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AN EMPIRICAL APPROACH TO LAND MONOPOLY: THE CASE OF BARRANQUILLA, COLOMBIA

Nestor Garza* and Colin Lizieri**

Abstract

A land monopoly is a theoretical "impossibility" which, nonetheless, allows for a spatial empirical approach. We specify spatial tests of land monopoly, understood as a pricing strategy where land prices can be 'over and above' the ones determined by city-wide location and market regulation. We use the city of Barranquilla (Colombia) as a case study. This city offers ideal conditions to investigate theories of land monopoly given extreme land concentration in its highly regulated elite northern fringe. We found no evidence of land monopoly pricing by using different specifications of the spatial tests, which conformed to standard urban economic expectations.

Keywords: *Urban Land Markets; Land Monopoly; Land Price; Spatial Panel Model; Colombia; Barranquilla*

JEL Classification: R14; R32; R52

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All the GIS analyses were made using Arc-GIS 10.2 and exported into MatLAB matrices by using GeoDa Space, created by the GeoDa Center of the Arizona State University www.geodacenter.asu.edu

AN EMPIRICAL APPROACH TO LAND MONOPOLY: THE CASE OF BARRANQUILLA, COLOMBIA

1. INTRODUCTION

Land monopoly has been a long-standing topic of debate in social sciences, particularly because of its alleged pervasive influence on general socio-economic performance and wealth disparities. These discussions were led by the political economists of the 19th century, and were a central issue in agriculture and poverty analyses in Europe and the USA at the time.

History and sociology rely heavily on land monopoly as a conceptual framework and see it as a deterrent to social change and progressiveness in rural medieval Europe, while dismissing its importance for predominantly urban, contemporary, economies. This rural bias in the original land monopoly controversies may have had an impact on the current dearth of analyses following this research line.

Mainstream economics has essentially remained silent about land monopoly, by moving away from the traditional concerns over land ownership, agriculture, and poverty. In opposition to this silence, in the present article we argue that land monopoly is an important research subject for two reasons: first because the detection of a land monopoly remains a Marxian urban land economics academic challenge, based upon the concept of absolute rent; and, second because landowners' "strikes" could have a negative effect on the operation of planning systems, and this type of landowners' strategy is feasible under land monopoly conditions.

This paper specifies a set of spatial empirical tests of land monopoly in a medium-sized urban economy of a developing country, Barranquilla, Colombia. In order to do so, Evans' (1991) land monopoly scheme is used, but framed within Deng's (2009) taxonomy of cases that solve the Coase (1972) paradox of the impossibility of a durable goods monopoly.

Following this introduction, section two sets out the conceptual problem involved in the land monopoly question, while producing a spatial econometrics specification. In section three, we explain the advantages of the selected case study, and present the compiled database. The fourth section presents our empirical results, and section five is dedicated to the conclusions.

2. LAND MONOPOLY

2.1 Urban Economics and Land Monopoly

In urban economics, land monopoly is an almost non-existent subject of analysis. In spite of this dearth of studies, from the existing literature we can infer four broad approaches to the concept:

- Land owners are *monopolists as a class*, a statement from classical authors such as David Ricardo or Karl Marx;
- Land owners are *site monopolists*, in relation to the unique location characteristics of each individual plot of land;
- Land use regulation produces land monopolies, in particular the granting of development rights with a spatial schedule (Fischel, 1985; 1990);
- Land owners behave as monopolists in the microeconomic sense of the term. Evans (1991) extrapolates this from the Marxian concept of monopoly rent, but asserts that the application of microeconomics, even when outside the Marxian tradition, may help simplify the concept and its implications[1].

The reason why surplus in the last case is not simply called economic profit, but rather Marxian monopoly rent, is that it is imposed by the land seller over and above location rents. This means, contrary to criticisms (Foldvary, 1993), that it goes beyond the site monopoly.

This paper focuses on this fourth land monopoly possibility but, in order to further enhance Evans's debate, it is necessary to take into account that land is a durable good and, as such, it is limited by the Coase paradox (1972). This paradox can be summarized as an inter-temporal selling dilemma for the owner of all the land in a country or city. As long as the owner tries to retain land in order to increase prices, rational buyers will not buy until all the land goes on sale. The reason for this behaviour is that if some buyers pay for overpriced land in the first

[1] The same author plays down the welfare economic implications of a land monopoly in another document, stressing that from a planner point of view it is better to deal with one large landlord-developer than with a myriad of small firms (Evans, 2004).

period, they will suffer asset losses during the second period devaluation as the monopolist puts the rest of the land up for sale[2].

The Coase paradox makes sense in an urban land economics context because each plot of land is being sold at its 'maximum and highest use', and there is no place for a land monopolist. The development potential in each one of the plots of land in a city is determined by its location characteristics in relation to the CBD, environmental quality, and the regulatory framework (Anas *et al*., 1998).

The non-existence of land monopolies has been challenged by historical experiences with landowners' strikes, although they have not been long term strategies (Needham, 1981). This is why Deng (2009) reassesses the Coase paradox to take into account that urban land is not just a durable good, but a bundle of pure land *and* a public good that allows it to be used for urban purposes. In his interpretation, there exists a set of cases where the public good can be provided either by the actual land monopolist or by the local government. In each one of these cases, the maximizing objective varies from profit for the private firm, to social welfare for the government.

Deng uses a two period bundle of goods modelling strategy, in order to derive a taxonomy of land transaction cases. He produces simulation results on profit and welfare conditions, under different assumptions on population distribution and strictness of the regulatory framework.

The simulations resemble some real life cases in the United States where large suburban real estate developments become local governments in their own right, controlled by "first period" buyers. For the purposes of this paper, we will retain from Deng's simulations the following set of results:

- More plots of land are allocated when the government has to provide the public good, and the profits are higher.
- If a community is predominantly wealthy, more plots are allocated and private profit is higher.
- There is a positive relationship between more restrictive zoning and profit, with welfare increasing effects in predominantly wealthy communities.

[2] Even where renting (rather than selling), it is still in the interest of the landlord to rent all of the land in order to achieve maximum income

In other words, land monopoly pricing is more feasible in wealthier neighbourhoods, with public provision of the infrastructure, and stricter urban regulation.

2.2 A Spatial Land Monopoly: the Search for Specification

Evans's analysis of land monopoly relies on the idea that it is mistaken to follow the Ricardian concept of a perfectly inelastic land supply curve (Evans, 2004; and Evans, 2009). In Evans's criticism, land supply will be perfectly inelastic only when all of the available land in a region (or in the island of the Great Britain in the classic analysis of Ricardo) has been used.

We might argue against this idea, that each plot of land is already a site monopolist because of the irreproducibility of each and every one of its location particularities with respect to the other land uses on the region. Furthermore, even if all the land available in an island is used there is always the chance of creating more, and the newly created locations will still be site monopolists due to their location characteristics[3].

We should, however, add that even if the starting point for Evans' criticisms might be flawed, his insights are extremely useful for the empirical formulation of a land monopoly test. We must remember that Evans's approach to land monopoly draws from Marxian urban land economics where the existence of absolute urban land rent remains a valid intellectual challenge (Park, 2014).

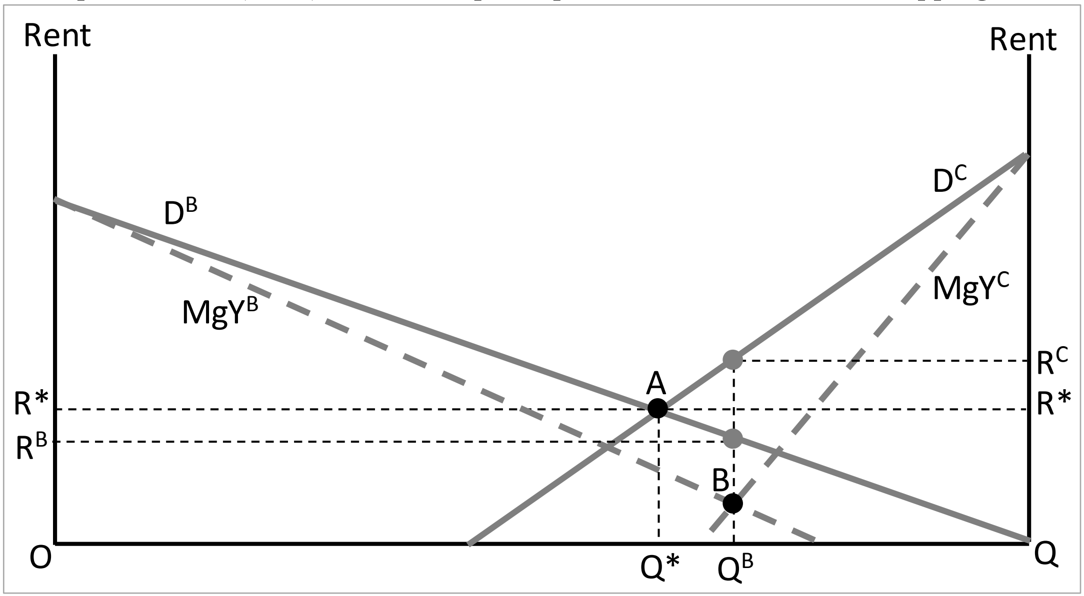
In order to understand the practical implications of Evans' approach we will follow Graph 1, adapted from his 2004 book, which examines space allocation within a shopping mall. Inside the shopping mall, there are rental spaces that are, in all possible senses, equal. However they end up being allocated to different uses with different rental prices[4].

In Graph 1, the shopping mall has a total rental space OQ, which can be allocated to Banking (B) or Clothing Stores (C). Each is represented by a demand function decreasing as a function of total space, D^B and D^C respectively. These demand functions have corresponding marginal

[3] The possibility of creating new land, for example in the Netherlands, refutes Evans' interpretation of Ricardo, but it does not refute the existence of site monopolists (Needham, 1992).
[4] Evans' analysis differs from a Hotelling city because it is the mall manager who will define the allocation of spaces, while in that case the players will determine locations and rents by spatial competition.

income functions MgY^B and MgY^C. If the mall administrator does not follow a monopoly pricing strategy, the spaces are allocated up to the point where the two demands equal at the point A, with a rental of R* and OQ* space for Banking.

Graph 1: Evans (2004): model of spatial price discrimination in a shopping mall



If, on the contrary, the mall administrator discriminates prices, the spaces are allocated up to the point where the marginal incomes from the two demands are equal. This is the point B in Graph 1. Under these new conditions each one of the demands is assigned its own reservation rental price $R^C > R^* > R^B$, with a new $Q^B > Q^*$ space assigned to Banking.

We extrapolate Evans' ideas to a city level by stating that a land monopolist must be able to exploit the different income to land price elasticities of the different individual demands to be allocated inside its plot of land. The land monopolist would be then able to overprice each subdivision accordingly, and we would add these extra rents to the ones determined by location. The land rents would lie 'over and above' the ones determined by location. The detection of such a spatial pattern with city level information is the subject of the next section.

2.3 Testing Frameworks

This section presents a spatial econometric structure to be estimated under different specifications and testing the existence of a land monopoly in a city section. We first consider land rents per square metre in each location and period r_{it}, to be determined by pure cross-sectional variables like distance to the CBD d_i, and regulatory framework as summarized by height limits h_i. There are also pure time-series variables such as city building output Q_t, and income per capita in each period y_t:

$$r_{it} = (d_i, h_i, Q_t, y_t) \quad (1)$$

The income is an external demand side force that increases land rents in the entire city; however, its impact should be different in the land monopolist's zone $(i = A)$, compared to its most comparable neighbours $(i = B)$, and over any other property in the city $(i \neq A, B)$:

$$r_{it} = (d_i, h_i, Q_t, y_t) + y_t[i = A] + y_t[i = B] \quad (2)$$

We consider that the income impact on the different zones must follow a spatial structure as determined by the corresponding spatial weights matrices (W_A) for the land monopolist zone and (W_B) for its neighbours (La Sage and Pace, 2009). As we have different observations in time, the estimation framework will be satisfied by Kronecker-expanding these matrices in the total amount of periods T (Anselin *et al.*, 2008)

Spatial econometrics is needed because in equation 2 we have a pure time-series variable y_t that will impact on the dependent variable r_{it} through its own spatial structure. In order to present this idea more clearly, we should recall that in a cross-section framework, a positive sign of the spatial autoregressive parameter means that its spatial distribution clusters high values close to other high values, while a negative sign is evidence of the opposite. A non-significant parameter is evidence of a random spatial structure.

From these cases, a positive spatial correlation of the land rents is the only possibility compatible with the land monopolist spatial discrimination suggested by Evans in Graph 1. This is why a first step in identifying a spatial monopoly is to determine that the corresponding zone has an internal spatial structure of its own, with positive spatial correlation of the land prices.

We need to find this spatial correlation of land prices inside the land monopolist area in a context where location in relation to the CBD (gradient) has already been econometrically controlled. This is done in order to separate the internal spatial correlation in the land monopolist area from the city-wide spatial land prices structure.

We must then identify the external income impact, which we expect will cause higher land prices in all the locations. However, we expect that existence of a land monopoly will produce a spatially differentiated effect of the income growth on the price in each location, just as in Graph 1.

This idea will be used in a panel estimation with the impact of income on land prices divided into two components: $r_{it} = y_t + (I_T \otimes W_N) y_t$. The first one will be the city income per period t positively related with the land prices in all the locations per period $y_t \rightarrow r_t$. The second component will be the same income in each one and all of the T periods, weighted by the N sized (N: number of locations) spatial matrix for $W_{NT} y_T [T = t] \rightarrow r_i [T = t]$.

We cannot separate the time and spatial effects in the second component, as the time will be pooled over all of the cross-section units in a panel estimation. However, both effects must be positive in order to produce a positive second component. In other words, to have positive income to land price elasticity mediated by positive spatial correlation, means that the positive income to land price elasticity is higher in the more expensive locations. This could be an evidence of land price discrimination with a spatial agenda, as set out in Graph 1.

We will perform the same estimation in the most similar control group, the zone immediately neighbouring that of the (supposed) land monopolist. If we find the same spatial patterns, we will conclude that it is not caused by a price discriminating land monopoly, because the immediate neighbour zone does not have that same extreme concentration of land ownership.

The estimated parameters will be then compared, in order to know if the spatial income to land price elasticity is higher in the monopolist zone than in its neighbours. This is the Spatially Controlled (SCM) panel to be estimated:

$$lnr_{it} = \alpha + \beta_j (lnd_i, lnh_i, lnQ_t, Z_{it}) + \sigma lny_t + \gamma W_{AT} lny_t + \eta W_{BT} lny_t + \varepsilon_{it} \qquad (3)$$

The variables are introduced as logarithms so that we can directly assess the parameters as elasticities. We will include a set of control variables Z_{it}, and focus in the spatial (γ, η) and non-spatial (σ) income to land price elasticities. ε_{it} are the panel error terms.

We expect the parameter σ to be positive, and γ to be positive and significantly larger than η. These are the conditions for a spatially structured income to land price elasticity in the monopolist zone. If, on the contrary, we find that η is positive and significantly larger or non-different from γ, we will have to consider that the spatially structured income to land price elasticity is not caused by land concentration.

However, detecting that there are different spatially structured income to land price elasticities per zone, does not necessarily mean that the land monopolist will be the one able to exploit them with higher land rents. We will use then a dummy variable (a) for the land monopolist zone and (b) for the neighbours, in order to detect and compare land pricing 'over and above'. This is the equation to be estimated:

$$lnr_{it} = \alpha + \beta_j(lnd_i, lnh_i, lnQ_t, Z_{it}) + \sigma lny_t + \pi a + \rho b + \varepsilon_{it} \tag{4}$$

In Equation 4, regardless of the income to land price elasticities of Equation 3, a positive and larger parameter π when compared with ρ implies overpricing in the land monopolist zone.

Finally we will use a Spatially Autoregressive component (SAR) to check the required positive spatial autocorrelation of the land prices regardless city-wide location, in both the land monopolist zone A, and its neighbours B. We do not use the entire city spatial weights matrix here or elsewhere in this paper, because the neighbouring is the most similar zone to the land monopolist one, and its most appropriate control group:

$$lnr_{it} = \alpha + \beta_j(lnd_i, lnh_i, lnQ_t, Z_{it}) + \sigma lny_t + \delta W_{AT} lnr_{it} + \theta W_{BT} lnr_{it} + \varepsilon_{it} \tag{5}$$

It is worth mentioning that this use of spatial econometrics is not simply exploiting the spatial character of contemporary databases (Gibbons and Overman, 2012). We use spatial econometrics because we are trying to resemble the processes behind Graph 1 with information from an entire metropolitan area. This is why further explorations in the use of spatial error and spatial Durbin models, popular in the recent literature on spatial econometrics, are beyond the requirements of this paper.

3. A CASE STUDY IN BARRANQUILLA, COLOMBIA

3.1 The context

Returning to Deng's interpretation of the land monopoly problem, urban land cannot be sold based solely on its location characteristics, but it has to include a 'production function' so that the firm can make a bundled product artificially scarce. The economic surplus must not be extracted by the land market mechanism of residual rent as a function of location.

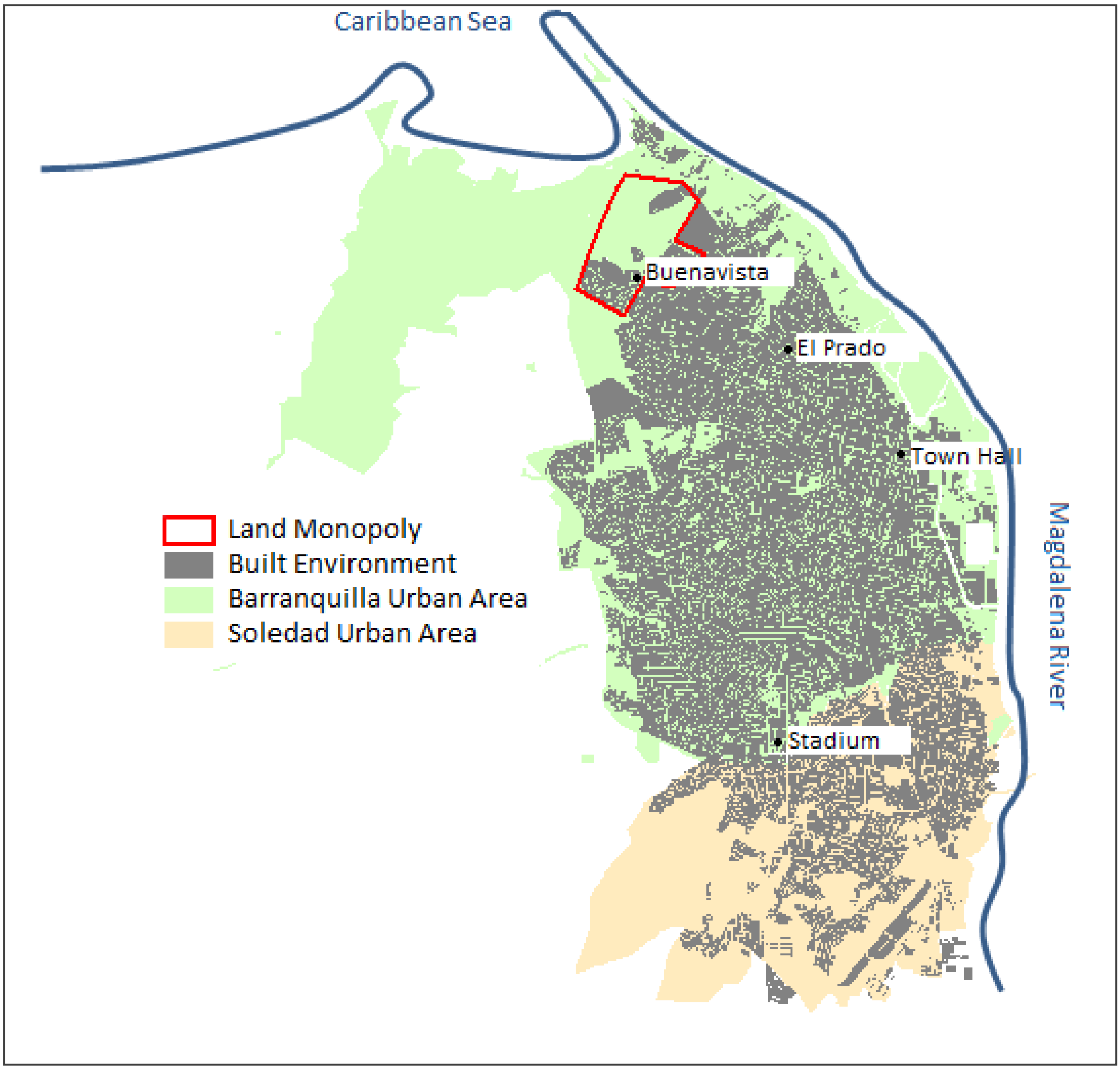
In order to accomplish this analysis, we will take into account that, in accord with Campbell (1974) and Caceres (2006), shopping mall development is representative of urban transformation of Latin American metropolises, and represents a turning point for spatial development for analytical purposes.

The Buena Vista shopping centre in Barranquilla was inaugurated in 2001, coinciding with the onset of an economic boom in the city. It is located towards the city's north-western border, where higher income residents have been relocating over the last decades, and its market area includes the northern urban and peri-urban zones. The land sale process in these areas is being undertaken by a single landowner, thus taking on the appearance of a land monopoly process.

Map 1 represents the city of Barranquilla, the fourth largest in Colombia, and the first largest metropolitan area in its Caribbean region (1,726,000 inhabitants). The city is limited by the Magdalena River to the east and the Caribbean Sea to the north.

Middle income neighbourhoods are located towards the south and southeast, while higher income neighbourhoods and retail service areas are located towards the north and northwest. Industrial zones and low-income neighbourhoods are located on the south and south-western peripheries, in a typical example of Latin American informal urbanization. We should note that despite the informal sector, urban land markets do exist and show an increasing prices trend.

Map 1: Barranquilla and Soledad, land monopoly zone and sub-centres



Source: Own elaboration using city cartography block level

In Map 1, we depict the two larger, conjoined, municipalities of the metropolitan area: Barranquilla (1,148,606 inhabitants), and Soledad (503,477 inhabitants). In both cases we use a background colour to represent the urban area of each city. Blocks of built environment are represented as grey polygons.

In Map 1, we also depict the historic centre of the city as represented by the town hall, and some urban landmarks: El Prado hotel, built in the 1930s; the Stadium, built in 1985; and the Buena Vista shopping mall, built in 2001. The land owned by the single land owner around the Buena Vista mall is represented in Map 1 as a red line bounded polygon.

The land owner accomplishes the process named ‘urbanization’ in Colombia, as it requests land development permissions from the local authority, adds local connective infrastructure (although not all of that required), and then proceeds to sell the land to developers. These in turn, build elite residential and commercial developments under stricter regulation conditions than in other areas of the city[5]. All of these characteristics classify this case into Deng’s most likely land monopolist scenario.

3.2 Land Price Source and Database Construction

This research uses appraisal datasets from the publication *“El Valor del Suelo Urbano en Barranquilla y su Area Metropolitana”* by *Lonja de Propiedad Raiz de Barranquilla*. This institution is the local association of real estate business and professionals in the city of Barranquilla, and the publication is the result of an effort to use appraisal information from their associates in order to highlight the spatial land prices structure and general trends in the city in the period 2000 – 2010.

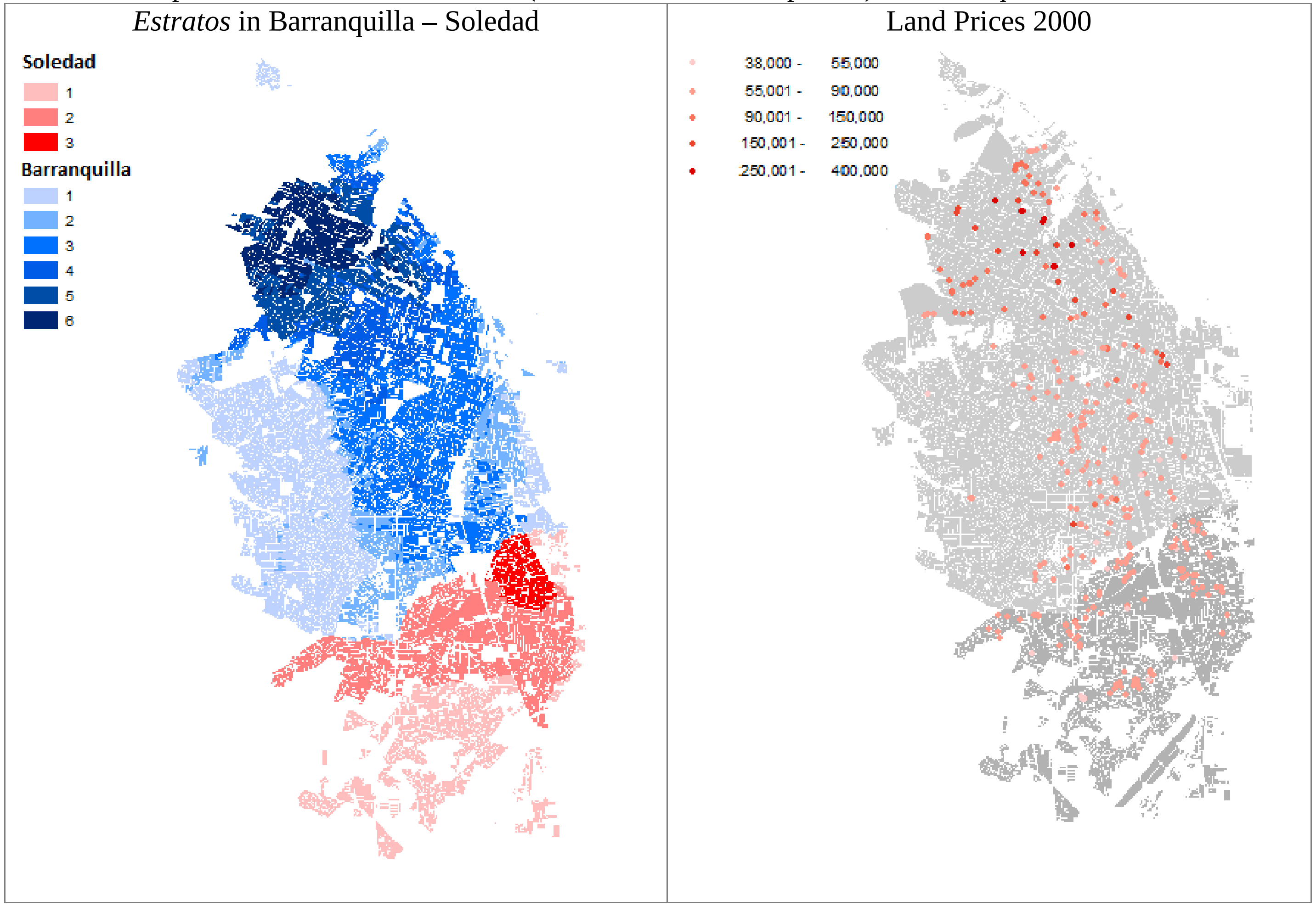
These appraisals are carried out by request of properties’ owners when their properties are about to enter the market, or when a buying bid has already been made, and the mortgage bank wish to check its feasibility. In Colombia, the professionals associated with the *Lonjas* produce secret but regulated appraisals, which are legally examined when considered biased or leading to unsatisfactory business decisions. In general terms, surveying is a reasonably competent profession in the country. As a result, the appraisals may be noisy but should not be systematically biased.

The appraisals report land prices for both developed and undeveloped properties, as surveyors use residual valuation techniques to determine pure land value in the case of already developed plots of land. It is important to use land values (as appraised) because our analysis deals with pure land rents as a function of location.

From the dataset, we compiled those observations that had all of the characteristics required for the empirical analysis; these were 3,984 independent valuations for the entire period 2000-2010. This information is represented in Map 2 over a background map of the built environment in the metropolitan area comprised by the municipalities of Barranquilla and Soledad.

[5] As opposed to the locations where poor inhabitants dwell, where regulation is almost absent, consistent with the typical Latin American pattern of spatial segregation (e.g. Rolnik, 2006)

Map 2: *Estratos* and Land Prices (2012 constant COP$ per m^2) in Barranquilla – Soledad



Source: Own elaboration using city cartography block level and *Lonja* appraisals

In the first panel of Map 2 we present the blocks in Barranquilla and Soledad classified according to their socio-economic status or *estrato*. The *estrato* is a national housing survey spatial classification and it ranges from 1 (the poorest) to 6 (the wealthiest). As we can see in the map, Barranquilla contains all 6 *estratos*, while the top *estrato* in Soledad is 3, indicative of its status as a smaller and impoverished municipality.

As expected, most of the appraisals in Map 2 are in the northern and north-western areas of the city where high income housing and elite commerce activities are located. In a typical Latin American city, these submarkets are more connected to formal finance mechanisms and the corresponding formal appraisals processes.

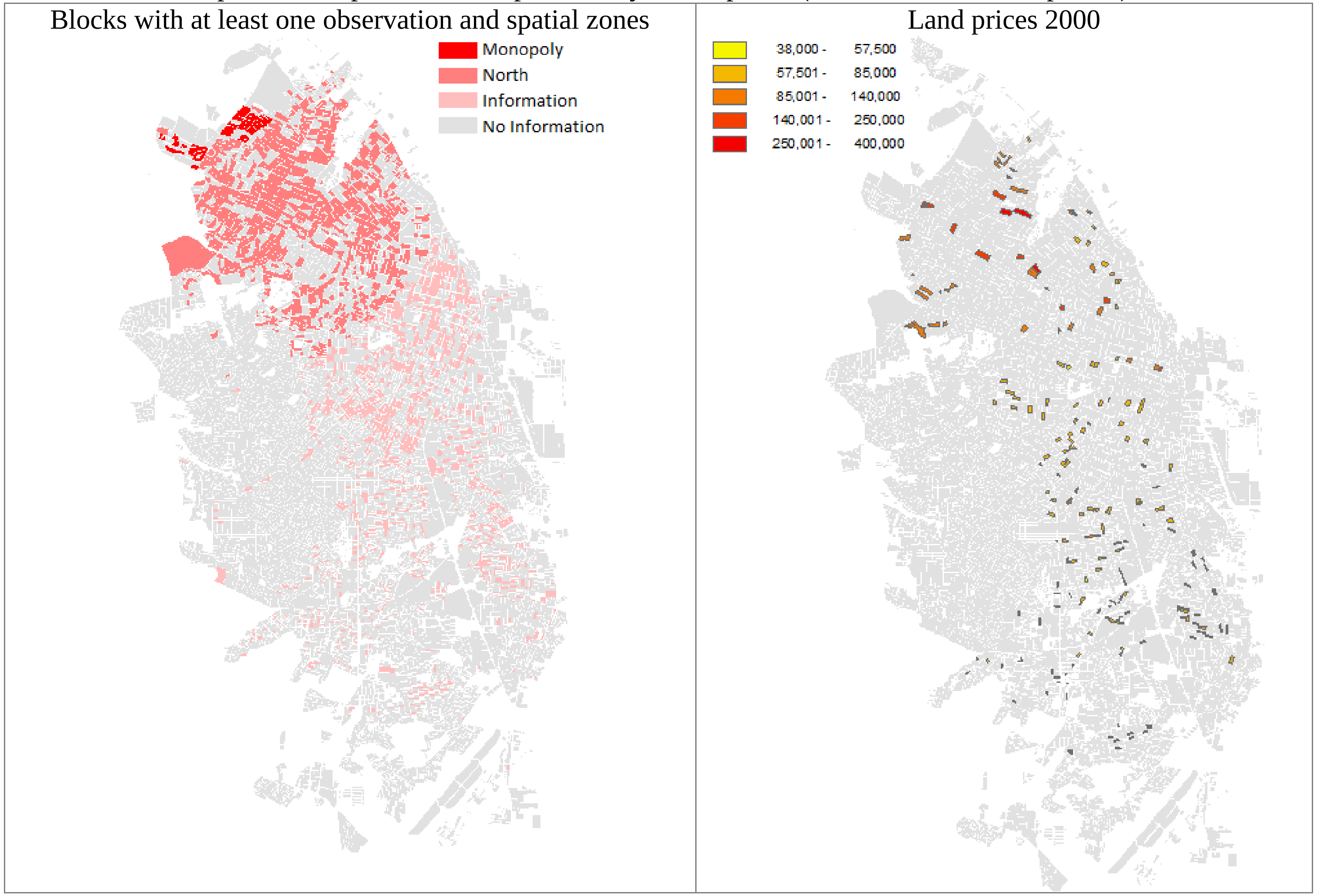
In the other panels of Map 2 we compare the land prices (2012 constant COP$) in three different years of our analysis period: 2000, 2005, and 2010. We can see that the average land prices have grown in all the categories but in particular in the upscale sectors. We can also see a widening of the low scale prices category when comparing 2000 with 2005 and 2010. This has been caused by upgrading of infrastructure which has opened the traditionally impoverished south-western periphery to formal development.

We deal with the presence of these extreme individual values in this dataset by aggregating the property level information into larger spatial units: the blocks. These are the minimal built environment units surrounded by streets and roads in the background of all panels of Map 2. Barranquilla-Soledad has, in total, 7,224 blocks. The blocks are spatial units small enough to produce micro-spatial econometric relationships, but sufficiently large to diminish the bias produced by the extreme observations in Map 2.

By using blocks, we approach a panel database without extreme observations, although we will still have to deal with an unbalanced panel structure since not all of the blocks have values in all the years of the database. The resulting land prices database per block is depicted in Map 3, where the first panel shows the 1,984 different blocks where average prices are reported in at least one of the years under analysis. In the same panel, there are 38 blocks located inside the land monopolist property, depicted in dark red. These blocks comprise the land monopolist spatial weights matrix W_A.[6]

[6] Because of the unbalanced panel structure of the spatial weights matrices these are not normalized, and they are pure 1,0 weighting matrices, specific to each year.

Map 3: Blocks per zones for spatial analysis and prices (2012 constant COP$ per m^2).



Source: Own elaboration using city cartography block level

In order to determine the blocks to be included in the neighbours' spatial weights matrix, we averaged the distance between all of the block-observations and used it as a geographical threshold for a spatial buffer departing from each point of the boundary of the land monopolist zone. The threshold thus defined was 6,895 meters: all the 780 blocks fully or partially included are depicted in light red in the first panel of Map 3. These blocks comprise the neighbours' spatial weights matrix, W_B, and although we recognize that this is a somewhat ad-hoc procedure, what we are trying to produce is a zone small enough to be considered similar to the monopolist, but large enough such that the monopolist zone remains a special spatial unit.

In the remaining panels of Map 3 we show the land prices per blocks in three different years (2000, 2005, and 2010). We can observe that the extreme values in the classification have been moderated while they still retain the general spatial and time trends of Map 2.

A summary of the information per blocks is presented in Table 1, where we report the average land and built environment prices per year. The entire database is composed of 2,987 blocks with information from 1999 to 2010, since many of the 1,984 different blocks have information in two or more years.

Table 1: Summary of information in the database per year

Year	Blocks	Land Price per M^2	Built Price per M^2	Appraisals
1999	52	98,534	239,554	60
2000	192	84,845	269,899	225
2001	228	89,834	278,061	282
2002	230	104,346	305,113	290
2003	216	136,536	345,205	368
2004	170	156,234	408,124	278
2005	226	150,205	385,213	331
2006	265	164,245	397,916	465
2007	309	185,414	421,649	459
2008	391	188,859	487,074	572
2009	359	211,186	558,570	510
2010	349	205,151	496,966	444

(Prices in 2012 constant COP$)

It can be seen that land and built environment prices in Barranquilla grew during the analysis period, particularly during the 2005-2010 period. This is specifically noted in the *Lonja* book and by other authors who make use of this source of information (Payares, 2012).

3.3 Other variables

The variables gathered for each year-block and used in the empirical section are:

- *Estrato*: As explained above, this is a standardized Colombian geographical classification based on built environment quality and it proxies for wealth. This variable will be introduced in the estimations as a dummy per *estrato*, with *estratos* 1 and 2 as the baseline. The resulting parameter should be positive and increasing in *estrato* rank.
- Building Output: this is the Construction GDP for Atlántico, the province where Barranquilla is located. Atlántico has 2,373,550 inhabitants so the city has a disproportionate participation in the population (73%) and economy of the province. We could not find more disaggregated information, so this is a pure time-series variable, and it is expected to have a positive effect on land price.
- Height: as determined by city regulations. It proxies for planning influence, and it is expected to have a positive impact on prices.
- Soledad: this is a dummy variable for all of the blocks in the municipality of Soledad. We expect it to have a negative influence, because this southern municipality is poorer than Barranquilla.
- Count: this is the number of appraisals per block-year. It may be positively related to price because when more appraisals are performed on a block, it indicates a higher market potential or higher activity levels.
- Distance: in metres from the centroid of each block to the Town Hall represented in Map 1. We expect it to show a negative sign, consistent with standard urban economics models.
- Income per capita: this is a pure time-series variable and we expect it to be positively related to prices. This variable will also be used in conjunction with the spatial matrices to perform the spatial income-price elasticity tests as explained in section 2.
- Property types: dummy variables for each of five property types: Housing, Apartment, Commercial, Industrial and Empty Lot.

A summary of these information sources, adaptation to the block-level panel estimation environment, and units of measurement is presented in Table 2. The corresponding descriptive statistics are reported in Table 3.

Table 2: Summary of information sources, precision, and units of measurement

Variable	Type	Final Spatial Precision	Original Spatial Precision	Source	Units
Land price	Panel	Blocks per Year	Property appraisal	*Lonja*	2012 constant COP$ per M^2
Building Output	Time-series	City per year	City per year	DANE	Square meters
Estrato	Cross-section	Block	Block	City Cartography	Dummy
Height	Cross-section	Block	Block fractions and/or sets of blocks	City Cartography	Floors
Soledad	Cross-section	Block	Block	City Cartography	Dummy
Count	Panel	Block	Property appraisal	*Lonja*	Count
Distance	Cross-section	Block centroid	Block centroid	City Cartography	Meters
Population	Time-series	City per year	City per year	DANE	Number
Income	Time-series	City per year	City per year	DANE	2012 constant COP$ per person
Property types	Panel	Block	Property appraisal	*Lonja*	Dummy
Built Price	Panel	Blocks per year	Property appraisal	*Lonja*	2012 constant COP$ per M^2
Lot Size	Panel	Blocks per year	Property appraisal	*Lonja*	Square meters

Table 3: Descriptive statistics of the information per blocks (2,987 block-year)

Variable			Mean	Std. Dev.	Max	min
Land price			221,690	164,867	2,035,394	11,200
Intra-monopoly $[i = A = 38]$		n = 72	300,143	128,975	700,000	20,000
Neighbours $[i = B = 780]$		n = 1,388	221,566	150,595	2,035,394	43,488
Rest of the city $[i \neq A, B = 1{,}166]$		n = 1,527	101,167	69,769	1,100,000	11,200
Building Output			123,346	48,399	196,187	23,350
Estrato	Estrato 2		0.17	0.38	1	0
	Estrato 3		0.27	0.45	1	0
	Estrato 4		0.16	0.37	1	0
	Estrato 5		0.17	0.38	1	0
	Estrato 6		0.17	0.38	1	0
Height			9.43	3.54	20	1
Soledad			0.06	0.24	1	0
Count			1.75	1.78	27	1
Distance			3,419	1,993	10,005	1
Income			9,417,332	768,287	10,295,983	8,136,945
Property types	Empty Lot		0.02	0.15	1	0
	Residential		0.49	0.49	1	0
	Apartment		0.47	0.49	1	0
	Commercial		0.20	0.38	1	0
	Industrial		0.05	0.19	1	0
Built Price			498,845	364,999	3,125,000	1
Lot Size			915	9,065	241,372	1

4. EMPIRICAL RESULTS

4.1 One equation specification

As already mentioned, we do not have prices for all the blocks in all the years and our panel database is extremely unbalanced. In order to avoid estimation problems, we use Full Maximum Likelihood (ML), a technique which is also well suited to deal with the autocorrelation problems involved in the using of spatial lags (Le Sage and Pace, 2009).

There will be large differences between the information per block but we cannot correct this problem by using a fixed effects estimator because variables as Height or Distance are purely cross-sectional. The results are represented in Table 4, including different combinations of the SCM represented in equations 3 and 4, and the SAR represented in equation 5.

Table 4: Land monopoly tests

		ML 1	ML 2	ML 3	ML 4	ML 5	ML 6
	Constant	-12.031 ***	-12.029 ***	-12.033 ***	-12.049 ***	-12.049 ***	-11.576 ***
Theory Variables	Building Output	0.066 ***	0.065 ***	0.065 ***	0.066 ***	0.066 ***	0.063 ***
	Height	0.150 ***	0.123 ***	0.123 ***	0.145 ***	0.145 ***	0.108 ***
	Income	1.502 ***	1.500 ***	1.500 ***	1.505 ***	1.505 ***	1.491 ***
	Distance	-0.174 ***	-0.166 ***	-0.166 ***	-0.176 ***	-0.176 ***	-0.197 ***
Land Monopoly Tests	Monopoly Income elasticity · (1,000)		1.365 ***				
	Neighbour Income elasticity · (1,000)		1.143 ***				
	Monopoly SAR · (1,000)			1.767 ***			
	Neighbour SAR · (1,000)			1.529 ***			
	Monopoly Dummy				0.060 **		0.084 **
	Neighbour Dummy					0.080 **	0.252 ***
Property Types	Empty Lot	-0.137 ***	-0.137 ***	-0.137 ***	-0.138 ***	-0.138 ***	-0.150 ***
	Residential	-0.270 ***	-0.260 ***	-0.260 ***	-0.270 ***	-0.270 ***	-0.285 ***
	Apartment	0.123 ***	0.105 ***	0.104 ***	0.122 ***	0.122 ***	0.114 ***
	Commercial	0.206 ***	0.198 ***	0.198 ***	0.207 ***	0.207 ***	0.184 ***
	Industrial	-0.229 ***	-0.248 ***	-0.248 ***	-0.229 ***	-0.229 ***	-0.247 ***
Controls	Estrato3	-0.033 *	-0.031	-0.031	-0.033	-0.033	-0.050 **
	Estrato4	0.260 ***	0.187 ***	0.187 ***	0.263 ***	0.263 ***	0.073 ***
	Estrato5	0.617 ***	0.507 ***	0.505 ***	0.618 ***	0.618 ***	0.432 ***
	Estrato6	1.024 ***	0.904 ***	0.900 ***	1.017 ***	1.017 ***	0.833 ***
	Soledad	-0.123 ***	-0.122 ***	-0.122 ***	-0.123 ***	-0.123 ***	-0.073 **
	Count	0.014 ***	0.015 ***	0.015 ***	0.014 ***	0.014 ***	0.015 ***
	Log-Likelihood	-1,011	-977	-976	-1,009	-1,009	-960
	Akaike	0.690	0.670	0.670	0.690	0.690	0.650
	Schwartz	0.720	0.700	0.700	0.720	0.720	0.690
	Std Error	0.340	0.337	0.337	0.340	0.340	0.335
Waldman Tests	Income Elasticities		0.378				
	Spatial Lag			0.458			
	Dummies						0.000

Unbalanced Pooled FML
Maximum Likelihood Estimation – 2987 observations
***Significant at 99%; **Significant at 95%; *Significant at 90%

The estimation is controlled by two pure time-series variables, Building Output and Income per capita, which are used in the estimations presented in Tables 4, 5 and 6. Even where these have a high degree of correlation (0.657), they are never correlated with the OLS error terms. Regardless of this good feature, we will try to avoid any remaining endogeneity problem between these series and with the land price, by using Instrumental Variables (IV) in further analyses below.

All of the controls and property types perform well in Table 4, producing the expected signs and being significant in most specifications. In particular, Building Output, Height and Income impacts are always positive and significant, as expected. We also can see that the inclusion of Income has not controlled for Building Output in any of the specifications, while distance to the CBD was always negative and significant.

In the model ML2 we estimate the spatial income to land price elasticities as explained above[7]. The elasticity for the Land Monopolist zone is slightly larger than for its neighbour; however, the Wald test (presented at the bottom of the Table) reveals that they are not statistically different from each other. As these elasticities were positive, similar in dimension, and significant, we have reasons to consider that these spatial processes are common to the entire northern area of the city.

In order to produce a direct assessment of the 'over and above' condition for land monopoly in equation (5), we estimated the models ML4, ML5 and ML6, where we used combined and in isolation, dummies for the Land Monopoly and Neighbour zones. The parameters were always positive and significant, and the resulting prices lie 'over and above' the ones determined by all the other variables. However, the parameter was always slightly larger for the *Neighbour* when comparing ML4 and ML5, and clearly larger in ML6. The Waldman test confirmed this difference by rejecting the null hypothesis that the parameters are statistically equal. This result is important in testing for the existence of a land monopoly, because if the entire northern zone of the city has land prices 'over and above', then the overpricing is *not* being caused by land ownership concentration.

We infer from the above that this extremely large landowner does not seem to behave as a land monopolist and cannot price its land over and above city-wide and zone-wide determinants. The over overpricing could be due to spatial segregation, typical in Latin American cities (Gilbert, 2000).

Criticisms can be directed to the selection of the control zone, because it could be fine-tuned to reject the land monopoly hypothesis; however we argue that it has been quite the opposite.

[7] The spatial matrices have a structure with 4 neighbours, because we found that it produces slightly better goodness of fit, when compared to any of the options between 3 and 7 neighbours. These other options still produced the same signs and significance of the parameters.

It is a wide neighbouring zone and includes low priced central and south-western properties that should diminish the value of the overall North dummy.

Another source of criticism could be the small amount of spatial units comprised in the Land Monopolist zone; however, we can see that they have the highest land price average in the city in Table 3, while their SAR model was positive and significant in model ML3. This last observation is important, as both of the zones (land monopolist and neighbour) had positive, significant, and statistically non-different SAR parameters, regardless the use of a city-wide land price gradient. This is an indirect reliability indicator.

One final line of criticisms can be directed to the possibility of endogeneity between the two time-series variables Building Output and Income, and with the Land Price. Because of these reasons we use IV estimations in Table 5. The Building Output will be instrumented by the Population in the metropolitan area.

We also instrument the height with a related regulation indicator: front of the plot of land in meters. Height is instrumented in order to keep symmetry between the pure time-series with the pure cross-section variables in the analysis. Front of the plot was available only in 2,918 of the 2,978 total observations, and these are the observations used in the estimations presented in Table 5[8].

The signs and significance of Building Output, Height, Income and Distance are broadly the same in Table 5 as in Table 4. Most of the property types and other control variables also hold their corresponding signs and significance, except the dummy for Soledad, and the Appraisals Count.

The spatial income to land price elasticity was positive and significant for the north zone, but not for the land monopolist zone in the model IV2, while their difference was significant according with the Waldman test. This result coincides with lack of significance for the land monopoly dummy in the models IV4 and IV6, while positive and highly significant for the north dummy in models IV5 and IV6. The difference between the parameters for these two variables was also significant according to the Wald test in model IV6.

[8] We checked that in all the cases the changes in the results are not caused by the exclusion of these observations.

These results do not support the land monopoly hypothesis, while strengthening the explanation that the over pricing in the entire northern zone of the city is due to other determinants (particularly spatial segregation). This last hypothesis is reinforced because in model IV3, once again, the SAR parameters for both the land monopolist zone and its neighbour are positive, significant, and not statistically different from each other.

Table 5: Instrumental Variables Land Monopoly Tests

		IV 1	IV 2	IV 3	IV 4	IV 5	IV 6
	Constant	0.441	-6.154 ***	0.463	-5.760 ***	-6.124 ***	-6.113 ***
Theory Variables	Building Output	0.233 ***	0.141 ***	0.233 ***	0.146 ***	0.136 ***	0.136 ***
	Height	0.251 ***	0.657 ***	0.224 ***	0.754 ***	0.536 ***	0.521 ***
	Income	0.594 ***	1.022 ***	0.590 ***	0.986 ***	1.046 ***	1.047 ***
	Distance	-0.174 ***	-0.174 ***	-0.164 ***	-0.182 ***	-0.192 ***	-0.192 ***
Land Monopoly Tests	Monopoly Income elasticity · (1,000)		0.511				
	Neighbour Income elasticity · (1,000)		0.709 ***				
	Monopoly SAR · (1,000)			1.575 ***			
	Neighbour SAR · (1,000)			1.399 ***			
	Monopoly Dummy				-0.048		-0.004
	Neighbour Dummy					0.194 ***	0.197 ***
Property Types	Empty Lot	-0.147 ***	-0.116 **	-0.146 ***	-0.112 **	-0.130 **	-0.131 **
	Residential	-0.232 ***	-0.172 ***	-0.223 ***	-0.166 ***	-0.208 ***	-0.211 ***
	Apartment	0.094 ***	0.084 ***	0.076 ***	0.092 ***	0.093 ***	0.093 ***
	Commercial	0.196 ***	0.209 ***	0.191 ***	0.213 ***	0.195 ***	0.194 ***
	Industrial	-0.254 ***	-0.281 ***	-0.271 ***	-0.277 ***	-0.272 ***	-0.272 ***
Controls	Estrato3	-0.054 ***	-0.091 ***	-0.052 **	-0.099 ***	-0.095 ***	-0.094 ***
	Estrato4	0.194 ***	-0.045	0.126 ***	-0.036	-0.098 ***	-0.094 **
	Estrato5	0.525 ***	0.226 ***	0.421 ***	0.250 ***	0.210 ***	0.216 ***
	Estrato6	0.936 ***	0.661 ***	0.820 ***	0.694 ***	0.640 ***	0.646 ***
	Soledad	-0.104 ***	-0.014	-0.107 ***	0.006	-0.005	-0.008
	Count	0.011 **	0.006	0.013 **	0.004	0.009	0.009
	R2	0.689	0.654	0.696	0.630	0.679	0.682
	Std Error	0.352	0.371	0.348	0.384	0.358	0.356
	Jarque-Bera	0.000	0.000	0.000	0.000	0.000	0.000
	Q Stat (1 lag)	0.000	0.000	0.000	0.000	0.000	0.000
	Durbin-Wu-Hausman	0.000	0.000	0.000	0.000	0.000	0.000
	Cragg-Donald (F-stat)	0.000	0.000	0.000	0.000	0.000	0.000
Wald Tests	Income Elasticities		0.017				
	Spatial Lag			0.657			
	Dummies						0.000

Unbalanced Pooled FML
Maximum Likelihood Estimation – 2918 observations
Instruments: Population per Building Output, and Lot Front per Height

The selected instruments in Table 5 seem reasonably strong according to the p-values of the Craigg-Donald tests, while the p-values of the Durbin-Wu-Hausman tests make us confident of the endogeneity of Building Output and Height when compared to Population and Lot

Front. However, and according to the p-value of their Jarque-Bera and Q-Statistic, these IV estimations are not normal and have auto-correlation. We consider that FML is a more adequate estimation strategy, although now we know from the IV estimation that the signs and significance of all the variables of interest hold when Height and Building Output were corrected for endogeneity.

The normality and correlation problems could be due to the use of unbalanced pooled FML estimation, particularly in a spatial econometrics context. Future research with this database will try to solve these problems by using more aggregate spatial units, even when there will be a loss of precision of the spatial analysis. In the present paper, we will try to tackle these limitations by taking advantage of the abundance of information block-level in order to produce system estimations in the next section.

4.2 System Specification

In this section we explore if the relationships of income and location with the land price are mediated by their corresponding built environment prices. We take advantage of the abundance of appraisals information in the *Lonja* datasets, and use Pooled FML System estimation.

We try to accomplish this by recreating equation 3 as a system, where its resulting land price is incorporated into an equation for the Built Price per m^2 P_{it}:

$$lnr_{it} = \alpha + \beta_j(lnd_i, lnh_i, lnQ_t, Z_{it}) + \sigma lny_t + \gamma W_{AT} lny_t + \eta W_{BT} lny_t + \varepsilon_{it} \quad (6)$$

$$lnP_{it} = \lambda + \chi_j(V_{it}) + \psi \underline{lnr_{it}} + \phi lny_t + \vartheta W_{AT} lny_t + \varphi W_{BT} lny_t + \epsilon_{it} \quad (7)$$

The System FML estimation was performed sequentially, assigning values to equation 6, where the Land Price is the dependent variable. It then iterated the fitted values as one of the independent variables of equation 7, where the dependent variable was the Built Price.

The Built Price has its own set of V_{it} explanatory variables and controls, r_{it} land price, y_t income per capita, and the corresponding spatially structured income to Built Price elasticities in the Land Monopoly Zone $W_{AT} lny_t$ and its neighbours $W_{BT} lny_t$. ϵ_{it} is the vector of panel error terms for this new equation.

The system estimation also includes SAR and dummies for the Built Price equation in order to produce system versions of equations 4 and 5. In case of finding positive and significant spatially structured income to Built Price elasticities, it would mean that secondary market sellers have spatially-structured decision making. If the opposite case holds, the non-significant or negative parameters of these elasticities would mean that the secondary market sellers are pure price takers who have to accept land prices as determined by the residual mechanism (site monopolists or a land monopolist).

The results for this ML System estimation are reported in Table 6, where we can see that the main variables Building Output, Height, Income, and Distance, always have their expected signs and are significant. In particular, the inclusion and exclusion of Income in System1, System2, and System3, have no effect on their signs and significance.

We used Land Price and Land Plot Area as determinants in the equation for the Built Price, in addition to year dummies as time controls. The two determinants were always significant and had their expected signs.

The application of monopoly tests on the Built Price equation always produced non-significant parameters for their elasticities and SAR parameters (Sytems2, System3, and System4). Furthermore, Income was always rejected as a determinant in System1 and 2, while the land monopoly dummy was significant only when controlled by the neighbour dummy in System6.

These findings coincide with the results in Table 4 and 5, and the spatial economic structures are defined by the Land Price and not by the Built Price, as expected. The possible reasons for overpricing in the entire northern zone of the city are not in the built, but in the land market, and could thus be due to spatial segregation.

Table 6: Land Monopoly tests on Built Prices (System Estimation)

			System 1	System 2	System 3	System 4	System 4	System 5	System 6
Equation 1		Constant1	10.517 ***	10.664 ***	10.380 ***	-8.870 ***	-3.117 **	-4.536 ***	-5.940 ***
	Theory Variables	Building Output	0.203 ***	0.188 ***	0.211 ***	0.091 ***	0.122 ***	0.114 ***	0.104 ***
		Height	0.155 ***	0.186 ***	0.140 ***	0.137 ***	0.136 ***	0.140 ***	0.141 ***
		Distance	-0.174 ***	-0.183 ***	-0.167 ***	1.287 ***	0.907 ***	1.002 ***	1.097 ***
		Income				-0.170 ***	-0.173 ***	-0.174 ***	-0.175 ***
	Property Types	Empty Lot	-0.465 ***	-0.455 ***	-0.547 ***	-0.413 ***	-0.437 ***	-0.377 ***	-0.349 ***
		Residential	-0.271 ***	-0.288 ***	-0.253 ***	-0.256 ***	-0.257 ***	-0.263 ***	-0.264 ***
		Apartment	0.108 ***	0.122 ***	0.110 ***	0.121 ***	0.118 ***	0.120 ***	0.121 ***
		Commercial	0.166 ***	0.166 ***	0.181 ***	0.207 ***	0.195 ***	0.198 ***	0.200 ***
		Industrial	-0.268 ***	-0.251 ***	-0.227 ***	-0.196 ***	-0.212 ***	-0.219 ***	-0.220 ***
	Controls	Estrato3	-0.033	0.004	-0.027	-0.027	-0.029	-0.030	-0.031
		Estrato4	0.259 ***	0.299 ***	0.268 ***	0.273 ***	0.271 ***	0.263 ***	0.263 ***
		Estrato5	0.604 ***	0.644 ***	0.606 ***	0.626 ***	0.622 ***	0.617 ***	0.618 ***
		Estrato6	1.006 ***	1.056 ***	1.004 ***	1.029 ***	1.025 ***	1.025 ***	1.027 ***
		Soledad	-0.114 ***	-0.080 **	-0.129 ***	-0.123 ***	-0.124 ***	-0.123 ***	-0.123 ***
		Count	0.012 ***	0.012 ***	0.014 ***	0.015 ***	0.015 ***	0.015 ***	0.015 ***
Equation 2		Constant2	0.047	0.373	2.269 *	4.758 ***	3.806 ***	6.405 ***	7.141 ***
	Determinants	Land Price	0.892 ***	0.852	1.049 ***	0.806 ***	0.893 ***	0.656 ***	0.588 ***
		Land Area	-0.318 ***	-0.309 ***	-0.325 ***	-0.308 ***	-0.309 ***	-0.310 ***	-0.303 ***
		Income	0.234	0.251					
	Monopoly tests	Monopoly Income elasticity · (1,000)		2.040	0.944				
		Neighbour Income elasticity · (1,000)		0.344	-0.269				
		Monopoly SAR · (1,000)				2.867			
		Neighbour SAR · (1,000)				0.698			
		Monopoly Dummy					0.194		0.513 **
		Neighbour Dummy						0.276 ***	0.302 ***
	Time Dummies	2001	0.310	-0.013	0.009	0.117	0.111	0.101	0.084
		2002	-0.081	-0.321	-0.379	-0.119	-0.157	-0.134	-0.141
		2003	-0.166	-0.469	-0.589 **	-0.156	-0.236	-0.188	-0.176
		2004	-0.319	-0.555	-0.678 **	-0.293	-0.362	-0.304	-0.293
		2005	-0.383	-0.557	-0.777 ***	-0.293	-0.380	-0.298	-0.268
		2006	-0.373	-0.639	-0.743 ***	-0.450 *	-0.499 *	-0.411	-0.392
		2007	-0.555	-0.789	-0.913 ***	-0.653 **	-0.697 ***	-0.577 **	-0.545 **
		2008	0.083	-0.135	-0.193	-0.083	-0.092	-0.015	-0.004
		2009	0.343	0.096	0.028	0.199	0.178	0.244	0.261
		2010	0.082	-0.154	-0.224	0.006	-0.038	0.050	0.057
		Log-Likelihood	-7136	-7143	-7134	-7027	-7043	-7034	-7029
		Akaike	4.798	4.803	4.796	4.726	4.736	4.730	4.727
		Schwartz	4.856	4.865	4.857	4.788	4.796	4.790	4.790
		S.E. of Equation 1	0.356	0.357	0.359	0.343	0.346	0.344	0.343
		S.E of Equation 2	1.857	1.854	1.874	1.846	1.853	1.835	1.831
Waldman Tests		Income Elasticities		0.466	0.599				
		Spatial Lags				0.474			
		Dummies							0.320

Unbalanced Pooled FML

Maximum Likelihood Estimation – 2987 observations

***Significant at 99%; **Significant at 95%; *Significant at 90%

5. CONCLUSIONS

Given the Coase paradox, land monopoly is a theoretical impossibility when land is considered a commodity with its rent purely determined by location, but it becomes feasible if it is bundled with the public goods that make it suitable for urban uses. In this last case, there will be a higher degree of land monopolist pricing when the public good is provided by the government, the land regulation is strict, and its potential inhabitants are wealthy. Land monopoly is understood as a pricing strategy where the land rents lie 'over and above' what their location permits.

In the particular case of Barranquilla's northern fringe, a single firm owns more than 90% of all the land, which is destined for high-income housing and commercial developments, with strict urban regulation, and where the main connectivity expenses are carried out by the government. This firm gets urban expansion permissions and then proceeds to sell the land to best-bidder developers. All of these conditions are ideal for the existence of a land monopoly, creating a natural experiment for formally testing for the existence of land monopoly in this city.

We have used different spatial econometric specifications, with a double spatial matrix weighting of the income to land price elasticities, and dummy variables to identify over-pricing. None of these suggested the existence of a land monopoly in the candidate zone, in spite of its high prices and extreme concentration of land ownership.

Our analysis is restricted by lack of spatial information which, in turn, affected our panel modelling possibilities. In particular, in future research we would like to extend the regulatory variables in the database backwards into the past, in order to capture the econometric effect of changes in regulation, instead of relying on standardised levels of regulation. The unbalanced structure of the information constrains our ability to produce more robust results, a problem that might be overcome by re-aggregating information into larger spatial units (although this approach is not without its disadvantages with the larger units masking more local spatial and socio-economic effects). Regardless of these constraints, the results hold consistently for a variety of specifications, while the spatial land monopoly test is innovative and potentially replicable.

Even though land monopoly pricing effects were not detected, the displacement of high land price developments further north may not be a desirable result for Barranquilla, particularly given the fact that the traditional downtown is more accessible to lower income workers from the south of the city and that mass public transit has yet to reach the northern area to any great extent. Moreover, as a monopolist land-market structure has not been detected, all of the welfare implications for the northern fringe development must be 'urban planning' related rather than 'market concentration' related. In this sense, even if pricing over and above location rents is not detected, the political influence of the land monopolist firm may still constitute an important source of inefficiencies and concern for an urban research agenda.

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