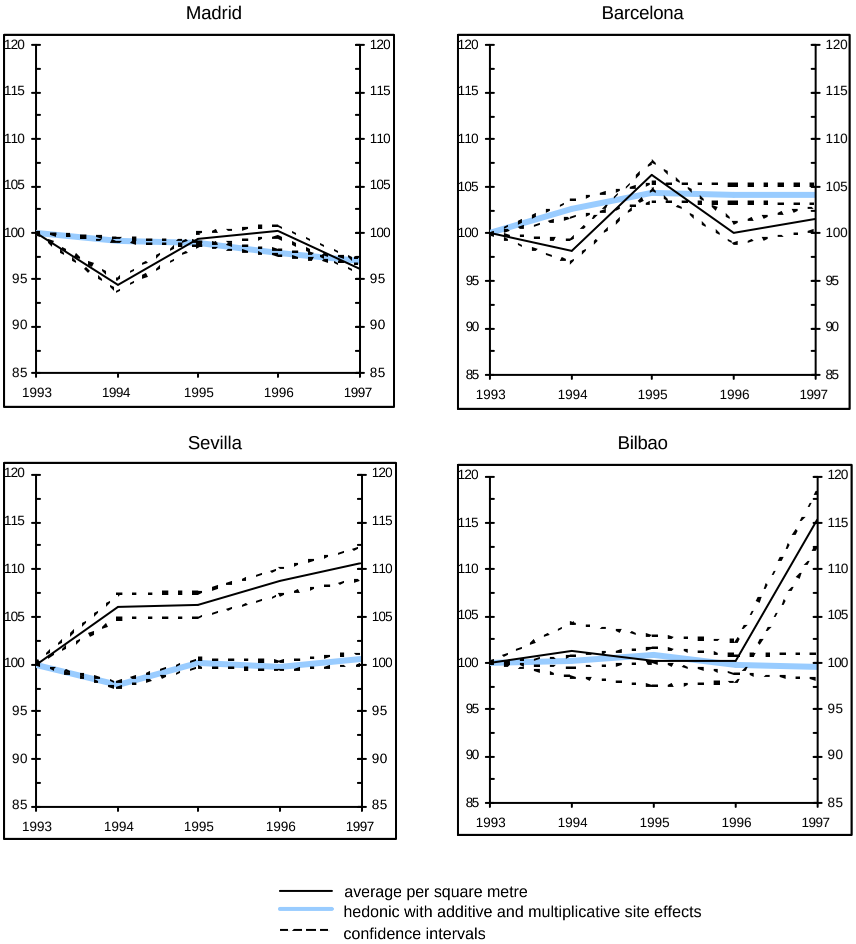


FIGURE 3.2

COMPARISON OF SITE SPECIFIC AND STANDARD HEDONIC PRICE INDICES

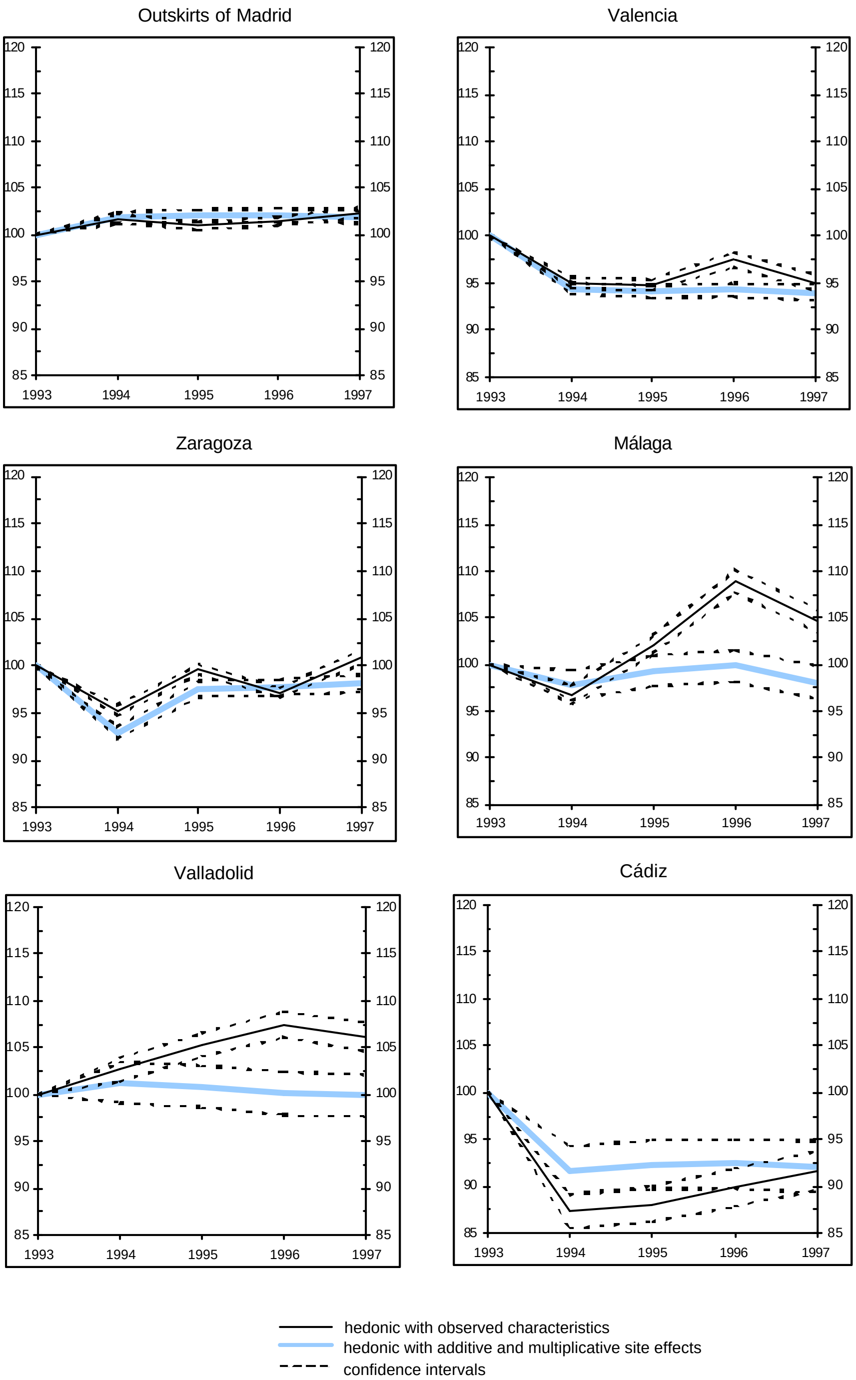


FIGURE 3.2 (contd.)

COMPARISON OF SITE SPECIFIC AND STANDARD HEDONIC PRICE INDICES

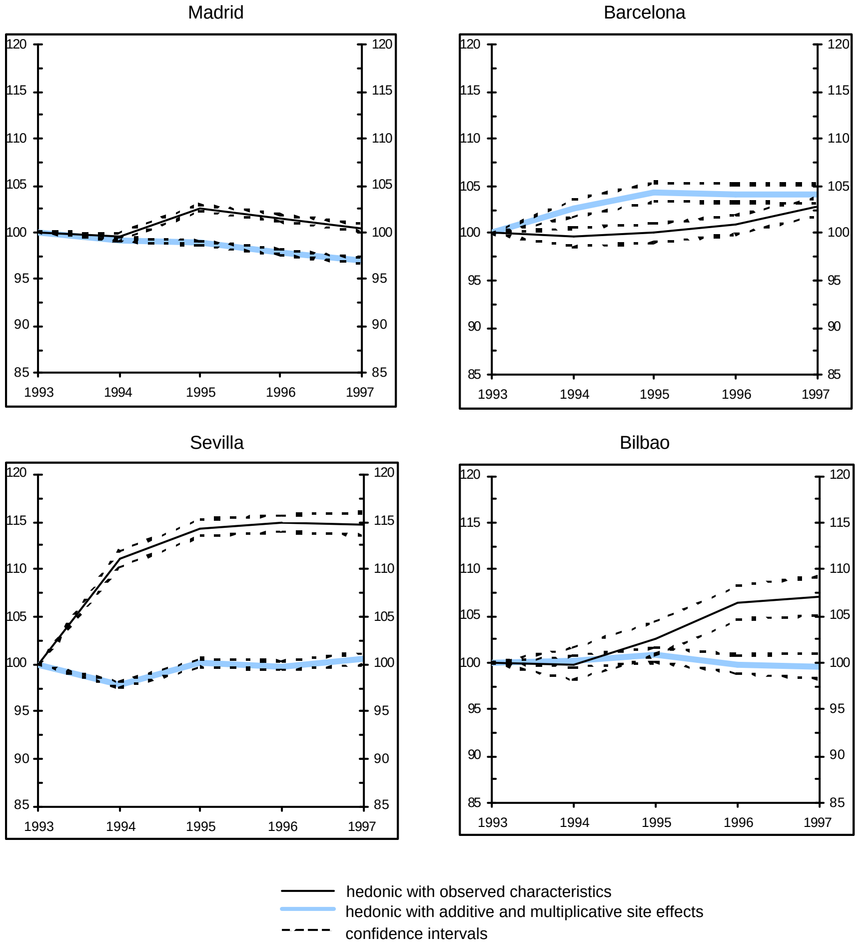


FIGURE 4

ESTIMATED AGGREGATE INDICES

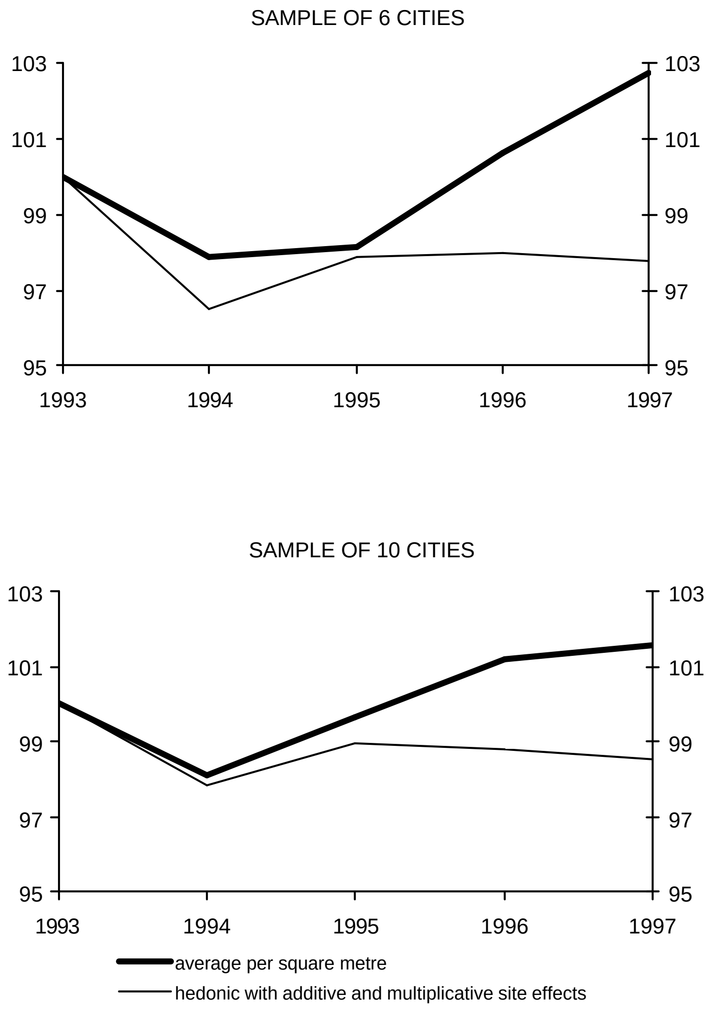


TABLE A.1

SOME INTERNATIONAL FIGURES

	GFKF in residential buildings as a % of GDP (1992)	GFKF in residential buildings as a % of total GFKF (1992)	Value of residential construction as a % of total construction (1990)	Value of residential construction (1990)	
				New dwellings and improvements as a % of residential construction	Maintenance and repairs as a % of residential construction
Belgium	5.4	28.0	43.3	80.5	19.5
Canada	6.4	33.9	39.9	90.6	9.4
Denmark	3.0	20.1	39.0	64.9	35.1
Finland	4.7	25.3	40.4	90.7	9.3
France	5.0	25.1			
Germany	6.1	28.9	49.5		
Greece	3.8	20.9	46.3		
Ireland	4.3	27.5	41.0	89.5	10.5
Italy	5.3	28.0			
Netherlands	4.8	23.6	45.2 (b)		
Norway	1.7	9.1	19.6 (c)	90.8 (c)	9.2 (c)
Portugal	6.1 (a)	21.5 (a)	31.7 (d)		
Spain	4.3	19.6	53.9 (e)	95.8 (e)	4.2 (e)
Sweden	5.9	34.7	47.8	73.3	26.7
United Kingdom	3.0	19.2	36.3	39.1	60.9
United States	3.7	23.6	45.0	78.1	21.9

Source: Annual Bulletin of Housing and Building Statistics for Europe and North America 1993 (Economic Commission for Europe).
(a) Year 1980.
(b) Excluding repairs and maintenance.
(c) Year 1991.
(d) Data refer to new dwellings.
(e) Year 1992.

TABLE A.2

DESCRIPTIVE STATISTICS. SAMPLE OF 6 CITIES.

	1993	1994	1995	1996	1997 (a)
			Total		
Number of dwellings	24,801	26,935	28,045	28,384	14,964
Number of property developments	1,587	1,825	1,869	2,060	1,126
			Mean and standard deviation (b)		
Price	16.146	15.133	15.238	16.205	16.435
(in millions of pesetas)	(7.031)	(6.933)	(6.872)	(7.182)	(7.084)
Price per square metre	134.569	134.647	135.219	137.758	139.535
(in thousands of pesetas)	(37.066)	(43.758)	(40.822)	(38.486)	(38.205)
Floor area	122.505	112.290	113.689	118.653	119.718
(in square metres)	(50.446)	(30.392)	(38.661)	(46.087)	(49.802)
			Percentage of dwellings		
Outskirts of Madrid	26.85	42.57	37.95	41.92	39.38
Valencia	27.91	26.07	20.40	18.91	21.07
Zaragoza	26.68	16.55	24.21	21.28	18.31
Málaga	9.91	5.87	7.84	8.61	9.42
Valladolid	4.00	4.57	5.35	5.21	6.15
Cádiz	4.64	4.37	4.25	4.07	5.67
Garage included	43.35	46.27	52.34	57.22	56.08
Garden	47.80	53.31	55.52	63.36	61.92
Swimming pool	21.89	31.15	34.53	37.27	36.21
Sports facilities	24.33	17.25	19.18	20.40	22.70
Air conditioning	6.76	6.44	5.48	7.80	5.58
Fitted kitchen	65.86	65.49	51.91	30.74	20.89
Fitted+equipped kitchen	18.20	8.45	23.06	50.99	60.66
Fitted cupboards	85.10	90.79	87.54	88.38	92.10
Utility space	47.30	45.88	50.62	53.27	52.62

Notes:
(a) Observations only for first semester.
(b) Standard deviation in brackets.

TABLE A.3

DESCRIPTIVE STATISTICS. SAMPLE OF 10 CITIES.

	1993	1994	1995	1996	1997 (a)
			Total		
Number of dwellings	45,263	46,222	47,208	50,900	28,201
Number of property developments	3,011	3,195	3,309	3,532	1,940
			Mean and standard deviation (b)		
Price	19.429	18.133	18.983	19.502	20.239
(in millions of pesetas)	(13.082)	(10.691)	(10.958)	(9.912)	(10.106)
Price per square metre	167.028	162.625	168.068	173.350	177.394
(in thousands of pesetas)	(72.750)	(69.461)	(70.780)	(67.881)	(67.879)
Floor area	118.052	111.859	113.465	114.624	115.694
(in square metres)	(48.621)	(34.388)	(38.333)	(40.992)	(42.189)
			Percentage of dwellings		
Outskirts of Madrid	14.71	24.80	22.54	23.38	20.90
Valencia	15.29	15.19	12.12	10.54	11.18
Zaragoza	14.62	9.64	14.38	11.87	9.72
Málaga	5.43	3.42	4.66	4.80	5.00
Valladolid	2.19	2.66	3.18	2.90	3.26
Cádiz	2.55	2.55	2.52	2.27	3.01
Madrid	21.78	22.18	24.80	26.98	30.95
Barcelona	8.86	6.41	5.15	6.45	5.84
Sevilla	13.14	12.11	9.70	9.16	7.41
Bilbao	1.43	1.03	0.94	1.64	2.73
Garage included	30.97	36.39	39.03	41.53	43.32
Garden	46.73	54.60	57.24	61.89	62.35
Swimming pool	27.05	33.61	37.15	41.32	42.18
Sports facilities	19.35	14.74	17.86	18.35	17.86
Air conditioning	19.17	15.42	11.61	10.48	11.58
Fitted kitchen	63.74	62.61	57.53	48.20	41.40
Fitted+equipped kitchen	14.50	8.20	17.14	31.67	37.17
Fitted cupboards	86.20	90.02	88.94	88.66	90.28
Utility space	33.50	35.86	41.38	46.57	47.79

Notes:
(a) We include only information on 1997.1. For Barcelona and Madrid 1997.2 observations have also been used in the city-by-city estimations but are not included here so as not to distort the aggregate descriptive statistics.
(b) Standard deviation in brackets.

TABLE A.4

ESTIMATED CITY INDICES:
OUTSKIRTS OF MADRID

	Log(P/M) on time dummies	Log(P) on log(M) and time dummies	Log(P) on log(M), time and location dummies	Hedonic with observed characteristics	Hedonic with site dummies: additive effects	Hedonic with site dummies: additive and multiplicative effects
1993	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
1994	100.1301	96.3483	97.9023	101.7451	105.5379	101.7858
1995	97.3167	94.7053	97.9121	100.9646	105.6118	101.9895
1996	98.8467	97.6481	99.9800	101.4606	105.3165	102.0916
1997	102.6341	102.1835	101.4809	102.3983	105.4324	101.9386

VALENCIA

	Log(P/M) on time dummies	Log(P) on log(M) and time dummies	Log(P) on log(M), time and location dummies	Hedonic with observed characteristics	Hedonic with site dummies: additive effects	Hedonic with site dummies: additive and multiplicative effects
1993	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
1994	94.0165	93.9695	93.2767	95.0184	93.0996	94.4216
1995	97.2777	97.3556	95.7528	94.7716	93.1462	94.1106
1996	101.1870	101.3085	103.8835	97.4822	93.5663	94.2424
1997	100.2603	100.6018	101.7654	95.0374	92.8486	94.0071

ZARAGOZA

	Log(P/M) on time dummies	Log(P) on log(M) and time dummies	Log(P) on log(M), time and location dummies	Hedonic with observed characteristics	Hedonic with site dummies: additive effects	Hedonic with site dummies: additive and multiplicative effects
1993	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
1994	98.5703	99.1040	94.3744	95.2943	92.9508	92.9136
1995	98.1179	97.9905	98.6887	99.6805	96.7055	97.5603
1996	100.4309	100.3105	97.2972	97.1125	96.8507	97.7262
1997	105.7386	105.6858	102.3676	101.0050	97.4043	98.1572

TABLE A.4 (contd.)

MALAGA

	Log(P/M) on time dummies	Log(P) on log(M) and time dummies	Log(P) on log(M), time and location dummies	Hedonic with observed characteristics	Hedonic with site dummies: additive effects	Hedonic with site dummies: additive and multiplicative effects
1993	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
1994	95.9349	94.8380	95.0279	96.7345	98.6196	97.7556
1995	101.4403	98.8467	99.8102	102.1733	103.4999	99.3322
1996	105.3270	103.4274	105.2112	108.9697	103.9667	99.8401
1997	103.1176	100.5515	103.6449	104.6656	102.0712	98.0493

VALLADOLID

	Log(P/M) on time dummies	Log(P) on log(M) and time dummies	Log(P) on log(M), time and location dummies	Hedonic with observed characteristics	Hedonic with site dummies: additive effects	Hedonic with site dummies: additive and multiplicative effects
1993	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
1994	105.1376	104.7598	104.1540	102.6341	97.7165	101.2477
1995	107.3903	105.7175	105.3692	105.2849	96.7926	100.8536
1996	109.9659	107.5946	107.0579	107.4655	94.9899	100.0800
1997	112.1537	110.1750	110.2081	106.1200	93.4354	99.8901

CADIZ

	Log(P/M) on time dummies	Log(P) on log(M) and time dummies	Log(P) on log(M), time and location dummies	Hedonic with observed characteristics	Hedonic with site dummies: additive effects	Hedonic with site dummies: additive and multiplicative effects
1993	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
1994	90.9464	90.7465	91.5852	87.3366	70.2788	91.6769
1995	92.3578	92.2470	92.5057	88.0998	70.8787	92.3024
1996	95.4851	95.5520	95.5042	89.8705	70.8150	92.3763
1997	91.9155	91.9431	94.4027	91.6769	70.7796	92.0443

TABLE A.4 (contd.)

MADRID

	Log(P/M) on time dummies	Log(P) on log(M) and time dummies	Log(P) on log(M), time and location dummies	Hedonic with observed characteristics	Hedonic with site dummies: additive effects	additive and multiplicative effects
1993	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
1994	94.3650	94.2801	99.1437	99.5012	99.6406	99.2429
1995	99.3422	99.6108	102.8190	102.6033	99.5311	98.8467
1996	100.1902	100.4209	101.1971	101.5215	98.4816	97.8827
1997	96.2424	96.6862	100.7025	100.4510	97.5895	96.9088

BARCELONA

	Log(P/M) on time dummies	Log(P) on log(M) and time dummies	Log(P) on log(M), time and location dummies	Hedonic with observed characteristics	Hedonic with site dummies: additive effects	additive and multiplicative effects
1993	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
1994	98.1277	97.7067	98.5013	99.5809	100.8335	102.6341
1995	106.2793	106.8547	98.2456	100.0200	102.6033	104.3520
1996	100.0400	101.6230	98.0101	100.9041	102.4495	104.2165
1997	101.6230	103.3861	100.3807	102.8190	102.2551	104.2165

SEVILLA

	Log(P/M) on time dummies	Log(P) on log(M) and time dummies	Log(P) on log(M), time and location dummies	Hedonic with observed characteristics	Hedonic with site dummies: additive effects	additive and multiplicative effects
1993	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
1994	106.0881	105.4324	107.1651	111.0155	98.3931	97.7653
1995	106.1943	105.0430	112.6708	114.3393	99.4217	100.1201
1996	108.6868	108.1339	112.0080	114.7861	99.1139	99.8002
1997	110.6609	109.9329	113.1224	114.7631	99.8601	100.5515

TABLE A.4 (contd.)

BILBAO

	Log(P/M) on time dummies	Log(P) on log(M) and time dummies	Log(P) on log(M), time and location dummies	Hedonic with observed characteristics	Hedonic with site dummies: additive effects	additive and multiplicative effects
1993	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
1994	101.3592	101.3794	100.2202	99.8601	99.0149	100.1001
1995	100.1601	100.2002	110.9490	102.6444	99.0743	100.8335
1996	100.1101	100.2002	112.6370	106.3962	98.8961	99.8002
1997	115.3384	115.4307	114.4193	107.1436	97.4822	99.6207

TABLE A.5

SOME OF THE ESTIMATED AGGREGATE INDICES

SAMPLE OF 6 CITIES

	Average per square metre	Hedonic with observed characteristics	Hedonic with site dummies:	
			additive effects	additive and multiplicative effects
1993	100.0000	100.0000	100.0000	100.0000
1994	97.8590	97.0162	96.0712	96.4726
1995	98.1542	98.5886	97.5804	97.8499
1996	100.6266	99.6360	97.6282	97.9811
1997	102.7251	99.8477	97.3550	97.7889

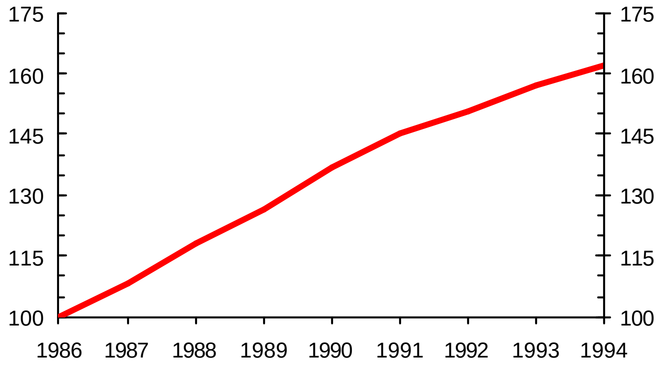
SAMPLE OF 10 CITIES

	Average per square metre	Hedonic with observed characteristics	Hedonic with site dummies:	
			additive effects	additive and multiplicative effects
1993	100.0000	100.0000	100.0000	100.0000
1994	98.1339	99.6644	97.6177	97.8435
1995	99.6663	101.7170	98.7135	98.9839
1996	101.2011	102.2457	98.4545	98.7770
1997	101.5582	102.3059	98.1711	98.5557

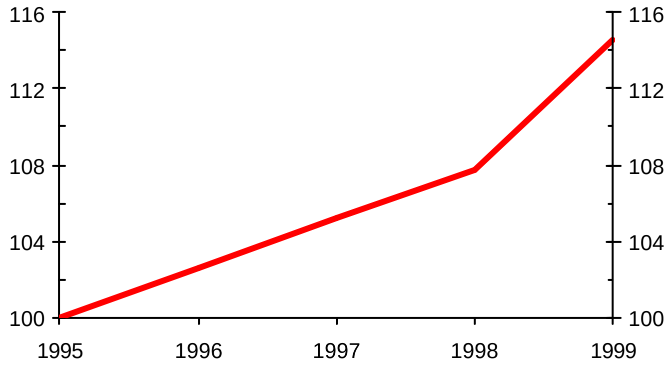
FIGURE A.1

RESIDENTIAL CONSTRUCTION DEFLATOR IN GROSS FIXED CAPITAL FORMATION (SPAIN)

1986 BASE



1995 BASE



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