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THE NORTH–SOUTH DIVIDE AND HOUSE PRICE ISLANDS: THE CASE OF CÓRDOBA (SPAIN)

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ABSTRACT

This paper uses the theory of hedonic prices for housing services. The classical approach in this field of urban economics is the monocentric model. The model is often criticized due to the restrictiveness of its assumptions. The most important hypothesis is that the rental value per unit of housing service declines with the distance from the central business district (CBD). We consider some other physical and geographical information in an econometric model for the estimation of house prices. The results indicate that the most significant variables are the physical attributes of the houses and the existence of North–South differences.

KEYWORDS

Housing price, distance models, externalities, North–South effects, hedonic models

1. INTRODUCTION

The economic study of cities really began in the nineteenth century (von Thünen (1826), and later Christaller (1933) or Losch (1940)), although the first systematic analysis of the configuration of cities, under a micro-economic framework, was not undertaken until the pioneering work of Alonso (1964).

This analysis of cities, referred to as the 'monocentric model', is a study of the household choice of residence location under a static framework where the structure of the city is linear and with a unique centre called the central business district (CBD). This approach has been developed by others (Mills 1967; Muth 1969; DeSalvo 1977; Fujita 1989) with the general result that commuting cost is the main variable for explaining the price of houses.

The main objective of this paper is the analysis of factors influencing

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house prices other than the standard city centre range (distance); but first we need to explain briefly the main features of the monocentric model. Its basic assumptions are: (i) all the jobs are located at the unique CBD; (ii) there is a dense transport system (that is, an individual who wants to travel between any two points can follow a straight line) and there is no congestion externality (population density is not relevant for the utility functions); (iii) all the housing units are similar in their attributes except distance to the CBD. Hence, the only important characteristic is the distance to CBD, and this distance is unidimensional. The consumer problem can be represented:

$$\max U(z, h) \quad \text{s.t. } z + P(k)\cdot h = Y - T(k),$$

where h is the quantity of housing units determined by the location choice, z represents expenditures on all other goods, $P(k)$ is the price of the dwelling, k is the distance to the CBD, Y is income and $T(k)$ are commuting costs. Solving this model gives house prices as a decreasing function of the distance to the CBD, defined by the equation:

$$-P_k(k)\cdot h = T_k(k)$$

where sub-indices denote partial derivatives.

Other model hypotheses are also important: (iv) there is no externality in housing consumption; (v) there is constant price elasticity and unitary income elasticity of housing demand; (vi) housing and commuting costs are a significant part of the family budget.

This argument, well known in the literature, is a simple and clear explanation of the spatial distribution of house prices within the city and also of the population density. Fujita (1989) proves that the localization equilibrium is optimal.[2] However, the simplicity of this model and its low significance level in empirical estimations make it vulnerable to criticism on both empirical and methodological grounds. The assumption of no externality in housing consumption has been heavily studied from a theoretical standpoint (Fujita 1989); also, empirically it is easy to show the existence of externalities and their consequences on location choice.

In this sense, many authors have analysed the importance of externalities in housing demand and city configuration: these include environmental attributes and congestion (Duff and Straszheim 1982; Alonso-Villar 1996; Bra as *et al.* 1999), neighbourhood or quality of the neighbourhood (Schafer *et al.* 1975; Kain and Quigley 1975; Freeman 1979; Duff and Straszheim 1982; Dubin and Chein 1990; Case and Mayer 1996; Sivitanidou 1996, amongst others) and racism (Massey and Denton 1993; Borjas 1995; Cutler *et al.* 1999). Other externalities and public goods, such as education (Alonso-Villar 1997; Benabou 1993; Raugh 1993), school quality (Clapp *et al.* 1997), crime (Glaesser 1998), and other related questions have also been examined in depth.

Other research has generalized the model's ideas into a dynamic framework in which there are problems of agglomeration and positive depreciation of the stock of capital invested in houses (Anas 1978; Wheaton 1982; Arnott 1987; Fujita and Thisse 1996).[3]

But probably the main critique of the monocentric model is the reality of a modern city: their decentralization seems a general phenomenon, in both commercial activity and labour localization. The work of Henderson (1985)[4] considered the existence of decentralization in big cities, where the distance gradient becomes lower as commercial sub-centres and employment clusters are born. The critique of Turnbull (1990) reveals not only the decentralization of the real city but also the creation of other CBDs: this rationalizes the *polycentric structure* of the modern metropolis that cannot be explained by the monocentric model.

This later literature conforms, with much more precision, to the reality of the urban nucleus. In recent years, the growth of cities and the appearance of new business centres reveal the existence of a number of economic forces (Fujita and Thisse 1996). Some authors also examine the new urban spatial structures (Anas *et al.* 1998).

A key question therefore becomes the estimation of the effects of these polycentric structures on the location equilibrium described before. The CBD is no longer unique, so there is more than one inertial (centrifugal) force. Also, for residences used commercially, centripetal forces emerge from the different CBDs. Furthermore, the CBD is no more a desirable place of residence for those that prefer to live in the centre if other new zones have better infrastructures than the first.

The existence of externalities and the growth of other CBDs are two important questions to analyse in a model of house prices. The objective of this paper is to probe the impact that other factors such as income barriers or internal distances have on the determination of house prices. The assumption is that it seems more reasonable to include the distance to the centre as a supplementary exogenous variable of the model in contrast to the conclusions of earlier work.

In general, the concept of 'distance' in the urban literature is taken to mean the range from the centre of the city to any other point within it. The distance is used as a variable in some analyses to explain housing demand. The shorter the distance, the greater the demand for housing, and the higher the price.

The objective of the work here is to contrast the relationship of the equilibrium price with a set of variables in a classical model by paying attention to the distances typology (to the city centre or to the suburban core), introducing a variation supposing the existence of income distances (that is, differences in neighbourhood quality measured by the average income of its inhabitants), and testing North–South differences. A medium-sized urban nucleus is analysed, Córdoba in Spain, where an

extensive database exists, and where variables from more than a thousand houses sold in 1996 are available.

The second section of the paper details the methods used in the study. The third section formulates a series of questions concerning the classical urban model relating to the role of the internal (short) distances in the model, the distance to the CBD as a determinant and the role of North–South differences. The fourth section analyses the results and offers some answers to the questions posed. The fifth adds a few remarks about our observations. A concluding section then follows.

2. THE CITY OF CÓRDOBA, DATA AND METHODOLOGY

The city of Córdoba

Córdoba is a medium-size (350,000 people) city located in southern Spain. It has a privileged geographical position because is located at the centre of Andalucía, 140 kilometres. from Sevilla, 170 from Málaga and 160 from Granada. Its communications with the rest of Spain are excellent. It is connected to Madrid (400 km) by high-speed train and by highway.

Regarding the city itself, we need to point out several important factors that influence spatial distribution of housing price (see also Figure 1):

1 The city of Córdoba is located in a valley. To the northwest are mountains, to the southeast is the Guadalquivir river, and to both the northeast and the southwest are plains. Given its extreme climate, especially in summer, the northwest is the most desirable place to live.
2 Until 1992 the city was divided on an east–west axis by the railway, and connecting routes between the sides were minimal. The railway complex was completely reformed and buried by 1992, unifying the city. The covered areas have been converted into new neighbourhoods with modern infrastructure (gardens, parks, etc.) and relatively high prices, 130–150,000 pesetas per square metre (see also in Figure 1 the areas with lines).
3 With regard to the general maintenance of the city, there are two zones that have traditionally been underprivileged. The area on both banks of the river has not been maintained, relegating it to a marginal position. One could say that this city has turned its back to the river. The other zone of evident neglect up to 1992 borders the railway tracks. This explains why prices were very low here, in spite of its proximity to the centre. It is interesting to note that prices remain low here.
4 Córdoba has three CBDs (see Figure 1 again). The largest is located in the centre of the city, generating most of the commercial activity and employment. The second, situated to the northeast, is characterized by

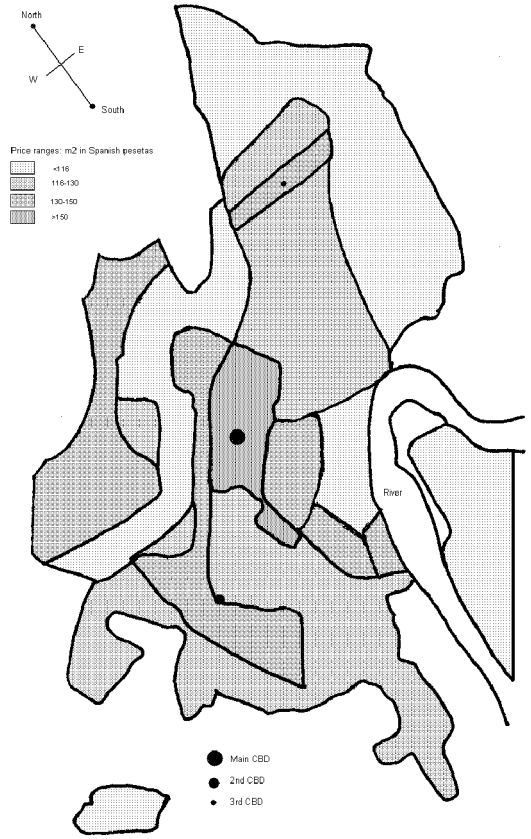


Figure 1 A map of Córdoba with average house prices

high-end commercial activity and generates substantial employment. Housing prices are understandably high here. The third, much less important, is to the southwest of the city. It has some commercial activity but generates little employment. In particular, it tends to be shifting even more towards the southwest, an area of new development.

Data

The database used for the analysis is from the Statistics Department at the University of Córdoba. The database is built on surveys from real-estate agents in Córdoba and the opinions of municipal experts from the Town Hall, the Department of Urban Planning and the Traffic Department. Surveys were made at three real-estate agencies that are located in the CBD, the southwest and the northeast. These were carried out from January to

April of 1996. Each sample reflects the spatial position of the dwelling and its particular characteristics: surface, price, condition, orientation, etc.

The sample consists of 1,023 dwellings, about 20 per cent of total sales for 1996. All of the dwellings under study are apartments, none of which are individual houses with gardens. It must be emphasized that the survey reflects the spatial localization of housing for the entire city, its twenty-six neighbourhoods.

The data have been used to formulate indices that represent characteristic sets of houses summarizing the information collected in the survey. In this way, the following groups of variables are attainable (see the Appendix):

- House prices (P), surface area of the house measured in square metres (S).
- Distance to the CBD ($DCBD$), and distance from the house to the centre of the neighbourhood (DI).
- Congestion index (IC) and neighbourhood quality in terms of income (R).

Methodology

To contrast, the importance of the different attributes of houses on house prices the technique of hedonic price models is employed (Lancaster 1966; Griliches 1971).[5] The purpose of this is to analyse the price of a good, in relation to its multiple characteristics, estimating the implicit price of each one. The main developments of the hedonic methodology, applied to the analysis of housing demand, appear in Rosen (1974), Witte *et al.* (1979) and, more recently, in Bartik (1987).

The hedonic tradition indicates that the function of implicit prices (obtained from the regression of the prices on the characteristics) mimic the market price that answers the demand function and, in consequence, their utility function depending on a set of attributes (Brown and Rosen 1982; Bartik 1987; Parker and Zilberman 1993).

This paper attempts to estimate the implicit prices equation for Córdoba. It is postulated that the estimated hedonic equations have simple functional forms, since the principal objective of this study is not the determination of the house price, but an analysis of the components involved. The model that is specified here analyses house prices as a function of housing n-attributes (or characteristics), in the hedonic tradition. Logarithmic regressions are contrasted with the following specification:

$$\ln \hat{P} = \ln \hat{\alpha} + \hat{\beta}_1 \ln z_1 \, \hat{\beta}_2 \ln z_2 + \hat{\beta}_3 \ln z_3 \ldots \hat{\beta}_n \ln z_n + e \qquad (1)$$

where z_i are the attributes[6] of the housing, $i = 1, \ldots, n$.

Through this procedure the implicit prices of the relevant attributes contained in the hedonic equation can be obtained and the estimates of attribute elasticity may be tested for significance. Goodman and Kaway

(1982) argue that house prices have a non-linear relation with variables, due to the influence of the interactions between these, since the relationships are given jointly and not through independent processes.[7]

As a consequence of the presence of heterocedasticity in the residues (that is, the variance of errors is not constant) then the estimations are not efficient, so some special methods are used; for example, to try to contrast the simultaneity of different samples, the 'seemingly unrelated equations' (SURE) method is used throughout the paper.

3. RESEARCH QUESTIONS

First, we should note why we are interested in introducing other variable than the sole distance[8] for explaining housing price in Córdoba. Using the available data for Córdoba, the simplest model of house prices (price as a function of DCBD) is analysed. Results may indicate that house prices are an inverse function of distance, but the adjustment is really poor (R^2 = 0.158). Then, seems obvious that new arguments are required to explain the spatial distribution in housing price. So, the problem is that housing price is affected by more variables than distance to the core of the city.

Second, in this section several hypotheses are analysed trying to define the nature of the problem. In order to systematize this approach, this section focuses upon the set of problems to be analysed and articulates the questions to be posed.

Question 1. What is the role of internal distances?

Definition 1. Internal distance (DI_f,i) is the length of the radius from the central point of an urban zone f to a point i of such zone f, $i = 0, 1, 2 \ldots$, being $i = 0$ the central point of the zone (CBD_f). Then $DI_{f,0} = 0$ for all f.

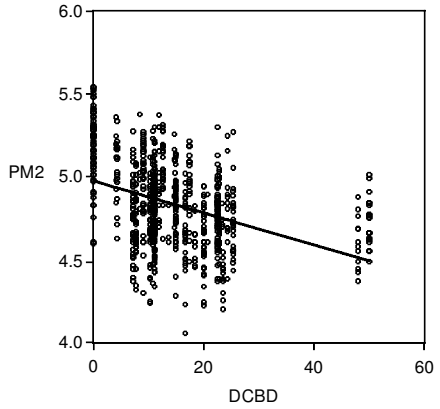


Figure 2 Housing price versus distance to CBD

Hypothesis 1. If the distance to the CBD provokes variations in house prices due to commercial activity, and if each zone has commercial activity, then there should be variations in the internal price of a zone ($p_{f,i}$) according to the distance of the i point to the central zone ($DI_{f,i}$), where the primary commercial transactions of inhabitants are carried out.

The study tries to find whether important differences exist in house prices, according to the location with respect to the central point in the neighbourhood to which it belongs.[9] Then, there must be other variables than the distance to the CBD which are important in the utility functions of residents or potential residents.

Question 2. Is the distance to the CBD really a determinant?

Definition 2. Distance to the CBD ($DCBD_f$) is the length of the radius from the central point (CBD) of a city to the centre of zone f(CBD_f), where $DCBD_{CBD} = 0$.

Hypothesis 2. Owing to the fact that not all the economic activity is concentrated in the CBD and not all the employment is offered here, then not all the citizens consider the reduction of $DCBD_f$ as bringing an increase in their utility function. That is, a decreasing function, g, does not exist, so that $p_{f,i} = g\,(DCBD_f)$, for all f.

According to the monocentric model, house prices are at a maximum in the CBD, since commercial housing demand increases its price. The study also needs to consider the possibility of depreciation of the CBD and if there are serious problems like traffic congestion, noise, begging, etc. that make it sub-optimal in the residential decision.

Question 3. Do differences exist between North and South?

Definition 3. A city is symmetrical (or circularly symmetrical) if, for every f, $DCBD_f = k$, then $P_{f,i} = c$, for all $i \in f$, k, $c \in \Re$.

Hypothesis 3. If production activity is not concentrated in the CBD and this is not unique, and if there exist some kinds of externality related to the geographical location, then cities are not symmetrical.

4. RESULTS

From the available data on Córdoba, the above questions and hypotheses are tested as a special case. As an introductory study, the matrix of correlations is analysed. Table 1 shows that there are not strong relations between

Table 1 Correlations between variables

	IC	*DI*	*S*	*DCBD*	*R*
IC	1.000000	−0.150885	0.001381	−0.255902	0.139439
DI	−0.150885	1.000000	0.197499	0.018131	−0.005194
S	0.001381	0.197499	1.000000	−0.225045	0.291162
DCBD	−0.255902	0.018131	−0.225045	1.000000	−0.416606
R	0.139439	−0.005194	0.291162	−0.416606	1.000000

the exogenous variables; only the correlation between income (R) and distance to *DCBD* seems to be relevant (−0.4). Therefore, there are not serious problems of multicollinearity in this set of variables and the OLS method can be employed to estimate the previous equation (1).

The estimation of house prices as a function of surface (S), distance to the CBD (*DCBD*) and neighbourhood core (*DI*), congestion (*IC*) and income level of neighbourhood (R) is discussed in this section. Table 2 resumes different estimations done throughout this research: column 1 shows the estimation of (1) in logarithmic form. In order to analyse the 'third question' (importance of the North and South asymmetry) columns 2 and 3 respectively show the estimation for North and South sub-samples.[10] To attempt the possible simultaneous relation between both sub-samples the estimation of (1) is done using fixed-effects panel data with SURE;[11] column 4 shows this estimation.

Column 1 presents the estimation of (1). Under this logarithmic specification $\hat{\beta}$ offers information about the elasticity of the variables from which can be derived the following:

Table 2 Estimations for different samples and methods

	(1)	*(2)*	*(3)*	*(4)*
DI	0.03 (9.6)*	0.03 (5.81)	0.03 (8.11)	0.03 (10.18)
S	0.89 (37.1)	0.88 (24.24)	0.89 (32.84)	0.90 (41.29)
DCBD	−0.07 (−12.8)	−0.05 (−6.31)	−0.06 (−11.68)	−0.07 (−16.91)
R	0.04 (8.2)	0.18 (5.30)	0.04 (8.11)	0.04 (8.58)
IC	(–)**	(–)	(–)	(–)
Constant	5.48 (48.96)	5.37 (32.51)	5.50 (43.70)	N: 5.42*** S: 5.47
Adj. R^2	0.787	0.847	0.80	0.812
F (p-value)	675.84 (0.00)	377.06 (0.00)	554.45 (0.00)	1415.21 (0.00)
White LM (p-value)	16.24 (0.29)	9.73 (0.78)	20.25 (0.12)	0.08 (0.77)****
Bera–Jarque (p-value)	3.52 (0.17)	20.48 (0.00)	2.70 (0.25)	N: 8.48 (0.01) S: 3.38 (0.18)
Method	OLS	OLS	OLS	SURE

Notes: *t-statistics in parentheses; **(–) means no significant coefficient; ***fixed effects. ****Levene (1960) test of equality of variances. References: Bera and Jarque (1981), White (1980).

- The elasticity of the surface (S_1) is greater than those of the rest of the variables. In this sense, it seems that the surface area is the variable that explains the greatest part of the price variability, and at the same time is the characteristic (or attribute) with higher implicit hedonic price.
- The variable that represents the classical distance (*DCBD*) has a negative sign – as expected – although it has a low elasticity, i.e. it does not provoke high variations in prices.
- The quality of the neighbourhood in income terms (R) is relevant, but it does not have a high elasticity.
- The internal distance (*DI*) is also significant and positive[12] – but with a low elasticity – with a lesser explanatory capacity.
- Because congestion (*IC*) was not significant in the regression analysis, it was eliminated from the model specification.

From these results, the following conclusions emerge: there is no homogeneity in the housing supply, and distances are not significantly relevant for the determination of house prices.

The third question examines the importance of the North and South asymmetry, and the possible influences that orientation may have on the residential market. The first approximation to such differences is found in the next figure (Figure 3), expressing the medium house price (where the x-axis represents the distances and the y-axis the prices).

Three important facts are emphasized: house prices do not drop exponentially from the CBD outwards. Second, the highest house prices are in the central area but high price 'islands' exists. Finally, there is a clear lack of North–South symmetry. The reason for this partition could be that physically Córdoba has been divided into two parts. The railway line has divided the city between 1950 and 1992, along the east–west axis (see Figure 1).

Crucially this analysis now focuses upon the North–South divide and whether clear differences do exist. Houses are divided between the North and South and the equations are re-estimated. Columns 2 (North) and 3 (South) show these results.

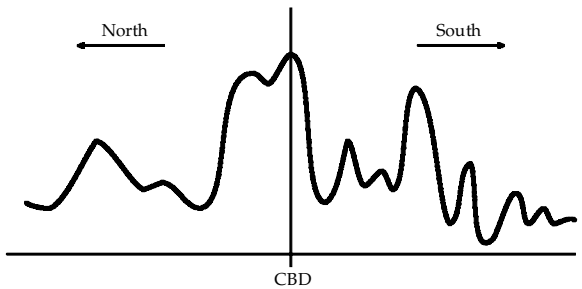


Figure 3 Price of houses, North–South

In a first approximation, significant differences are not observed between the results of column (2), those of (3) and those of (1), since the same variables appear in all the equations explaining house prices: surface, distances and income, without excessive variations in the *t*-statistic. However, it is obvious that the elasticity for the quality of neighbourhood in income terms increases substantially in (2), when it is compared with (3), and (1). So, in the North there is a greater sensitivity to variations in the quality of the neighbourhood. This change in the income elasticity variable offers an understanding as to why such variations between North and South exist.

The estimation done through panel data does not offer any additional information; results from column (4) are really similar to (1). Therefore, conclusions from (1)–(4) emphasize the following:

- The surface area of houses continues as the most relevant variable in the whole of the city, in the North and in the South.
- The distance to the CBD is the second most relevant characteristic in the case of the grouped observations and also in the South.
- However, the North demand function implies a greater preference for good quality in neighbourhood terms than in closeness to the CBD.
- The internal distance is relevant in the model, but it does not provide any strong results.

This leads to the following conclusions in terms of the previous analysis (questions):

(A.1) The role of internal distances (*DI*) in the grouped model and also in the case of the North, is limited. However in every case its sign is as expected.

(A.2) It has relative importance, though it does not show itself in a symmetrical way, i.e., its importance is not equal in the North as in the South.

(A.3) Differences exist: in the valuation of the quality of the neighbourhood, as well as in the valuation of the distance to the CBD.

5. OTHER OBSERVATIONS AND ANALYSIS

Although the neoclassical model supposes an adequate initial base, it does not explain in an adequate manner the real growth of cities.

In the neoclassical model, **houses are a family of identical goods** in all their attributes, with the exception of the characteristic of the Euclidean distance to the centre. If $X^{(i)}$ is a set of characteristics of a unit of housing surface (to assimilate the definition to the neoclassic model we take a surface unit, in reality it would be better to use characteristics of houses and include the surface as another attribute), defined in the space *X*, to simplify

we will call $x_j^{(i)}$ to each j characteristic of the house i, that is the element j of the X vector. We will suppose, without loss of generality, that the first attribute $x_1^{(i)}$, is the distance to the centre.

Definition 4. Houses are homogeneous by distances if $\forall i \,/\, x_1^{(i)} = k_1$, then $x_j^{(i)} = k_j \,\forall j = 2, \ldots, m$. We also call it homogeneous (unless distances) if $x_j^{(i)} = k_j \,\forall j = 2, \ldots, \forall i$. The last definition implies if it is fulfilled that $p^{(i)} = f(x_1^{(i)}; \mathbf{a})$ (as in the case of the typical neoclassic model), **a** being a vector of parameters and variables independent of the house.

Our data clearly contradicts this definition; not only are houses heterogeneous, but also they have intrinsic characteristics that are significant in an econometric model of price determination, like the internal distances or the North–South orientation.

There exist some attributes that determine the origin of zones with local maximum price, not only in the CBD, but in some determinate spatial positions, whose genesis is not clear.

Definition 5. We define local CBD (*LCBD*) as a point that $P_{LCBD} > P_i \,\forall i / d(i, LCBD) \leq \varepsilon$, for some $\varepsilon > 0$ and $d(i, LCBD) > 0$. *LocCBD* is the set of points that fulfil those properties, that means $LocCBD \equiv \{y \in X / P_y > P_i \,\forall i / d(i, y) \leq \varepsilon$, for some $\varepsilon > 0$ and $d(i, y) > 0\}$. By definition $CBD \in LocCBD$. Of course, for the neoclassic model the *LocCBD* set has only one element that is the *CBD*.

In the previous figure, we can observe the existence of several local CBDs; one of these is the CBD as defined in the Muth–Mills model, which contradicts the neoclassic hypothesis. Even these points are not symmetrical.

Some hypotheses about the causes of the existence of these *LCBD* can be formulated; the main hypothesis is to suppose that there exist some social (i.e. status-related) attributes that make some zones more desirable than others. However, to try to establish the genesis of these *LCBD* one must go beyond this argument, because the social attributes are created, i.e. they do not already exist, and in this area the ideas get more diffused (Fujita *et al.* 1999). Some explanations that can emerge are the differences of intrinsic quality in the zone (neighbourhood) compared to others; this can be caused for example by the existence of landscape zones, the establishment of a shopping mall, or the existence of barriers that guarantee that the inhabitants of the zone can keep high status (like large houses, urban development norms that limit the construction of low quality housing, or high prices in the first developments of the zone).

Also, we do not explain the transformation of a normal residential zone in an *LCBD*, which must be caused by the modification of some characteristic. The most obvious case is the own growth of the city: this increases the distances until they become intolerable for the consumer, implying the creation of intermediate CBDs as a reduction force for the displacement congestion.

Even though the linear model supposes circular symmetry of the city (see question 3), it is an empirically contrasted fact that most cities present a pronounced North–South asymmetry (curiously similar to other famous economic asymmetries). Most cities of the world present a greater concentration of high-rent citizens (and high house prices) in the northern zone of the city, while lower rents prevail in the South. There exist exceptions to this, usually caused by geographical features (the sea or the existence of natural obstacles), but even in these cases there exist asymmetries, although of a different character.

Our data have a technical character problem, because apartments are used exclusively as the housing unit, so we do not include houses with gardens. For this reason we do not consider an important source of asymmetry, houses located in the mountain range of the city (at the northwest) with high price and status, so the results are likely to be more pronounced than described. However, we can conclude:

- In the South the economic reasons for the acquisition of a house prevails, as in the general model; the principal determinant of price is surface area.
- In the North, income is much more significant than in other cases, which indicates that the quality of the neighbourhood is important in determining the price that will be paid for a house. This contradicts the hypothesis which suggests that externalities are absent from housing in the neoclassical model. If we look for possible explanations to this anomaly, we will have to look back to history, because in close geographical zones then emerge neighbourhoods of very different status levels.
- Finally, we need to emphasize the idea that even when we are considering asymmetries, our city is still being treated as linear (just one number is enough to characterize the position in the space of a point). A logical step would be the introduction of a two-dimensional model in which two axes would characterize each point. In this case our results would possibly be different.

In their work, Fujita and Thisse (1996) argue that a good urban economy study must analyse the importance of the centrifugal and centripetal forces. We can understand *centrifugal* force as the trend of dispersion of the population, i.e. to go out of the urban nucleus; and *centripetal* force as the trend to be agglomerated, i.e. agents find more benefits from living close to each other, than being dispersed.

Alonso-Villar (1996) found that there exist reasons (like pollution, high house prices in central zones, the traffic, etc.) that make the population leave the CBD. This phenomenon is usually called the *filtering process* in urban literature. This process implies that the highest income families acquire new[13] houses, placed in recently created zones, and sell their old

houses in deteriorating zones to families with lower income. If the filtering is associated with the non-malleability of the housing, then families with higher incomes get displaced from the CBD each period of time. However, in some cities inner districts become popular because of upgrading, gentrification and urban renewal. Moreover, if filtered processes are introduced in a city that grows by circles this results in a location in the periphery for the most favoured people, who sell their houses to those on lower incomes.

The fact that some people have higher income elasticity in the space demand than in transportation cost increases the intensity of the process. Transportation costs are not a relevant part of their budget, or at least a lower proportion than for the rest, so they have a higher incentive to go to the periphery if this offers them desirable living conditions (Fujita 1989).

In our analysis even in the North as in the South of the city we find certain displacement from the centre.

- In the North of Córdoba, avoid traffic problems, begging, dirt, noise, etc. of the CBD, since in the North there are green zones, comfort and high quality neighbourhoods.
- In the South, however, we find a different centrifugal force, following Turnbull (1990), the creation of two CBD alternatives to the initial one. In the same way, we find better public infrastructure for leisure, fewer congestion problems, and generally a greener environment.

Alonso-Villar (1996) found dominant centripetal forces: the existence of scale economies, transportation costs, workers' mobility, etc., i.e. the inertia that the CBD provokes over the rest of the city. In our study:

- Without any doubt, the best commercial and financial services are placed in the CBD. So for commercial use of the land this is still an inevitable reference point.
- Also, the continued existence of neighbourhoods of high quality in the central zones provokes an increase of the residential location demand in this zone.

But if we have to evaluate which one of the two forces prevails, then it appears that centrifugal forces begin to limit the influence of the CBD in the formation of prices and, consequently, the explanatory capacity of the neoclassic model.

Policy implications

Our previous analysis supposes that the usual monocentric model is far removed from the reality of the specific city chosen. This implies that the usual policy prescriptions are (at least in this case) invalid.

In Córdoba we can observe clearly a definite spatial localization of the

poorer families. Any urban planner aiming at a redistributive policy must set the property tax tariff intervals very carefully because the value of some properties does not have a correspondence with the income of its inhabitants. This is because the fast urbanization process has reshaped the house price distribution in Córdoba; a heavy taxation policy for high-value properties in some cases could mean that some low-income families could be displaced from houses they have occupied for decades because of this type of measure. A policy with a direct objective of improving the living conditions of the poorer inhabitants of the city must be aimed at the creation of environmental amenities in some depressed and under-equipped zones (most of the south of the city). An alternative policy could be the public promotion of cheap accommodation in zones with these infrastructures. Instead, the Town Hall has sold land resulting from railway closure and reclamation to the highest bidder.

The latest public project, the renewal of the river banks, could have important redistributive implications given the deterioration of all the neighbourhoods around the river and the low income of most of the families that live there. Concretely, the 'planned' leisure zone could change definitively the infrastructure endowment (and the living conditions) of the poor inhabitants of this area.

6. CONCLUSIONS

Internal distances (*DI*) are meaningful and with a similar importance to the distance to the centre (*DCBD*). In this sense, they should be included in the basic model, even if their importance is relative. Second, there exist North–South differences, even in the valuation of housing attributes in the influence of the CBD (*centripetal force*). Though in elasticity terms, we do not find important variations. Third, the perception on the neighbourhood's quality seems much greater in the North than in the South of the city. This may be due to the existence of multicentrical structures in the South, a phenomenon not found in the North.

We also find differences in terms of the good's attributes that lead us to assert that homogeneity in the housing supply does not exist. So, the basic model should include, at least, some particularity of the good in this sense. Clearly the relationship between the distance to the CBD and house prices is not causal, but casual. It is apparent that the concentration of some desirable attributes (maybe because there are scale economies in their production) in some zones, is what makes the house price rise in the CBD.

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APPENDIX: DATA VALUES

Price, *surface* and *distance* are numerical variables:

- price in Spanish pesetas;
- surface is square metres;
- distance is linear metres.

Congestion, *income* and *distance to neighbourhood* are discrete:

- Congestion index: rank = 0–4, being 4 maximum and 0 minimum;
- Income index: rank = 0–4, being 4 maximum and 0 minimum;
- Distance to neighbourhood core: rank = 0–3, being 0 at the edge and 3 at the core of the neighbourhood.

NOTES

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[2] It satisfies the Paretian conditions in the absence of externalities.

[3] Another line of research is devoted to design general equilibrium models with imperfect competition *à la* Krugman. This has been useful for explaining centre–periphery structures (see Krugman 1991; Alonso-Villar 2000) in which congestion and information spillover or cost of transportation are examined.

[4] Like Hochman and Pines (1982), where the spatial analysis of the city induced the lesser importance of the CBD, e.g. reducing its dimension and its influence on prices. Despite this, the paper models a city with a unique centre.

[5] See Berdnt (1991) for an introduction; Kanemoto and Nakamura (1986) for a theoretical discussion.

[6] Attributes are all those characteristics of the area around home (environmental quality or social amenities) or the neighbourhood of the property or physical properties of the good itself (surface, quality, antiquity, etc.) that create utility.

[7] Even though the Box–Cox transformation, applied in Bra as (1997) provides better results in term of heteroscedasticity, although Freeman (1979) indicates that the logarithmic form is a better adjustment for house prices.

[8] House price is explained as a function of the distance to CBD. See Martori (2000) for a discussion.

[9] Since travelling to the centre of the neighbourhood to accomplish primary purchases also has costs in terms of time and money.

[10] Crucially this analysis now focuses upon the North–South divide and whether clear differences do exist. Houses are divided between the North and South and equation (1) is re-estimated in both cases.

[11] For testing the hypothesis that the off-diagonal elements of estimated covariance matrix for the disturbances are zero, that is, that there is no correlation across areas (North–South), we have used the Lagrange multiplier test developed by Breusch and Pagan (1980). The general form of this statistic is:

$$\lambda_{LM} = T \sum_{i=2}^{n} \sum_{j=1}^{i-1} r_{ij}^2$$

where r_{ij}^2 is the ijth residual correlation coefficient. Being in our case the off-diagonal element equal to $(-)0.001$ the hypothesis of no relation is not rejected, that is simultaneous estimation should be similar to separated OLS estimations.

[12] In the case of internal distance the interpretation is different to the classical one, because the minimum value is the periphery and maximum value is the core. So, a positive sign means that a better location realizes a higher price.

[13] As the building 'dies', the citizens of higher economic capacity leave them.

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