A SPATIAL – TEMPORAL ASSESSMENT OF THE LAND VALUE DEVELOPMENT TAX

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Abstract

A pure land tax is market neutral because of being entirely paid by lowering prices in land supplied to the market; however it is an almost unattainable public policy objective. A Land Value Development Tax (LVDT) may be an alternative possibility, when levied where regulatory or infrastructural state interventions determine land prices increases. Even when the LVDT is still paid by means of a lowering of land prices (static neutrality), it might accelerate development timing (non-dynamic neutrality), and it can also have price increasing spatial feedback effects when not applied on all the spatial units of a region. We examine the LVDT applied in Bogotá (Colombia) during 2004-2010. This city offers an excellent opportunity for policy assessment since it has both a clearly determined pre and post-tax period, and spatial differences in application. This paper uses spatial panels to assess the LVDT impact on prices. We found that the LVDT had a negative effect on prices while not having any building output, or spatial feedback effects. The results allow us to conclude that the LVDT fulfils the static and dynamic neutrality conditions of a Pure Land Tax in spite of its scattered spatial implementation.

Keywords: Urban Economics; Land Regulations; Land Tax; Value Capture; Colombia; Bogota

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1. INTRODUCTION

Although there has been a long tradition of land use planning in Latin America, it is argued that much of this policy has used inappropriate enforcement, land use regulation that favours the elite in societies, and has exhibited a lack of attention to formal economic planning tools. In this paper, we address these concerns by making a spatial urban economics analysis of the Colombian Value Capture strategy: *Captura de Plusvalía*.

Captura de Plusvalía is a Land Value Development Tax (LVDT) that attempts to reduce unearned landowner gains. In particular, it is intended to capture windfall gains due to infrastructural or regulatory interventions in the urban space. This LVDT was introduced in national legislation in 1997 (Law 388) following a constitutional principle (Article 81 – Constitution of 1991). However, these constitutional and legal principles have been implemented slowly, mainly because of political resistance. We consider that lack of formal assessment of its achieved results is one reason for this resistance and one rationale for undertaking this case study.

We use information for the period 2000-2010 to assess the land market neutrality of the LVDT of Bogota, Colombia's capital and largest metropolis. This city introduced the LVDT in 2004, and offers an excellent vantage point for observation of its effects, because it follows a clear spatial and temporal application process, it is applied over an extended metropolitan area regulated by a single master plan throughout all the years of application of the tax, it comprises a single public authority for revenue and taxation purposes, and there has been no previous historical experience with the use of this type of land exaction in the city or region. These characteristics allow us to test the effects of an LVDT in an emerging urban environment, using single and multi-equation spatial panel techniques.

The paper uses spatial panel estimation where the land prices will depend on spatial and socio-economic variables extracted from urban land economics theory, and as a function of the LVDT rate per year and zones. It will be shown that the LVDT rate had a negative impact on land prices per year while not affecting corresponding building output per year. These results strongly suggest that the LVDT is market neutral, both in a static and a dynamic sense, a result in line with existing theory.

The paper is structured in six sections, the first being this introduction, while in the second we present a contextual and empirical literature review. In section three, we set an empirical framework for assessment while in the fourth section we introduce the case study and databases. The relevant empirical analyses are performed and presented in section five, while section six sets out our conclusions and policy assessment.

2. LAND TAXATION: THEORETICAL AND EMPIRICAL INQUIRIES

2.1 Land Taxation and Spatial Markets

A Pure Land Tax is often considered the ideal source for public finance. This is because the perfectly inelastic supply of land allows the spatial land rents and land use structures as determined by market forces to remain once the tax is collected (Wildasin, 1988; Anas, Arnott and Small, 1998). This characteristic has been analysed and theoretically demonstrated by following the so-called Henry George Theorem under different market and spatial structures (Arnot and Stiglitz, 1979).

However, a Pure Land Tax has been an almost unattainable ideal because of legal resistance to valuations and procedures, or political power held by landowners. The split rate tax, a variation of the pure land tax, was used in the city of Pittsburgh. Oates and Schwab (1997), and Plassman and Tideman (2000) found that this policy was market-neutral, as theoretically expected.

In spite of its advantages, the Pure Land Tax has not been widely used around the world. By comparison, the Land Value Development Tax (LVDT) has been an option that has led to less resistance, even though it might not necessarily share all the benefits of a Pure Land Tax. The LVDT tries to re-capture for the local government the land prices increases due to regulatory or infrastructural interventions. However, even where it can be statically market-neutral, it may also delay or accelerate development timing and, thus, not respect dynamic neutrality.

According to Rose (1973, 1976), if we analyse the LVDT as a one-time exaction to the instantly increased present value of future rents (the new land price) in a location subject ot intervenion, the development timing of the corresponding plot of land might be a function of the tax rate and, in that sense, the tax would not respect dynamic market neutrality.

The work of Rose has been contested by Neutze (1974), and Foster and Glaister (1975). These authors considered that the choice of a specific functional form for the present value of rents produces an effect from the tax rate to the development timing. Another flow of criticisms came from Evans (1983) and Needham (1983), because landowners' strikes may allow for the passing on of the tax to final land users via land holding[1].

The dynamic neutrality of both the LVDT and the pure land tax can also fail if not all the spatial units inside a region apply it, that is, a spatial general equilibrium feedback effect (Brueckner, 1986). This effect occurs when the tax is applied in a spatial unit but not in its neighbours, meaning that the static-neutral land price decrease can be counterbalanced by development migration from other neighbouring spatial units. There will be land price increases after the scattered spatial application of the tax.

The application of both pure land taxes and LVDTs has been resisted in Latin America, possibly because of its rural and landowner-biased political traditions (Sokoloff, 2012). Regardless of these limitations, Brazil and Colombia have recently implemented value-capture strategies, in a context full of controversies.

The Brazilian value-capture strategy is named *Solo Criado* (Created Land) and it gives freedom to build the first floor in one's property without any charges, but the government captures 100% of land price increases caused by building additional floors (Fernandes, 2011). Unfortunately there is scarce literature on the effects of this policy and, in particular, we still do not have a spatial, time controlled, metropolitan scale, and land oriented assessment.

[1] As one of the referees noted, landowners might also withhold land in anticipation of a legal or tax change in favour of their position. This falls outside the scope of this paper, although parallel work examining land monopoly effects addresses similar issues.

The Colombian value-capture is named *Captura de Plusvalia*, and it is an LVDT. It is set out in Law 388 of 1997, the current planning framework for this country. The Law states that all of its 1,038 municipalities need a Master Plan including the use of value-capture tools. The LVDT has been used only in the cities of Bogota, Medellin and Pereira, but it has proven to be operationally demanding and politically/legally resisted (Borrero and Duran, 2010).

2.2 Value Capture Assessments

Formal assessments of the Value Capture in Brazil or Colombia have been scarce, although we should recognize the pioneering effort by Borrero (2007) for Bogotá. Our analysis relies heavily on his pioneering contribution; however, our test framework is an improvement as that paper was unable to use time and spatial controls, properly specified test models, and metropolitan scale analysis. In addition, our information is public and controlled by geographic and social features.

In the international literature, we are very much aligned with the works of Ihlandfeldt and Shaughnessy (2004), and Ihlanfeldt (2007), as they use a full metropolitan scale urban economy model to test a land exaction strategy (the Impact Fee). But contrary to these authors, we do not assume a specific land price spatial function (they assume a cubic spline) and our time dimension allows us to use a ‘change’ in regulation approach and not a simple ‘levels’ of regulation approach (McLaughlin, 2012).

Lauridsen et al. (2013) is another precedent to our own research, as they use prices collected over time in relation to regulation and land tax in 25 municipalities in Denmark. They use housing price per city and regulatory variables impacting price in a spatial perspective. But these authors are not working with land prices (instead using house prices as a proxy), and their focus is on regulation not the land tax, which nonetheless, appears to have the expected negative impact on prices.

Bachis et al. (2012), constitutes our most immediate precedent as they assess the impact of a Land Transfer Tax (LTT) on housing sales within a Toronto suburb by using a Difference-in-Differences (DiD) estimation. The authors found that the tax had the effect of decreasing land prices although it was not market-neutral since transaction volumes slowed down. However, and due to their different research objectives, their transactions of fully developed properties mask the land prices that we directly analyse using appraisals.

It should be added that the income regressiveness or progressiveness, r and the incidence, of land taxes remain a contentious issue. In consolidated urban environments there can be ‘asset rich but income poor’ situations, but in fast expanding cities (like those in Latin America) those profiting the most from urban growth may be pure landowners. Experiments with pure land taxation in developing countries cities have been carried out in Mexicali (Delgado and Perló, 2000), and Johannesburg (Franzsen, 2005).

All of these are valuable contributions; however we consider that the existing literature has not offered a more conclusive answer to the question surrounding the neutrality (static and dynamic) of the LVDT because they lack a case study with clear and comparable information pre and post-tax period. There is also scant research about this subject with a spatial, and metropolitan-scale perspective, while it is evident that there is lack of knowledge about this subject in developing countries. The combination of these characteristics is a contribution of this paper to the literature on urban economics and land exactions.

3. AN EMPIRICAL FRAMEWORK FOR ASSESSMENT

In this section we follow the determinants of land rents in a city where land rent in each zone i is a residual after discounting building costs. Differences in regulatory restrictions per zone imply higher land rents in the zones where the restrictions are less strong than the citywide standards. Basically, the higher the Floor-to-Area-Ratio (FAR), the higher the land rent:

$$r_i = \frac{q_i(P_i - c)}{L_i} FAR_i \quad (1)$$

where r_i= residual Land Rent (Price) per m^2, q_i Building Output quantity in m^2, P_i Price of the building environment per m^2, c Construction costs per m^2, L_i Total available land in the zone in m^2, and FAR_i as average per zone.

According to Rose (1973), a correctly designed LVDT is market-neutral in a static sense; we simply have to discount its value from the equation (1). The tax base is the change in land rents due to government intervention, a theoretical condition that cannot be observed in a citywide analysis such as our case study. This is why we have to use the price change per zone. We have for every zone i and every period t:

$$r_{it} = \frac{q_{it}(P_{it} - c_t)}{L_{it}} FAR_i - \tau_{it}(r_{it} - r_{it-1}) \qquad (2)$$

Where τ_{it} is the tax rate per zone and period, and $(r_{it} - r_{it-1})$ is the land price change per zone between periods (which includes what accrued due to public intervention). By taking logarithms on both sides we have:

$$lnr_{it} = lnq_{it} + ln(P_{it} - c_t) + lnFAR_i - lnL_{it} - ln\tau_{it} + ln(\Delta r_{it}) \qquad (3)$$

Equation (3) represents a panel estimation model where r_{it} is also dependent on location. This is why we will require a pure cross-section variable representing distance to be introduced as a function (gradient or spline) of distance (D_i):

$$lnr_{it} = lnq_{it} + ln(P_{it} - c_t) + lnFAR_i - lnL_{it} - ln\tau_{it} + ln(\Delta r_{it}) - lnD_i \qquad (4)$$

Equation (4) represents a panel model that will permit us to determine if the relationship between the tax rate and the land prices per UPZ is negative, evidence of static market neutrality. It will also allow us to check the possibility of dynamic non-neutrality, by analysing the interrelationships between the tax rate, the land prices, and the building output. The information sources and methodology to accomplish this test are presented in the next section.

4. CASE STUDY AND DATA

This paper analyses the LDVT applied in Bogota during the period 2004-2010[2]. This city started LVDT processes in 2004, with a tax rate that increased from 30% in that year, to 40% in 2005, and 50% from 2006 onwards. Its base is the land value increase due to regulatory and/or infrastructural changes and it has been implemented piecemeal citywide following a spatial and temporal pattern that can be considered random (not guided by any policy or

[2] Bogota is the largest Colombian urban area (7,100,000 inhabitants), with one of its highest GDP per capita (11,565 US$ for 2011), and the main node for air transport, finance and services in the country. The city is located on a plateau 2,600 metres above sea level, and comprises approximately 36,000 hectares of built environment. It is limited to the east by the Andes mountain range and to the west by the River Bogota, with a north-south orientation and the downtown located towards the south-east, close to the mountains in the left panel of Map 1.

geographical principle)[3]. Its adoption rate has been determined by legal-urban rulings relating to the so-called Spatial Planning Units (UPZs).

There are 117 UPZs determined by the 2000Master Plan; they have an average land area of 375 hectares, and have required micro-planning legal/cadastral/geographic reports before being incorporated into the actions considered by the plan. Inside these reports, when development permission is requested, the value-capture processes are carried out. They include appraisals at block (or part block) level wherever an area is considered to be positively affected by regulatory or infrastructural interventions[4]. The UPZs are presented in the left panel of Map 1.

[Map 1 about here]

This case offers a good opportunity for assessment because we can explicitly track the appearance of the LVDT and its spatial application in different zones within the same city, with the same collection authority, and regulated by the same master plan. All of these are characteristics difficult to find in first world countries where the LVDTs have had longer traditions, and the applications have occurred in extended metropolitan areas with divided planning jurisdictions and collection authorities. In the next sections we will present our information sources, and the procedures that we have accomplished to adapt them into a single and comparable database to perform panel estimation of equation (4) per UPZs.

4.1 Land Prices per M^2

The land prices per M^2 used in this research are taken from the publications of the Local Surveyors and Real Estate Business Association named *Lonja de Propiedad Raíz de Bogota*. The spatial distribution of land prices (constant COP$ 2012) is presented in the right panel of Map 1.

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[3] No one interviewed in the city government or academia claims to know why certain areas of the city have been subject to value-capture processes, while some others have been neglected. The guiding principle looks like a ‘first-come-first-served’ where development permissions requests after the enactment of the LVDT determined their inclusion in the strategy.

[4] Some critics argue that the strategy has been expensive to implement and it does not pay its own collection costs. Vejarano (2007) has shown that it has already more than paid these costs, and moreover, collection is not the reason for having created it in the first place.

Lonja produces an annual book that reports land prices per zone for different land uses in the city. It was first published in 1988 and yearly since then and onwards and constitutes a unique source of information in the Latin American context[5]. This information is based upon appraisals that all of the *Lonja* associates make during the corresponding year, and it is classified by zone. In the left panel of Map 1 we represent the *Lonja* Zones, their type, location and extension, against the background of the already introduced 117 city UPZs.

The use of appraisals in real estate research has sometimes been criticized, since it is argued that they tend to lag market prices, miss turning points and smooth out volatility[6]. More recently, Devaney (2014) did not find particular advantages in the use of transaction-based information when compared with appraisal-based information for a range of European markets. The bulk of work on smoothing has focussed on commercial real estate indices. Sirmans and Slade (2011) have found that transactions-based land price indices for the USA Granger cause S&P/Case-Schiller and the Davis-Heathcote/Lincoln Institute series. The Lonja values are based on evidence of observed land transactions in the area: we would note that one of the original formulations of the smoothing issue, Quan & Quigley (1991) makes the point[7] that smoothing may be rational behaviour for appraisers given that observed transaction prices may be noisy signals of underlying fundamental value. Moreover, since the focus of the study here is relative price differences across times and zones, the Lonja values form a consistent set of indicators for our purpose.

Lonja (2010) uses a classification of its zones according to the expected or dominant use for the appraised land but they do not cover the entire urbanized area of the city, as we can see in Map 1. This is because they consider that their 129 zones are representative of all the city land uses and those areas which are the most active real estate markets.

Because of the lack of spatial coverage of this source of information, extreme differences and over-representation of high income residential and commercial areas, we cannot use the

[5] We may add that this source of information might slightly differ from cadastral registries because it is commercially oriented. In this sense it is thought to be a more accurate approach to yearly market dynamics, as recognized by local researchers on the subject (see e.g. Jaramillo, 2004).

[6] For recent reviews of the appraisal smoothing issue see, for example, Bond *et al.* (2012) who provide evidence that index level smoothing overstates the extent of smoothing at individual property level, or Lizieri *et al.* (2012) who discuss the time-varying nature of smoothing processes, as do Cho *et al.* (2014) who argue that on average smoothing is close to zero but increases sharply in extreme market environments.

[7] A point largely ignored in the subsequent literature.

Lonja information directly. Furthermore, much of the additional information required for modelling is available consistently at Spatial Planning Unit (UPZ) level. The prices are thus spatially averaged over the UPZs and represented in Map 2 for two years: 2000 and 2010[8].

[Map 2 about here]

In Map 2 it can be seen that while we still do not reach 100% spatial coverage, this characteristic has increased relative to Map 1. The averaging process has also moderated the influence of extreme values as they are now embedded within the average for larger spatial units. We have a spatial panel structure for 86 UPZs in the period 2000-2010[9].

4.2 Value Capture

Not all of the UPZs in the city have been subject to the LVDT charge because operation of the legal procedure to create the capture zones has been slow. The City Planning Department (SDP) created a special section to appraise the properties and calculate the tax, and every case so treated was publicly presented on their website. A summary of the cases can be consulted for 2004, 2005, 2006, 2007 and 2008[10].

There are no explicit published selection criteria for where planning authorities chose value-capture cases and the corresponding UPZs, for in the long term it is expected that the entire city will be included in the strategy. We represent this variable in Map 4 where the spatial randomness of the year when each UPZ was brought into the strategy can be appreciated. The UPZs covered every year increased from 12 in 2004, to 30 in 2005, 39 in 2006, 41 in 2007 and 42 in 2008 and onwards[11].

[8] This strategy has also been used by local researchers when using this information source (Garza, 2005).

[9] The city-average land price time series resulting from these prices per UPZs follows an extremely similar pattern to the city-average calculated directly from the *Lonja* information, even though the series from the averaged prices per UPZs shows values about half those of the one that directly averages *Lonja* zones. This is a good characteristic of the information per UPZ, as it has almost identical land prices trends and mean deviations but moderates the number of high-price cross-sectional units in a panel estimation.

[10] During the years 2009-10, the strategy remained in operation and we had access to the aggregate amounts collected. However, the specific cases were not publicly presented on the website of SDP. We are forced to assume that the UPZs under the strategy remained the same, which does not seem unrealistic, given the deceleration in the incorporation of UPZs into the strategy. Compare the change from 12 to 39 in 2004-2006, with 39 to 42 in 2006-2008

[11] The Moran's I (0.127) of the year of adoption of value-capture per UPZ was non-significant (p-value = 0.322). This is another way to approach its spatial randomness.

[Map 4 about here]

The tax rate also changed over time, increasing from 30% in 2004, to 40% in 2005, and 50% from 2006 onwards. For analytical purposes, the onset of charging the tax in a UPZ must cause its incorporation into developers' and land owners' balance sheets and, if the theory is correct, it will force the former to diminish their willingness to pay land rent and the latter will have to accept this reduction. In addition, in equation (4) the higher the rate the greater the impact, so a negative relationship is expected between the LVDT rate (τ_{it}) and land prices.

4.3 Other theory-driven variables

These are the other variables that are included in the equation (4) and where we have an a priori expected sign of their effect on the land prices. These variables are:

Building Output Following equation (4), we need the building output per UPZ i and period t. We will use the total amount of square metres built as reported in the yearly construction census from 2000 to 2010, available in the section *Inventario Estadistico* of the SDP website. This variable represents the Building Output per UPZ and per year, a variable that very much resembles q_{it} in equation (4). Map 3 shows this information spatially for the years 2000 and 2010[12].

[Map 3 about here]

Floor-to-Area ratio (FAR): We use the cadastral database of the city for the year 2009, composed of 887,778 plots of land. The information includes land and built area per plot, so that we can calculate the FARs per block, for the 44,535 blocks in the city. This information is then averaged per UPZ so that it is compatible with the land prices database and used as a cross-section variable in the estimation of equation (4). We expect it to be positively associated with land price.

[12] It is worth considering that the construction census is carried out on both formal and informal development sites, when they reach a size that can be visually detected by census bureau inspectors (both street level and with aero photographs). Because of these characteristics, the information proxies well the building output, regardless being a city with some degree of informal development.

Land Availability: This is the relative abundance of non-used land per UPZ as a proxy for L_{it} in equation (4). We will use the Urban Fill, defined as the $Urban\ Land/Total\ Land$ per UPZ as presented for the year 2000 in the website of SDP. This variable will be weighted by the population in each zone in each year divided by its own level in 2010[13]: $Population_{i,t}/Population_{i,2010}$. The resulting variable will be named Urban Fill per Population (UFP) and, in order to produce the Land Availability variable of equation (4), we will use $(1 - UFP)$. We expect it to be negatively associated with land price.

Distance: In order to proxy the differential land rents structure of the city, we use a land price gradient as extracted from traditional urban land economics theory, and also a cubic spline function (Muniz et al., 2003). This approach relies on the idea that Bogota seems to be changing its land prices spatial structure, from a traditionally mono-centric (Villamizar, 1981), to a moving mono-centric (Roda, 1999), and then a proper poly-centric structure (Avendaño and Henriquez, 2012). The CBD in our land price gradient estimations is the High Building District located in the traditional downtown. The knots for estimating cubic spline price functions for each one of the UPZs will be the two closest sub-centres as identified by the 2000 Master Plan.

Built Environment Price: The element $(P_{it} - c_t)$ in equation (4), requires information about built environment prices per UPZ and period, and construction costs which we consider common to all the construction industry in the city. However, it was impossible to assemble a data series of built environment or at least housing prices that can be exactly comparable with the land prices structure per UPZs as already defined. The best approach we have been able to produce is by using the Newly Built Housing prices per m^2 per UPZ extracted from the local housing journal: *La Guía Inmobiliaria*. This source has also been used by authors like Garza (2007), and by the National Economic Advisory Department (DNP) to build their non-spatial Newly Built Housing Prices Index per cities. The journal has a homogenous structure of its adverts, with prices and sizes of typical units in newly built housing projects in the city on a monthly basis and without discontinuities since 1992. We collected 17,522 adverts for the period 2000-2010. Unfortunately not all the UPZs report housing prices in all of the years, making it impossible to calculate the element $(P_{it} - c_t)$. In addition, there is no necessary coincide of UPZs with house price information in all years with the ones that report

[13] The smallest available spatial units with population information per year are the so-called localidades. The city is divided into nineteen of them, and they contain all the UPZs.

land prices in Map 2 and vice-versa. For this reason we will use this variable only when both databases report information for each one of the UPZs.

4.4 Control Variables

Other spatial and panel variables have been added to the analysis in order to fulfil the role of controls. These variables are described below, together with their expected impact on land prices.

Home Burglary: This variable has been calculated yearly per *Localidad*, which was the smallest spatial unit with information available. It is the total amount of burglaries per *Localidad* divided by the population, in order to reflect the relative safety hazard per geographical area and period, and it should have a negative impact on land prices. The source is *Observatorio de Seguridad* from the website of the Bogota Chamber of Commerce. This tends to be higher in the impoverished south and western peripheries than in higher income neighbourhoods.

Estrato: This is the spatial classification of the neighbourhood conditions according to the National Census, and determines the rates used when pricing public utilities in different zones. The city (and the country) is divided into six *estratos*, defined by the characteristics of the façade of the buildings and the neighbouring amenities and facilities. The lowest status *estrato* is one and the highest is six. This variable has been included as the average urban surface of the UPZs in each one of the *estratos*. It is, in this sense, a pure cross-section geographically weighted average per UPZ, and we expect higher status Estratos to be positively associated with land prices.

Planning Controls We will use the percentage urban area ruled as belong in certain use or treatment by the corresponding zoning ordinances per UPZ according to the Master Plan 2000. We do not know a priori the expected sign of the effect of these variables on the land prices, and because of this reason they will be introduced as pure regression controls following stepwise selection procedures. According to the Master Plan 2000, development (or its absence) in different areas of the city was going to be driven by two types of actions: Treatments and Zoning.

Treatments: Policy actions to encourage or forbid development per block and/or block fraction. In some cases they include specific infrastructure investments and/or micro-planning strategies such as property tax amnesties: Consolidation, Recuperation, Special Urban Areas, Development, Betterment, and Re-Development.

Zoning: Traditional planning tool that determines land uses per block and/or block fraction: Residential, Industrial and Warehouse, Facilities, Commerce and Services, Central Core, Integral Urban Area, Mining – Leather, Green Areas.

A summary of the variables, original sources, and adaptation process to a panel structure is presented in Table 1. Descriptive statistics of the variables are presented in Table 2.

[Table 1 about here]

[Table 2 about here]

5. EMPIRICAL STRATEGY AND TESTS

Equation (4) describes a panel structure where some of the UPZs applied the LVDT from 2004 onwards. This structure resembles a policy change analysis, which implies use of a Difference in Differences (DiD) estimation.

Unfortunately the DiD analysis requires no variation of the units with and without policy during the period of analysis, and this characteristic does not hold for our database; the UPZs with the policy vary per period. Thus we focus instead on panel estimations with and without spatial controls.

Spatial panel estimations have been gaining importance in urban economic analyses, regardless of intellectual disagreements about the correct specification of the spatial controls. The reason is that in correctly specified models, these spatial effects are expected to capture non-theoretical spatial interrelationships while leaving untouched the theoretically expected relationships between the variables.

5.1 Spatially and Non-Spatially Controlled Panels

A non-spatial specification of the panel model suggested by Equation (4), including control variables, is presented in Equation 5:

$$Land\ Price_{it} = \alpha + \beta X_{it} + \theta D_i + \delta Y_{it} + \mu_{it} \quad (5)$$

where the land price per UPZ is a function of X_{it} explanatory variables per UPZ as already defined in equation (4), D_i are distance related variables, Y_{it} are control variables, and μ_{it} the vector of panel error terms.

As we already know that the land price spatial distribution must be explained by theoretically driven mono-centric or cubic-spline price functions, we will not use spatial lags of the land prices as spatial controls in our panel estimation. However, as we do not know the structure of the remaining spatial impacts between UPZs, it is prudent to use spatial panel error terms. This is because spatial lags might interfere with the already defined spatial structure or be redundant, while spatial errors capture the spatial land prices variation not due to mono-centric or cubic-spline price functions (La Sage and Pace, 2009).

The type of estimation presented is a Spatial Error Model (SEM) which, when used in a panel context, requires a time-expanded version of the spatial matrix W_N. The one used is that produced by the Kronecker product, pre-multiplying it by the T number of periods: $W_{NT} = I_T \otimes W_N$. Another particularity of the panel SEM is that the errors may have time, space, and time-space variation. This then requires the assumption that the spatial effects remain constant across time, making it impossible to use fixed or random effects panel estimation. In fact, as some of the independent variables (FAR, distance, planning) are purely cross-sectional, it would be impossible to estimate a fixed effects model and consequently there would also be no comparison model for a random effects estimation (Anselin et al., 2008).

Given these characteristics we can proceed to a direct representation of the errors by considering that their covariance between two different zones is a direct function of the geographical distance that separates them:

$$E\left[\varepsilon_{ij}\varepsilon_{ij}\right] = \sigma^2 f\left(d_{ij}\right) \quad (6)$$

Where σ^2 is variance, d_{ij} the distances between every pair of UPZs, and f is an unknown distance-decaying association function that relates them. The most general (and simple) panel SEM estimation assumes a linear relationship between the panel errors mediated by the spatial weights matrix (Anselin et al., 2008):

$$\begin{gathered} Land\ Price_{it} = \alpha + \beta X_{it} + \theta D_i + \delta Y_{it} + \varepsilon_{it} \\ \varepsilon_{it} = \rho W_{NT} \varepsilon_{it} + \mu_{it} \end{gathered} \quad (7)$$

The corresponding estimation is performed for the 86 UPZs where all the information available could be used simultaneously; we also add land prices for 1999 in order to generate the element $(r_{it} - r_{it-1})$ for 2000. In this section, we do not use the variable $ln(P_{it} - c_t)$ or its simplified form as Housing Prices, due to the already explained lack of coincident information per UPZs and years between this variable and Land Prices. It will be used in the next section as a corroboration of the general results.

According to equation (4), natural logarithms of all the variables are used and all the relationships can be interpreted as elasticities. LVDT Rate, Land Availability, and Planning Variables include non-transformable zero values and their relationship with Land Price are log-linear.

According to La Sage and Pace (2009), in the estimation of any spatially lagged model we need to use Full Maximum Likelihood estimation (FML), because of the spatial correlation of the errors. The results for six different model specifications are reported in Table 3. The selection of the planning controls (treatments and uses) variables was made following a stepwise procedure using the four with the best fit in each one of the models.

[Table 3 about here]

In Table 3 the models P1 to P3 do not use spatial errors, while models P4 to P6 introduce them. In both groups of models we include options with and without differential land rents functions (gradient and cubic-spline)[14].

[14] These distance parameters were always significant and had their expected signs. Outputs without controls and zoning controls, exclusion of other variables, and the yearly price difference produced broadly similar results in all the specifications, but are not included here due to space constraints. These can be provided upon request by the authors.

The LVDT rate impact was always negative and significant in all of the models in Table 3, regardless of specification. This result is evidence of static market-neutrality, while Building Output, FAR, Land Availability, and Price Difference had their expected signs and were always significant. The test of redundant variables never rejected the use of these variables in each specification.

We can approximate the relative impact of the LVDT rate on land prices by calculating the combined effect of the increasing Price Difference and the decreasing LVDT rate on each UPZ price. The effect was a land price decrease of between 18% and 25% in the different specifications. This does seem a reasonable LVDT rate effect, as the tax rate ranged between 30% and 50% during the research period, and we already discussed above that the Price Difference in equation (4) is higher than the pure land value increase due to public intervention. This value seems reasonable when compared to our most immediate academic reference, Ihlandfeldt and Shauggnessy (2004), who found that in Dade County each $1 of Impact Fee decreased land prices by approximately $1. Our estimation however falls short of Borrero (2007) who found LVDT application negative impacts of even 200% on price change in Bogota, a difference that we accrue to our more compelling spatial and temporal specification.

By following Akaike and Schwartz criteria, the favoured models are P3 and P6, where the cubic-spline price function was used. Models P2 and P5, both with a traditional price gradient also performed well. The results show that the spatial errors effect was positive and significant and did not control any of the other variables.

In spite of these good results, we must recognize that Building Output might have an important degree of endogeneity to Land Price, precisely mediated by the LVDT. This is an important discussion as, according with Rose (1973, 1976), even a well-designed LVDT may accelerate or decelerate development timing and consequently, the Building Output.

In order to overcome this potential endogeneity problem we will perform a system estimation of the test. Solving the Equation (4) for Building Output and replacing $ln(\Delta r_i)$ with $ln(\Delta q_i)$, we have:

$$lnq_{it} = lnr_{it} - ln(P_{it} - c_t) - lnFAR_i + lnL_{it} + lnD_i - ln\tau_{it} + ln(\Delta q_{it}) \quad (8)$$

Equation (8) might have collinearity problems when used in a system context together with equation (4). Therefore, we use spatial lags of all the other theory-driven variables (Land Price, FAR, Land Availability), except for the tested LVDT Rate. This results in the following System Panel SEM:

$$\begin{gathered} Building\ Output_{it} = \gamma + \lambda W_{NT} Z_{it} + \upsilon_{it} \\ Land\ Price_{it} = \alpha + \beta X_{it} + \theta D_i + \delta Y_{it} + \varepsilon_{it} \\ \varepsilon_{it} = \rho W_{NT} \varepsilon_{it} + \mu_{it} \end{gathered} \tag{9}$$

where the Building Output equation has the Z_{it} variables presented in equation 8, and then its predicted value is introduced within the X_{it} variables for the Land Price equation. υ_{it} are the panel error terms of the Building Output equation, but only the ε_{it} panel error terms of the Land Price equation will be used in the SEM estimations.

The results using System Panel SEM are presented in Table 4. Once again models S1 to S3 do not have spatial errors, while models S4 to S6 use them.

[Table 4 about here]

The main results from Table 3 hold in Table 4; once again models S3 and S6, using the cubic-spline price function, are favoured when using Akaike and Schwartz criteria. The LVDT rate impact on Land Prices was negative and significant in all the specifications, while Building Output, FAR, Land Availability and Price Difference were always significant and had their expected signs. The impact of the LVDT rate on prices ranged from 21% to 30%, similar to the single equation results, but increasing in accuracy.

Another result that holds in Table 4 is the neutrality of the spatial errors, because they were always positive and significant but did not alter the other variables' signs or significance. We can assert that the negative impact of the LVDT on Land Prices implies its dynamic-neutrality, because its effect on Building Output has already been discounted in the system estimation. At the same time all the other theoretically expected relationships are holding, evidence that this model of the Bogota spatial-temporal urban land market 2000-2010 is reasonably good as an estimation framework for assessment.

5.2 Spatially and Non-Spatially Controlled Unbalanced Panels

As already explained, it was impossible to assemble a database of housing or built environment prices per UPZs that could be fully comparable for all of the years with the Land Prices information and with the construction costs. This is why in order to use the element lnP_{it} from Equation (4) we will have to estimate an unbalanced panel. The problem with the inclusion of this variable is that, not only that we will lose some of the panel observations, but that we will have to deal with an unbalanced spatial weights matrix.

We need to make amendments to the structure proposed in Equation (7) as, from the spatial weights matrix, we will eliminate the rows and columns representing the UPZ-Year where no Housing Price was collected. The new estimations are performed with only 505 observations and reported in Table 5.

[Table 5 about here]

In Table 5 we can see that after the introduction of the Housing Prices the effect of LVDT remains negative and significant, while Building Output, FAR, and Price Difference remain positive and significant. The Spatial Errors effect remains positive, and the introduction of the theory variables was never rejected according to the redundant variables test.

According to the Akaike and Schwartz criteria, our favoured models are still HP3 and HP6. Housing Price was always positive and significant, and it has not changed any of the above mentioned results, but it has controlled Land Availability in all of the specifications, and the constant in models HP2, HP3, HP5, and HP6.

In order to be sure that Land Availability is being controlled by Housing Price and not just rejected by the absent observations in the unbalanced panel, we also performed the corresponding regressions excluding the same observations and the Housing Price. Those results showed that it is the Housing Price and not the lacking observations, which controls for Land Availability. We think that this problem is due to the fact that in the most peripheral UPZs, the Land Availability variable is larger but decreasing faster than the city average, while at the same time in these UPZs the Housing Price is lower but increasing faster.

In this section, we also correct for possible endogeneity between Building Output, Land Price, and LVDT rate, by using a system estimation, shown in Table 6. The results again support the hypothesis of market neutrality because the LVDT rate impact on land prices is negative, while Building Output, FAR, Price Difference, and Housing Price effects are always positive. Land Availability is still controlled by the Housing price, regardless of the endogeneity correction. Consistent with the prior analyses the favoured models are the cubic-spline price function models HS3 and HS6; as before, models HS1 to HS3 did not have spatial errors, but models HS4 to HS6 do.

[Table 6 about here]

6. CONCLUSIONS

A pure land tax is an ideal source of public finance; however it is an almost unattainable policy because of legal and technical problems. A Land Value Development Tax (LVDT) is an alternative that is charged when regulatory or infrastructural interventions increase land prices.

The Colombian version of value-capture, (*Captura de Plusvalia)* is an LVDT. The way it has been applied offers a quasi-experimental setting with clearly determined pre and post-tax periods, plus time but not cross-section varying rates, and a non-strategic spatial application agenda. These characteristics have permitted us to design a spatial panel testing framework that resembles a simplified spatial urban land market for a large developing country city. These characteristics give a unique character to our research in the international literature on land markets, regulation, and taxes.

In order to make an empirical assessment of the LVDT, we took into account the fact that it may not be as market neutral as the pure land tax because of its effect on development timing (Rose, 1973), or because of its lack of application in all of the spatial units in a region (Brueckner, 1986). In fact our case study has this last characteristic, and it has a spatially scattered and time-varying application. Because of these characteristics, we could not perform a policy assessment using Difference in Differences estimation, but rather use panel models to test the impact of the LVDT on land prices.

We performed single and multi-equation spatial and non-spatial specifications of the panel tests about the impact of LVDT on prices, including and excluding land prices functions. In all of the estimations the effect of the LVDT on prices was negative, while the underlying urban economy models always performed in a manner consistent with theory. These results are congruent with our policy claim that the LVDT is market neutral.

The neutrality of the LVDT was also extended to its dynamics, finding no evidence that it changed Building Output in the UPZs where applied (as per Rose, 1973), and nor was there evidence of feedback spatial general equilibrium effects on the land prices (as per Brueckner, 1986).

The first result was produced by using a system estimation, where the possible endogeneity between the Land Price, Building Output, and LVDT rate, was controlled. The second result was produced using specifications including panel spatial errors; unfortunately their use limited our possibilities of trying more compelling estimation techniques (fixed effects). We may add however, that some of the variables in the database are pure cross-section and already limited these estimation options. Future research on the area would require extending the database into past periods, so that we can overcome this limitation, at least in non-spatial panel analysis.

BIBLIOGRAPHY

Anas, A; R. Arnot and K. Small (1998), *Urban spatial structure*. Journal of Economic Literature 36 – 3, 1426-1464.

Anselin, L.; J. Le Gallo and H. Jayet (2008), *Spatial panel econometrics*. In Matyas, L. and P. Sevestre (eds), *The Econometrics of Panel Data: Fundamentals and Recent Developments in Theory and Practice*. Springer-Verlag Heidelberg, Berlin.

Arnott, R. and J. Stiglitz (1979), *Aggregate land rents, expenditure on public goods, and optimal city size*. Quarterly Journal of Economics 93, 471–500.

Avendaño, A. and H. Henriquez (2012), *Polycentric structure and the co-agglomeration of economic activities in Bogota: A nonparametric perspective*. Universidad Sergio Arboleda – Escuela de Economía.

Bachis, B; G. Duranton and M. Turner (2011), *The effects of land transfer taxes on real estate markets: evidence from a natural experiment in Toronto*. Journal of Economic Geography 12 – 2, 327-354.

Bond, S., Hwang, S. and Marcato, G. (2012) *Commercial Real Estate Returns: An Anatomy of Smoothing in Asset and Index Returns.* Real Estate Economics, 40 – 4, 637-661.

Borrero, O. (2007), *The Effects of Land Policy on Urban Land Prices in Bogotá*. The Lincoln Institute of Land Policy, Working Paper LPZ00C89.

Borrero, O. and E. Duran (2010) *Effects of Land Policy on the Price of Undeveloped Urban Land in Colombia: The Cases of Bogotá, Medellín and Pereira*. The Lincoln Institute of Land Policy WP10OB1.

Brueckner, J. (1986), *A modern analysis of the effects of site value taxation*. National Tax Journal 39 – 1, 49-59.

Cho, Y., Hwang, S. and Lee, Y. (2014) *The Dynamics of Appraisal Smoothing.* Real Estate Economics 42 – 2, 497-529.

Delgado, A. and M. Perló (2000), *El Estado del Conocimiento sobre el Mercado del Suelo Urbano en México*. El Colegio Mexiquense. Zinancantepec, México.

Devaney, S. (2014), *Measuring European property investment performance: comparing different approaches*. Journal of European Real Estate Research 7 – 1, 112-132.

Evans, A. (1983), *The determination of the price of land*. Urban Studies 20 – 2, 119-129.

Fernandes, E. (2011), *Regularization of Informal Settlements in Latin America*. Policy Focus Report – The Lincoln Institute of Land Policy. Cambridge, MA.

Foster, C. and S. Glaister, (1975), *The anatomy of a development value tax*. Urban Studies (1975), 10, 213-218.

Franzsen, R (2005), *The property tax in South Africa*, 147-188. McCluskey W. and R. Franzsen (eds), *Land Value Taxation: An Applied Analysis*. Ashgate Publishing Limited.

Garza, N. (2007), *Desempeño del mercado de vivienda nueva en Bogotá 1992-2004*. Cuadernos de Economía 26. 23-52.

Garza, N. (2005), *Precios del suelo en Bogotá: crecimiento versus especulación*. Territorios 13, 133-154.

Ihlanfeldt, K. (2007), *The effect of land use regulation on housing and land prices*. Journal of Urban Economics 61 – 3, 420-435.

Ihlanfeldt, K. and T. Shaughnessy (2004), *An empirical investigation of the effects of impact fees on housing and land markets*. Regional Science and Urban Economics 34 – 6, 639-661.

Jaramillo, S. (2004), *Precios inmobiliarios en el mercado de vivienda en Bogota 1970-2004*. Documentos CEDE 10 – Universidad de los Andes.

Lauridsen, J.; N. Nannerup and M. Skak (2013), *House prices and land regulation in the Copenhagen are*a. Journal of Property Research 30 – 3, 205-220.

Le Sage, J. and K. Pace (2009), *Introduction to Spatial Econometrics*. CRC Press – Taylor and Francis Group, Boca Raton FL.

Lizieri, C., Satchell, S. and Wongwachara, W. (2012) *Unsmoothing Real Estate Returns: A Regime-Switching Approach*, Real Estate Economics, 40 - 4, 775-807.

McLaughlin, R. (2012), *Land use regulation: where have we been, where are we going?* Cities 29 – 1, S50-S5.

Muniz, I.; A. Galindo and M. Garcia (2003), *Cubic spline population density functions and satellite city determination: the case of Barcelona*. Urban Studies 40 – 7, 1303-1321.

Needham, B. (1981), *A neo-classical supply-based approach to land prices*. Urban Studies 18 – 1, 91-104.

Neutze, M (1974), *The development value tax: A comment*. Urban Studies (1974), 11, 91-92.

O'Sullivan, A; T. Sexton and S. Sheffrin (1995), *Property Taxes and Tax Revolts*. Cambridge University Press.

Oates, W. and Schwab, R. (1997), *The Impact of urban land taxation: the Pittsburgh experience*. National Tax Journal, 1-21.

Plassman, F. & Tideman, N. (2000), *A Markov chain Monte Carlo analysis of the effect of two-rate property taxes on construction*. Journal of Urban Economics 47-2, 216-247.

Quan, D. and Quigley, J. (1991), *Price Formation and the Appraisal Function in Real Estate*. Journal of Real Estate Finance and Economics 4 – 2, 127–146.

Roda, J. (1999), *Precios del Suelo y Formacion de la Renta en Santa Fe de Bogota*. Observatorio de Dinámica Urbana, DAPD-SECI.

Rose, L. (1973), *The development value tax*. Urban Studies (1973), 10, 271-275.

Rose, L. (1976), *The development value tax: reply*. Urban Studies (1976), 13, 71-73.

Sirmans, C. and B. Slade (2011), *National transaction-based land price indices*. Journal of Real Estate Finance and Economics 45, 829-845.

Sokoloff, K. (2012), *Economic Development in the Americas since 1500: Endowments and Institutions*. Cambridge University Press, New York.

Vejarano, M. (2007), *Bogotá, D.C. Primera experiencia de recuperación de la plusvalía urbana para la colectividad, en el marco de la ley de desarrollo territorial*. En: Vejarano, M. ed. (2007). *Movilización social de la valorización de la tierra: casos latinoamericanos.* Lincoln Institute of Land Policy Cambridge, Massachussets. CD Rom.

Villamizar, R. (1981), *Comportamiento de los precios de la tierra, sus determinantes y sus efectos sobre la estructura urbana*. Corporacion Centro regional de poblacion, Bogota.

Wildasin, D. (1988), *Urban public finance*. *Harwood Fundamentals of Pure and Applied Economics*. Routledge – Taylor and Francis Group. London.

Table 1: Summary of variables adaptated to an 86 UPZ, 2000-2010 panel Structure

Variable	Type	Final Spatial Precision	Original Spatial Precision	Source	Units
Land Price	Panel (Interpolation 2006-2007)	UPZs	*Lonja* Zones (sets of blocks)	*Lonja de Propiedad Raíz*	2012 COP$ per M^2
Building Output	Panel	UPZs	UPZs	SDP website	Square Meters
FAR	Cross-Section	UPZs	Property Plot	Cadastral census	Private Space/Plot of Land
Land Availability	Panel	UPZs	UPZs and *Localidad*	SDP website	Percentage
LVDT Rate	Panel	UPZs	Set of Blocks	SDP website	Rate
Diff. Land Price	Panel	UPZs	*Lonja* Zones (sets of blocks)	*Lonja de Propiedad Raíz*	First difference of logarithms
Distance to CBD	Cross-Section	UPZs (centroid)	UPZs	City Cartography	Decimal Degrees
Distance to Knots					
Housing Price	Panel	UPZ	Block	Own collection from *La Guía Inmobiliaría*	2012 COP$ per M^2
Home Burglary	Panel	*Localidad*	*Localidad*	Chamber of Commerce website	Events / Population
Estrato	Cross-Section	UPZs	Block	City Cartography	Spatially Weighted Average (Hypothetical range: 1 to 6)
Land Use Treatments	Cross-Section	UPZs	Sets of Blocks and/or Block Fraction	City Cartography	Spatially Weighted Average (urban land use)
Land Use Zoning					

Table 2: Descriptive statistics (946 observations)

Variable	Mean	Std. Dev.	Max	min
Land Price	636,830	614,920	4,550,235	122,818
Building Output	231,397	321,748	2,397,892	1
FAR	0.63	0.40	1.62	0.01
Land Availability	0.17	0.16	0.71	0.00
LVDT Rate	0.09	0.19	0.50	0.00
Diff. Land Price	35,804	172,477	2,342,048	-2,217,963
Distance to CBD	7,601	3,796	15,634	1
Housing Price (n = 505)	1,587,255	850,114	5,057,729	454,361
Home Burglary	83.55	78.58	605.38	2.85
Estrato	2.22	1.05	5.40	1.42
Land Use Treatments				
1. Consolidation	0.03	0.11	0.92	0.00
2. Recuperation	0.58	0.36	1.00	0.00
3. Special Urban Areas	0.19	0.30	0.94	0.00
4. Development	0.03	0.09	0.57	0.00
5. Betterment	0.16	0.23	0.98	0.00
6. Re-Development	0.00	0.00	0.00	0.00
Land Use Zoning				
1. Residential	0.54	0.33	0.99	0.00
2. Industrial and Warehouse	0.06	0.16	0.87	0.00
3. Facilities	0.10	0.15	0.95	0.00
4. Commerce and Services	0.09	0.18	0.77	0.00
5. Central Core	0.03	0.14	0.98	0.00
6. Integral Urban Area	0.13	0.19	0.85	0.00
7. Mining – Leather	0.01	0.05	0.45	0.00
8. Green Areas	0.02	0.07	0.41	0.00

Table 3: FML Panel SEMs for 86 UPZs 2000-2010 (946 Observations)

		P1	P2	P3	P4	P5	P6
	Constant	11.472 ***	11.984 ***	12.205 ***	11.459 ***	11.917 ***	12.153 ***
		0.144	*0.210*	*0.298*	*0.143*	*0.208*	*0.291*
Test Variables	Building Output	0.055 ***	0.067 ***	0.065 ***	0.052 ***	0.061 ***	0.059 ***
		0.010	*0.009*	*0.009*	*0.009*	*0.009*	*0.008*
	FAR	0.069 ***	0.067 ***	0.086 ***	0.075 ***	0.068 ***	0.092 ***
		0.013	*0.012*	*0.012*	*0.013*	*0.012*	*0.011*
	Land Availability	-0.759 ***	-0.729 ***	-0.754 ***	-0.554 ***	-0.549 ***	-0.495 ***
		0.159	*0.160*	*0.141*	*0.158*	*0.164*	*0.155*
	LVDT rate	-0.280 ***	-0.298 ***	-0.229 ***	-0.271 ***	-0.277 ***	-0.206 ***
		0.080	*0.079*	*0.077*	*0.078*	*0.079*	*0.077*
	Price Diff	0.896 ***	0.887 ***	0.883 ***	0.900 ***	0.887 ***	0.885 ***
		0.087	*0.090*	*0.087*	*0.080*	*0.084*	*0.080*
	Spatial Error				0.010 ***	0.010 ***	0.012 ***
					0.001	*0.001*	*0.001*
Land Price Gradient			yes			yes	
Land Price Cubic Spline Function				yes			yes
Controls		yes	yes	yes	yes	yes	yes
Zoning Controls		yes	yes	yes	yes	yes	yes
Log-likelihood		-592	-596	-544	-571	-571	-509
Akaike		1.292	1.288	1.187	1.234	1.238	1.115
Schwartz		1.355	1.355	1.274	1.301	1.310	1.207
Redundant variables (p-value)		0.000	0.000	0.000	0.000	0.000	0.000
Regression Std. Error		0.459	0.458	0.434	0.445	0.446	0.418
LVDT rate impact on price change		-0.25	-0.26	-0.20	-0.24	-0.25	-0.18

Dependent Variable: Log Land Price per M2.

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

Standard errors in italics and under the corresponding parameter

Table 4: FML System Panel SEMs for 86 UPZs 2000-2010 (946 Observations)

		S1	S2	S3	S4	S5	S6
	Constant	11.292 ***	12.073 ***	12.031 ***	11.318 ***	12.000 ***	11.995 ***
		0.149	*0.194*	*0.305*	*0.151*	*0.196*	*0.299*
Test Variables	Building Output	0.073 ***	0.075 ***	0.083 ***	0.066 ***	0.068 ***	0.076 ***
		0.011	*0.011*	*0.009*	*0.011*	*0.011*	*0.009*
	FAR	0.070 ***	0.068 ***	0.088 ***	0.077 ***	0.076 ***	0.094 ***
		0.012	*0.012*	*0.012*	*0.013*	*0.013*	*0.011*
	Land Availability	-0.742 ***	-0.793 ***	-0.728 ***	-0.530 ***	-0.546 ***	-0.475 ***
		0.156	*0.154*	*0.140*	*0.158*	*0.161*	*0.153*
	LVDT rate	-0.313 ***	-0.337 ***	-0.265 ***	-0.301 ***	-0.304 ***	-0.240 ***
		0.081	*0.079*	*0.079*	*0.080*	*0.078*	*0.078*
	Price Diff	0.889 ***	0.895 ***	0.879 ***	0.897 ***	0.900 ***	0.881 ***
		0.086	*0.084*	*0.086*	*0.079*	*0.078*	*0.079*
	Spatial Error				0.010 ***	0.011 ***	0.012 ***
					0.001	*0.001*	*0.001*
Land Price Gradient			yes			yes	
Land Price Cubic Spline Function				yes			yes
Controls		yes	yes	yes	yes	yes	yes
Zoning Controls		yes	yes	yes	yes	yes	yes
Log-likelihood		-1,706	-1,700	-1,653	-1,682	-1,673	-1,619
Akaike		3.644	3.635	3.544	3.596	3.580	3.473
Schwartz		3.737	3.732	3.662	3.694	3.682	3.596
Regression Std. Error		0.457	0.456	0.435	0.446	0.442	0.419
LVDT rate impact on price change		-0.28	-0.30	-0.23	-0.27	-0.27	-0.21

Dependent Variable: Log Land Price per M2.
***Significant at 99%; **Significant at 95%; *Significant at 90%.
Standard errors in italics and under the corresponding parameter

Table 5: FML Unbalanced Panel SEMs for 2000-2010 (505 Observations)

		HP1	HP2	HP3	HP4	HP5	HP6
	Constant	-2.173 ***	-1.070	0.072	-1.982 ***	-1.058	0.215
		0.664	*0.753*	*0.752*	*0.665*	*0.739*	*0.744*
Test Variables	Building Output	0.041 ***	0.025 *	0.054 ***	0.049 ***	0.032 **	0.064 ***
		0.015	*0.015*	*0.014*	*0.014*	*0.015*	*0.014*
	FAR	0.093 ***	0.100 ***	0.104 ***	0.091 ***	0.097 ***	0.104 ***
		0.016	*0.016*	*0.014*	*0.016*	*0.016*	*0.013*
	Land Availability	-0.073	0.038	-0.093	0.012	0.077	-0.035
		0.213	*0.224*	*0.182*	*0.215*	*0.224*	*0.183*
	LVDT rate	-0.504 ***	-0.423 ***	-0.340 ***	-0.522 ***	-0.436 ***	-0.358 ***
		0.099	*0.100*	*0.091*	*0.097*	*0.099*	*0.089*
	Price Diff	0.614 ***	0.631 ***	0.584 ***	0.630 ***	0.637 ***	0.596 ***
		0.097	*0.093*	*0.096*	*0.095*	*0.092*	*0.095*
	Housing Price	1.017 ***	0.971 ***	0.861 ***	0.995 ***	0.962 ***	0.832 ***
		0.052	*0.052*	*0.053*	*0.052*	*0.052*	*0.053*
	Spatial Error				0.011 ***	0.007 **	0.015 ***
					0.003	*0.003*	*0.003*
Land Price Gradient			yes			yes	
Land Price Cubic Spline Function				yes			yes
Controls		yes	yes	yes	yes	yes	yes
Zoning Controls		yes	yes	yes	yes	yes	yes
	Log-likelihood	-252	-245	-199	-246	-242	-189
	Akaike	1.050	1.026	0.858	1.028	1.020	0.824
	Schwartz	1.159	1.143	1.008	1.145	1.145	0.982
	Regression Std. Error	0.404	0.399	0.365	0.399	0.397	0.359
	LVDT rate impact on price change	-0.31	-0.27	-0.20	-0.33	-0.28	-0.21

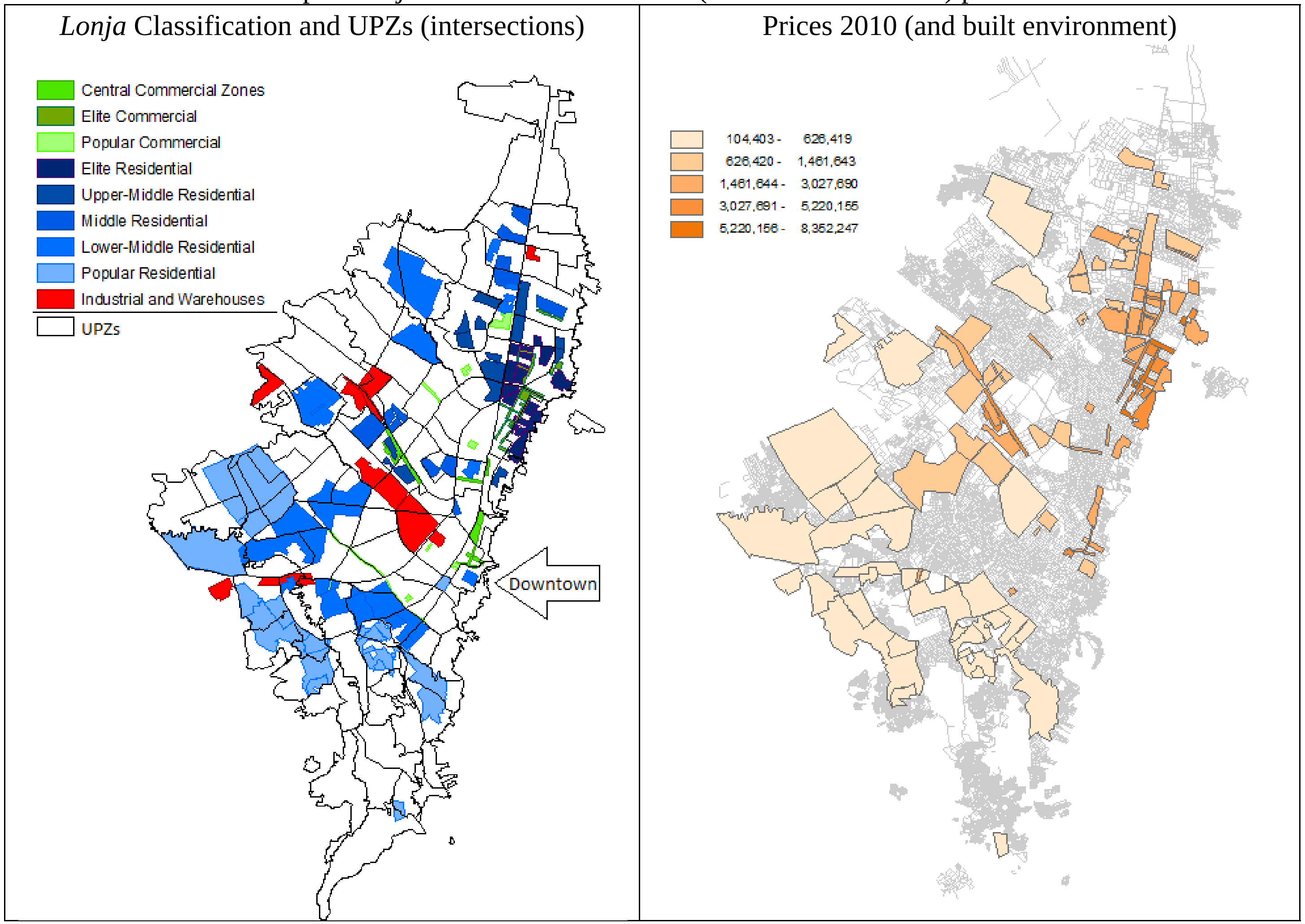
Dependent Variable: Log Land Price per M2.
***Significant at 99%; **Significant at 95%; *Significant at 90%.
Standard errors in italics and under the corresponding parameter

Table 6: FML Unbalanced System Panel SEMs for 2000-2010 (505 Observations)

		HS1	HS2	HS3	HS4	HS5	HS6
	Constant	-2.216 ***	-1.154	0.015	-2.029 ***	-1.146	0.155
		0.673	*0.773*	*0.756*	*0.675*	*0.759*	*0.751*
Test Variables	Building Output	0.064 ***	0.041 *	0.081 ***	0.070 ***	0.049 **	0.089 ***
		0.023	*0.023*	*0.023*	*0.023*	*0.023*	*0.023*
	FAR	0.096 ***	0.102 ***	0.107 ***	0.094 ***	0.099 ***	0.106 ***
		0.016	*0.016*	*0.014*	*0.016*	*0.016*	*0.013*
	Land Availability	-0.031	0.052	-0.048	0.051	0.093	0.006
		0.213	*0.225*	*0.181*	*0.216*	*0.225*	*0.182*
	LVDT rate	-0.527 ***	-0.444 ***	-0.370 ***	-0.544 ***	-0.459 ***	-0.387 ***
		0.104	*0.106*	*0.098*	*0.103*	*0.105*	*0.096*
	Price Diff	0.610 ***	0.627 ***	0.580 ***	0.626 ***	0.633 ***	0.591 ***
		0.098	*0.094*	*0.097*	*0.095*	*0.094*	*0.096*
	Housing Price	1.001 ***	0.964 ***	0.840 ***	0.981 ***	0.954 ***	0.814 ***
		0.054	*0.054*	*0.055*	*0.054*	*0.054*	*0.055*
	Spatial Error				0.069	0.007 **	0.015 ***
					0.073	*0.003*	*0.003*
Land Price Gradient			yes			yes	
Land Price Cubic Spline Function				yes			yes
Controls		yes	yes	yes	yes	yes	yes
Zoning Controls		yes	yes	yes	yes	yes	yes
Log-likelihood		-756	-751	-701	-750	-748	-691
Akaike		3.073	3.056	2.874	3.052	3.049	2.840
Schwartz		3.241	3.232	3.083	3.228	3.234	3.058
Regression Std. Error		0.405	0.399	0.367	0.400	0.398	0.360
LVDT rate impact on price change		-0.32	-0.28	-0.21	-0.34	-0.29	-0.23

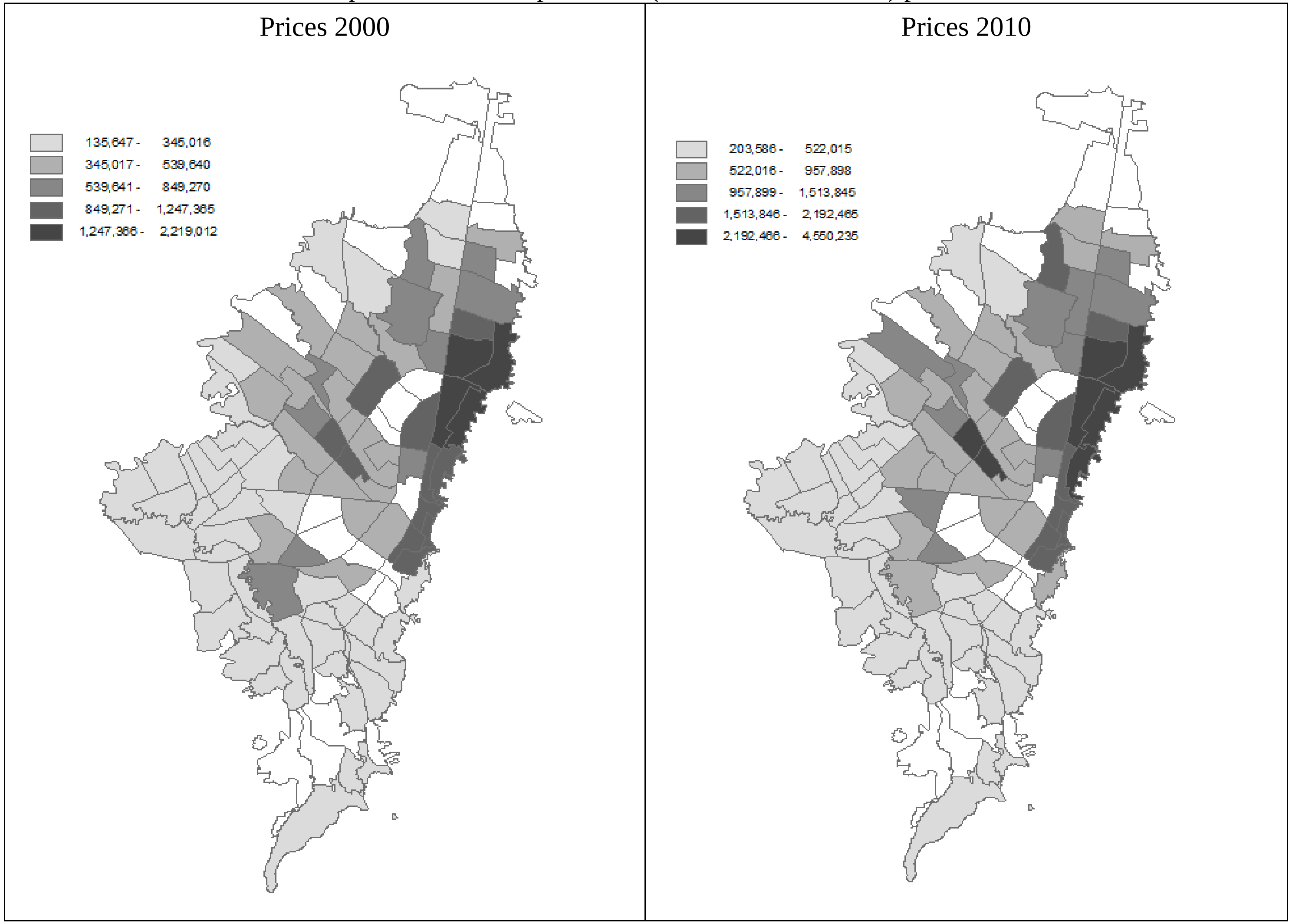
Dependent Variable: Log Land Price per M2.
***Significant at 99%; **Significant at 95%; *Significant at 90%.
Standard errors in italics and under the corresponding parameter

Map 1: *Lonja* Zones and Land Prices (constant COP$ 2012) per M^2



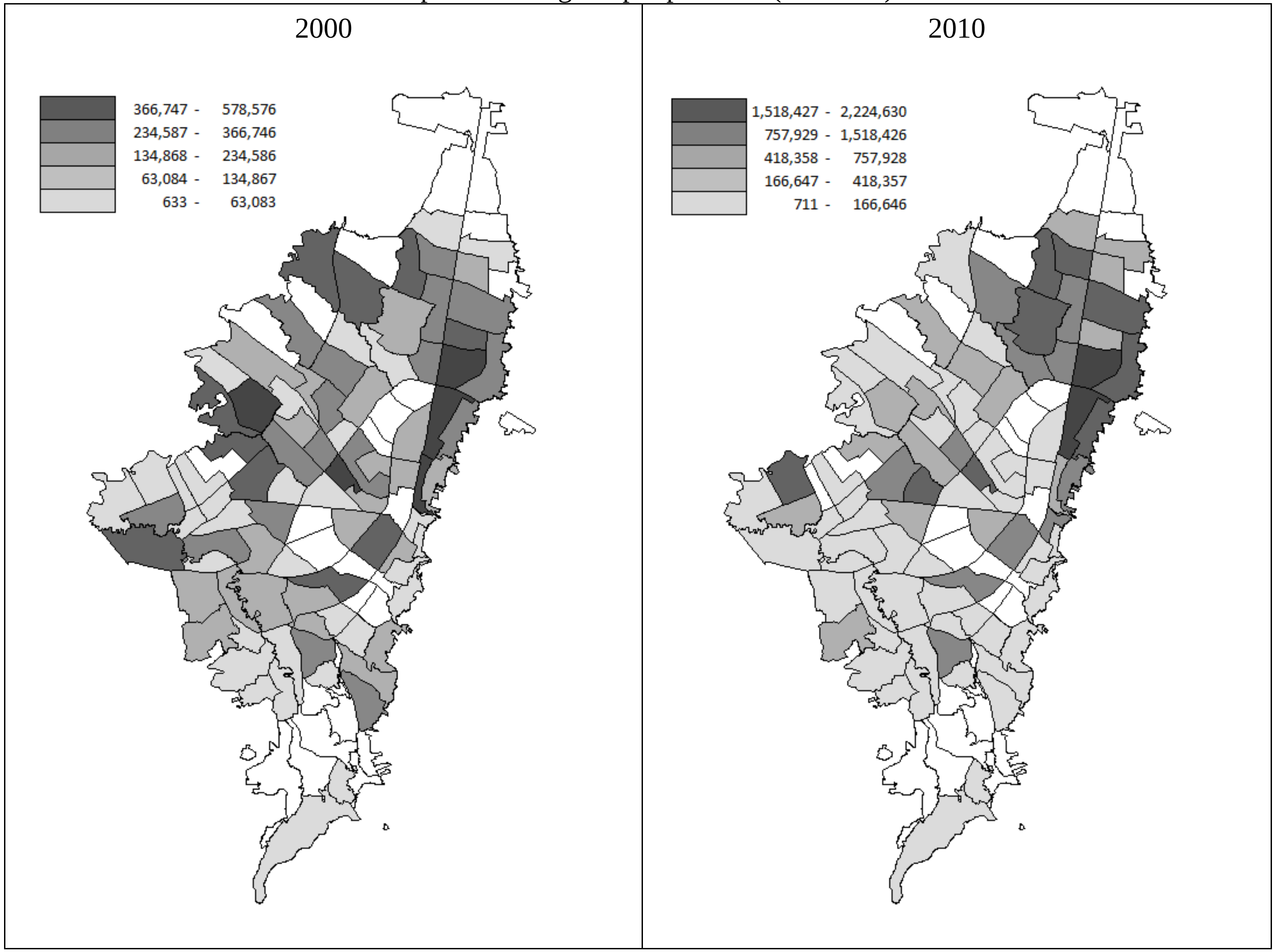
Source: Own elaboration using information by *Lonja de Propiedad Raiz* and city cartography block level.

Map 2: Land Prices per UPZs (Constant COP$2012) per M^2



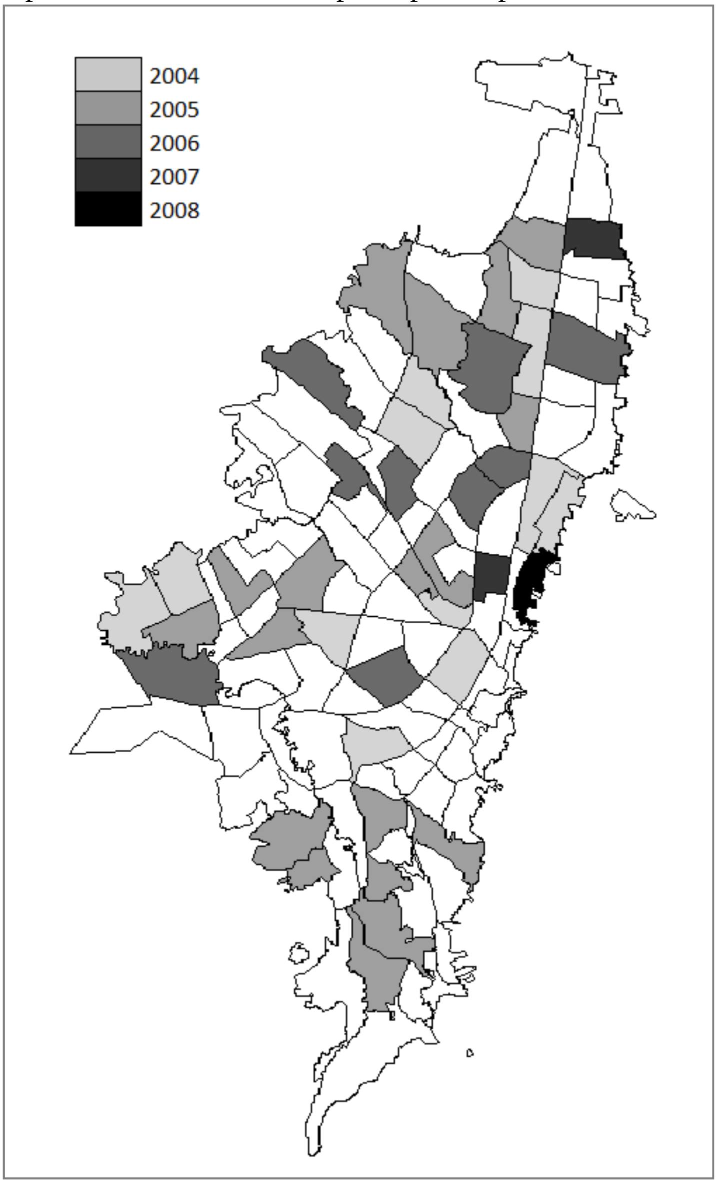
Source: own elaboration by averaging *Lonja* Zones land prices per m^2 into UPZs per year

Map 3: Building Output per UPZ (Total M^2)



Source: own elaboration using *Inventario Estadistico* in the website of City Planning Department (SDP).

Map 4: UPZs with value-capture public processes 2004-08



Own elaboration following SDP website value-capture cases