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EFFECT OF PUBLIC INFRASTRUCTURE ON URBAN LAND PRICE

CASE OF THE CITY OF CUENCA, ECUADOR[1]

EFECTO DE LA INFRAESTRUCTURA PÚBLICA EN EL PRECIO DEL SUELO URBANO
CASO DE LA CIUDAD DE CUENCA, ECUADOR

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En el presente documento se analiza el precio esperado de venta de predios urbanos versus el capital incorporado al suelo por infraestructura. Para esa tarea, se emplean los precios de oferta de mercado de 1,393 predios en la ciudad de Cuenca-Ecuador, obtenidos de anuncios en la web, inmobiliarias y letreros en sitio. Los resultados muestran que para el 95% de los predios, el capital incorporado por infraestructura representa hasta un 22.4% del precio solicitado, sin embargo, la ganancia esperada por los propietarios (precio solicitado menos capital incorporado) es alta, alcanzando como media 6.35 veces el costo de inversión. En base a la distribución espacial de los predios, se identificó que la zona del centro histórico y sus alrededores, constituye el sector donde se evidencian las mayores ganancias esperadas. Distinguir adecuadamente las áreas que captan dichas ganancias puede contribuir en la toma de decisión respecto a las políticas de recuperación de plusvalías generadas por la inversión pública.

Palabras clave: infraestructura urbana, mercado de suelo, política urbana, urbanización.

In this paper, the expected sale value of urban properties is analyzed compared to the capital incorporated to the land by infrastructure. For this task, the market prices of 1,393 properties in the city of Cuenca, Ecuador, were collected using different sources, including online ads, realtors, and for-sale signs. The analysis reveals that in 95% of the lots, the capital incorporated by infrastructure represents up to 22.4% of the asking price. However, the profit expected by the owners -expected price minus incorporated capital- is high, reaching an average of 6.35 times the investment cost. Based on the lot's spatial distribution, it was identified that the historic city center and its surroundings were areas where the highest expected profits are seen. Accurately distinguishing the areas that capture these profits can contribute in decision making regarding the capital gains recovery policies generated by public investment.

Keywords: urban infrastructure; land market; urban policy; urbanization

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I. INTRODUCTION

Infrastructures help cities to work well, as their material base and physical support, contribute towards minimizing poverty and socio-territorial inequality (Erazo Espinosa, 2013) and facilitate the production of goods and services, which is why they positively influence productivity (Barajas & Gutiérrez, 2012). However, infrastructures can also lead to significant rises in land prices, through the transfer of the value contained in public works to the private land (Jaramillo, 2009).

Two of the most important and urgent issues, that Latin American urban planners face, are: i) land speculation; and, ii) the lack of resources to provide a suitable infrastructure for the land that satisfies social needs (Smolka, 2013a). In Latin America, given accelerated urban growth, concentration of land ownership, and laws regulating its use, access to available land is very limited, which leads to price hikes and large speculative profits (Rojas & Smolka, 2013). The so-called speculative investments or speculative capitals can be seen in the cities, whose goal is capturing gains generated by the purchase-sale of properties, i.e., buying land with the expectation of an increased end price (Daher, 2015; Gasic, 2018).

Several authors, aiming at somewhat attenuating the effect of land speculation, have proposed different ways of recovering gains, considering that the benefits of investments in urban infrastructure are capitalized in the land value (Furtado & Acosta, 2013, Smolka, 2013a; Peterson, 2009). In this way, capital gains tax has been considered in different countries, adopting values that vary between 30% and 60% of the increased land value attached to infrastructure projects (Smolka, 2013b).

The recovery of capital gains can contribute towards a sustainable, efficient, and equalitarian urban development. However, the main problem is the difficulty of calculating the land value increase generated by infrastructure projects. This difficulty has led to other alternatives being looked into, including charging tax and charging to recover investments, are commonly found. This is the case of Ecuador, which has a dominant capitalist dependent economic model, oriented towards the external market, whose municipal governments have public policies and instruments to intervene in the land market. Some of their attributions, in this sense, are charging land tax, the regulation to capture capital gains (President of the Republic of Ecuador, 2010), and the implementation of instruments to regulate the land market (National Assembly of the Republic of Ecuador, 2016), but, for sociopolitical reasons, their application is often overlooked (Guamán & Vivanco, 2020).

In most towns, the base value of the tax determines the land valuation the market offers, making different discounts depending on the land's features. Nevertheless, it is common that the commercial value differs from municipal assessment. For example, in Cuenca (Ecuador), the market price is 2.27 times the assessment value and can even be 11 times this value (Bojorque, Chuquiguanga, Peralta & Flores, 2020), so it is necessary to properly make urban land valuation in order to not affect either the local government or the land owners.

The infrastructure there is increases land value in a complex way, insomuch that a suitable quantification of the capital incorporated by infrastructure would contribute to making the land value increases transparent. Given that infrastructure plays a very important role in land development and exercises an influence on productivity, both in cities and the countryside, also generating an increase in land price, the purpose of this document is to research into the relationships of the capital incorporated to the land through drinking water, sewerage, electricity, telephone networks, and road infrastructure, regarding the land price expected by the market offer in urban lots of the city of Cuenca, Ecuador.

In this way, an exploratory cross-sectional study is made to identify possible connections between infrastructure investment and expected land price. The spatial distribution of the relationship of the capital incorporated compared to the nominal asking price is also analyzed, with the intention of supporting decision-making when it comes to defining tax collection policies for improvement contributions.

In specific, the document is structured into five sections. The first establishes the theoretical framework, where different regional studies on the impact of infrastructure on land values are mentioned. The second section comprises the methodology that includes the analysis of the land prices, infrastructure data considered, and the determination of the profit expected by the owners. The third provides the main results, which are discussed in the following section. Finally, the conclusions of the study are presented.

II. THEORETICAL FRAMEWORK

Analyses on land prices have emerged in different types of studies, like econometric ones that seek to identify the relationship of the land and/or rent price, with variables like the distance to centers of employment, public facilities or transport infrastructure, among others. This is the case of the work of Ipia Astudillo and Pacheco (2017)

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which shows spatial clusters in Cali, with a differentiated pattern in the center and some of the city's intersections, and with higher values compared to the periphery, starting from which a strong residential segregation is seen. Also, the study of López-Morales, Sanhueza, Espinoza and Órdenes (2019), made in Santiago de Chile, shows that proximity to the Metro increases the net profit of real estate developers by approximately 25.6%. These research projects that use regression models, show the spatial dependence between variables, although they point to the likelihood that the projected relations may be due to other factors that are not considered, like the socioeconomic composition. Beyond this, the need of having detailed information of several parameters has limited their use in certain practical applications.

Other studies refer to the analysis of specific variables in the configuration or impact on land price. In the work carried out by Serra, Dowall, Motta and Donovan (2005), it is reported that, for three Brazilian cities, the impact on the increase in land price is due to: provision of infrastructure; property ownership; lot size; and distance from the city center. It is established that the presence of infrastructure increases land value by 179% in Brasilia, 11% in Curitiba, and 89% in Recife. The authors estimate that, on average, investments in sewerage generated a land value increase equivalent to 3.03 times the investment cost. In the case of paved roads, it was 2.58, and for drinking water, 1.02.

According to Borrero (2013), in the Latin American peripheries, the cost of urbanizing one meter square varies between US$20 and $40. In an average city, considering a gross land cost of US$12/m^2 and an infrastructure investment of US$30/m^2, there is a total investment value of US$42/m^2. So it is worth asking, how can the land price sometimes reach US$2,000/m^2? And the answer lies in the speculative or intangible factor of the market. This is why Borrero finds, in analysis of different sectors, capital gain values of 172% (periphery sector), 789% (middle-class sector), 2,381% (commercial sector), and 4,700% (mall), which are extremely high and diverse.

Meanwhile, Ronconi, Casazza and Reese (2018) researched, among other aspects, the impact of different public service networks on the land price in two municipalities of Buenos Aires, Argentina. Based on a prototype urbanization project of 200 lots, they determined the costs of different infrastructure networks, obtaining values in USD/m^2 of 1.6 for water, 5.8 for sewerage, 9.8 for paving, 1.6 for lighting and electricity, and 2.0 for gas. It was calculated that the percentage difference between lots with and without infrastructure was 184% for sewers, 156% for gas, 136% for water, and 130% for paving. However, as the authors note, these direct differences hide other different attributes with respect to dissimilar lots. Ronconi et al. (2018), based on a multivariate analysis, identified that the infrastructure provision cost is substantially lower than the average increase in land price, outlining a 12% increase for paving, 184% for the gas network, 195% for sewerage, and 677% for drinking water.

In this context, this study looks to contribute in the analysis of the capital incorporated by public infrastructure compared to the expected urban land price. It is worth highlighting that the infrastructure does not only generate capital gains, as there are also differential attributes with respect to the lots that make their value higher in the market, aspects like distance to shopping centers, higher permitted density, availability of property ownership, lower flood risk, greater distance from landfills, and provision of other infrastructure services, to mention a few, which can have repercussions on the capital gains value (Serra et al., 2005; Jaramillo, 2009; Ronconi et al., 2018), despite these qualities not representing a direct capital investment.

III. METHODOLOGY

The characteristics of the study area, the collection of land price information, and infrastructure costs are presented in this section, while the difference between the investment and the expected land price is determined.

Land prices

The information on land prices was collected through extensive fieldwork and telephone calls to owners or realtors between October 2019 and March 2020. 1,393 records were collected in the urban areas of Cuenca, which addressed an area of approximately 74.33 km^2. Information was gathered for each site for: real estate tax code, lot's occupation condition (without building, with building or horizontal property), location within the block, land shape, lot's topography, construction area, and total cost. In addition, any comments on the lot were recorded.

Considering the type of occupation, there are 567 lots without buildings, 758 with buildings, and 68 horizontal properties. The spatial distribution of the information within the city of Cuenca, is presented in Figure 1.

Lots with and without buildings cover the entire area of interest, while horizontal property ones are absent in some

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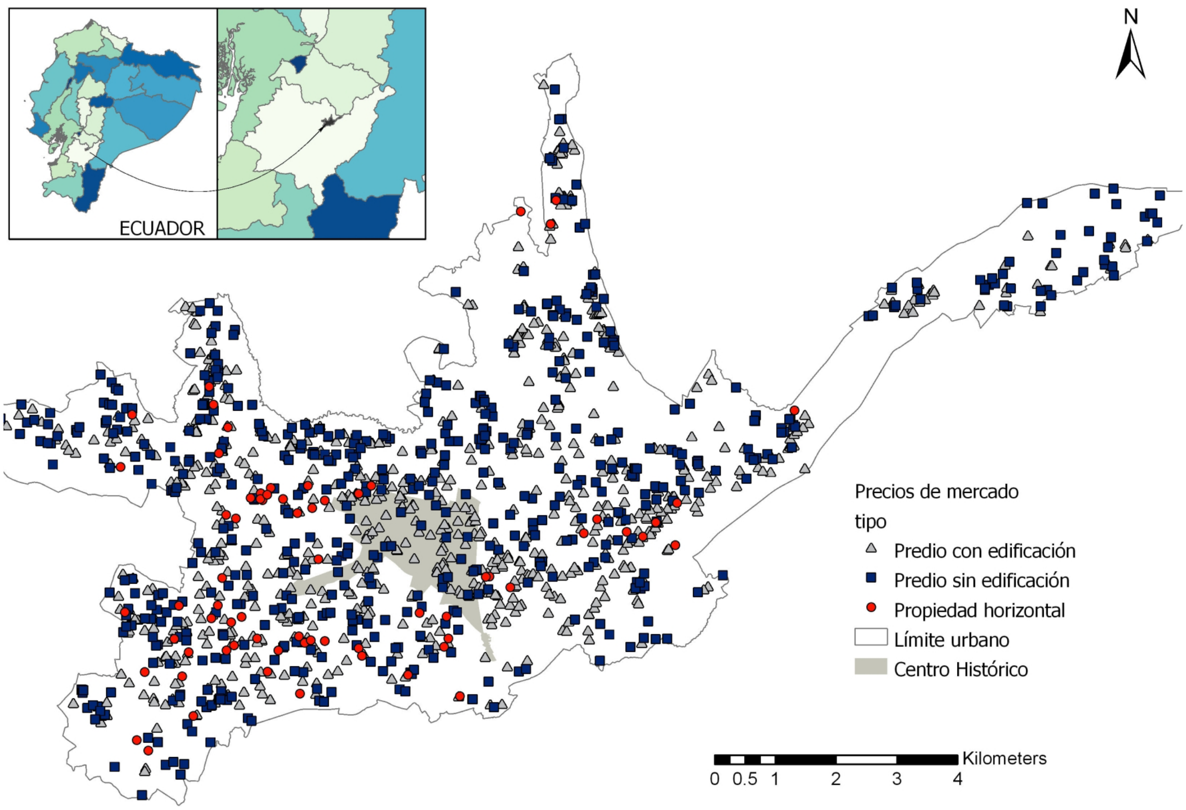

Figure 1. Geographical location and spatial distribution of the values collected considering the lot type: without building, with building, and horizontal property. Source: Preparation by the authors based on data collected between October 2019 and March 2020.

areas, among other reasons, because of the regulation controlling land use and occupation in the city. The areas where there are no lots for sale, generally constitute sites destined to services like: airport, stabilization ponds, industrial parks, parks, military barracks, cemeteries, hospitals, among others.

To determine the gross price of the lot, i.e., excluding the building, the residential value process was considered, taking the year it was built, and the depreciation rate considering the construction material. The residual method consists in deducting from the property's total value, the costs attributable to the depreciated construction. This is how the land value is obtained (GAD Quito, 2019).

Infrastructure information

In order to define the costs of different infrastructures, the GAD Municipal information of the Cuenca District, referring to the special contribution of improvements, was used. The basic infrastructure considered was: telephone, drinking water, and sewerage, performed by the company ETAPA; urban roads, which fell upon the Decentralized Autonomous Government of Cuenca; and the electricity network, managed by the company, Empresa Eléctrica Regional Centro Sur C.A.

The drinking water cost generated for a standard lot (140.5 m^2) was US$488.85, which represents a cost of US$3.48/$m^2$ for a 100 mm diameter pipe, 3.84 for 100-250 mm pipes, 4.12 for 250-450 mm, and 4.54 for pipes over 450 mm. The information on charges to pay for improvements for the sewerage and water sanitation areas was US$1,593.49, leaving a total of US$11.34/$m^2$.

With the purpose of assigning the capital incorporated to the lots by road infrastructure, the cost per linear meter of road, depending on its material, was determined. The cost generated was US$3,443.20, which represents a cost of US$24.51/$m^2$ for hydraulic concrete paving. The cost of rigid reinforced concrete and paving per meter in length and per meter was US$118.90. Based on the price analysis, the cost was calculated for other road structures: cobbles

Statistics (USD/m2)	Lots without buildings	Lots with buildings	Horizontal property	All lots
Mean	384.17	446.88	560.34	426.89
Standard error	8.95	8.40	29.03	6.12
Median	337.08	401.07	565.02	381.94
Standard deviation	213.10	231.4	251.85	229.49
Minimum	15.00	30.06	114.98	15.00
Maximum	1,319.63	1,839.95	1,289.50	1,839.95
Number of lots	567	758	68	1,393

Table 1. Statistical values of the different data groups related to the land price. Source: Preparation by the Authors.

in the historic hub (US$106.16), asphalt (US$84.93), cobbles and stones (treated material) (US$65.92), dirt tracks (US$4.25).

In the case of the electricity network, it was seen that some lots have an aerial network system and others, a buried one. To set the cost per meter squared, the information of charges to contribute to improvements with the electrical network areas was considered. For a site of 140.5 m^2, the generated cost was US$525.73, namely a value of US$3.74/m^2.

The telephone value generated was US$433.70, which means a cost of US$3.08/m^2. According to ETAPA, the entire city of Cuenca has this service. As such, on the entire urban area being covered, a uniform cost was considered for all the lots.

Based on the cost information of the different infrastructures and using GIS (Geographic Information System), a value was assigned to each lot, corresponding to infrastructure considered in the particular features of each system.

Expected land gain

The discussion on the analysis of urban land prices begins by defining whether the land itself, has a price or not. In general, it is supposed that the gross land value -in the rural periphery- is the base price (Jaramillo, 2009). In the case under analysis, the base land value was the one the Municipality of Cuenca manages for land with no infrastructure, namely a price of US$20/m^2 (GAD Cuenca, 2019). The expected or potential gain will be considered as the difference of the value expected by the owners minus the capital incorporated and the base land value.

IV. RESULTS

The main results obtained from the market price analysis are presented in this section. The incorporated capital for each lot and infrastructure is likewise determined, and the values are compared to analyze the expected gain. The results of the price statistics by lot type are expressed in Table 1.

From Table 1, it can be indicated that, for lots without buildings, the mean is US$384.17/m^2 and for lots with buildings, the mean is US$446.88/m^2, which represents an increase of 16.3%. In the case of horizontal property, the mean of 560.34 represents a 45.9% increase compared to lots without buildings. The mean land price, considered for all the lots, is US$426.89/m^2, a relatively high value, which limits access to urban land for the great majority of the population, encouraging them to search for lots in distant areas that have the same services, but that are far from the urban area.

Land price is very important, especially for housing production, as an increase therein, clearly brings with it, an increase in housing prices, so land policies must place emphasis on the regulation and control of land value to procure access to a "suitable dignified dwelling, regardless of social and economic situation", just as outlined in the Constitution of Ecuador (National Constituent Assembly of Ecuador, 2008).

Capital incorporated by infrastructure

The contributions generated from the different infrastructures on the lots that form the urban area were determined. In Table 2, the costs are presented by

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Systems (USD/m2)	Lots without buildings (P50/P95/P99)	Lots with buildings (P50/P95/P99)	Horizontal property (P50/P95/P99)	All the lots (P50/P95/P99)
Drinking Water	3.3/3.7/3.8	3.5/3.7/3.8	3.4/3.7/3.7	3.4/3.7/3.8
Electricity	3.0/3.7/3.7	3.7/3.7/3.7	3.5/3.7/3.7	3.7/3.7/3.7
Sewerage	9.9/11.4/11.4	10.9/11.4/11.4	10.7/11.4/11.4	10.5/11.4/11.4
Roads	13.1/51.5/79.7	19.8/50.7/74.7	21.4/47.7/66.9	17.7/51.5/75.4
All systems	32.0/72.8/99.3	40.8/71.4/95.7	41.6/69.1/88.4	38.0/71.5/96.2

Table 2. Percentiles 50, 95 and 99 of the infrastructure costs considering the type of lot Source: Preparation by the Authors.

Statistics	Lots without buildings	Lots with buildings	Horizontal property	All the lots
Mean	5.96	6.48	8.20	6.35
Standard error	0.13	0.14	0.41	0.09
Median	5.48	5.77	8.16	5.71
Standard deviation	3.21	3.73	3.42	3.54
Minimum	-0.44	0.01	2.06	-0.44
Maximum	25.13	31.51	17.84	31.51
Number of lots	567	758	68	1,393

Table 3. Statistical values of the relationship of expected gain compared to the capital incorporated for basic infrastructure. Source: Preparation by the Authors.

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infrastructure, considering the 50, 95 and 99 percentiles, depending on the type of lot.

It is seen that road networks are the system that adds most to the price, with values that reach US$51.50/m² in 95% of the lots. Sewerage comes next, whose contribution is US$11.40/m², then electricity and drinking water, with values of US$3.70/m², and telephone with a constant value of US$3.08/m².

On dividing the cost of each system for the expected sale price of each lot, the percentage of the capital incorporated to the sale price is obtained. Figure 2 shows the relative contribution of each one of the infrastructures compared to the expected price.

Considering the 95% percentile -1,323 lots of the 1,393-, it can be indicated that the contribution of the drinking water system to the expected lot price is 1.8% or lower; that of electricity is also 1.8% -figure superimposed with that of drinking water; telephone, 2.2%; sewerage, 5.6%; and road networks reach 13.0%. The total infrastructure

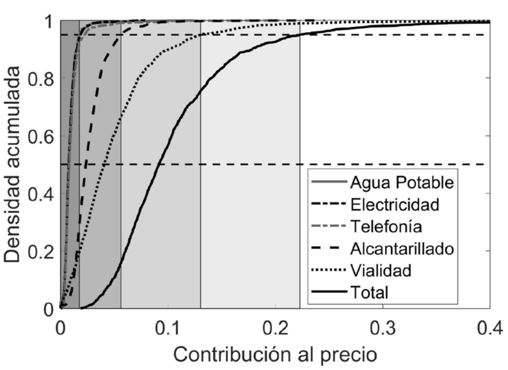

Figure 2. Percentage contribution of each infrastructure to the expected total price. Source: Preparation by the Authors.

contribution is 22.4% of the expected price, where road networks represent 53.2%; sewers, 23.0%; telephone, 9.1%; electricity 7.5%; and drinking water, 7.2%.

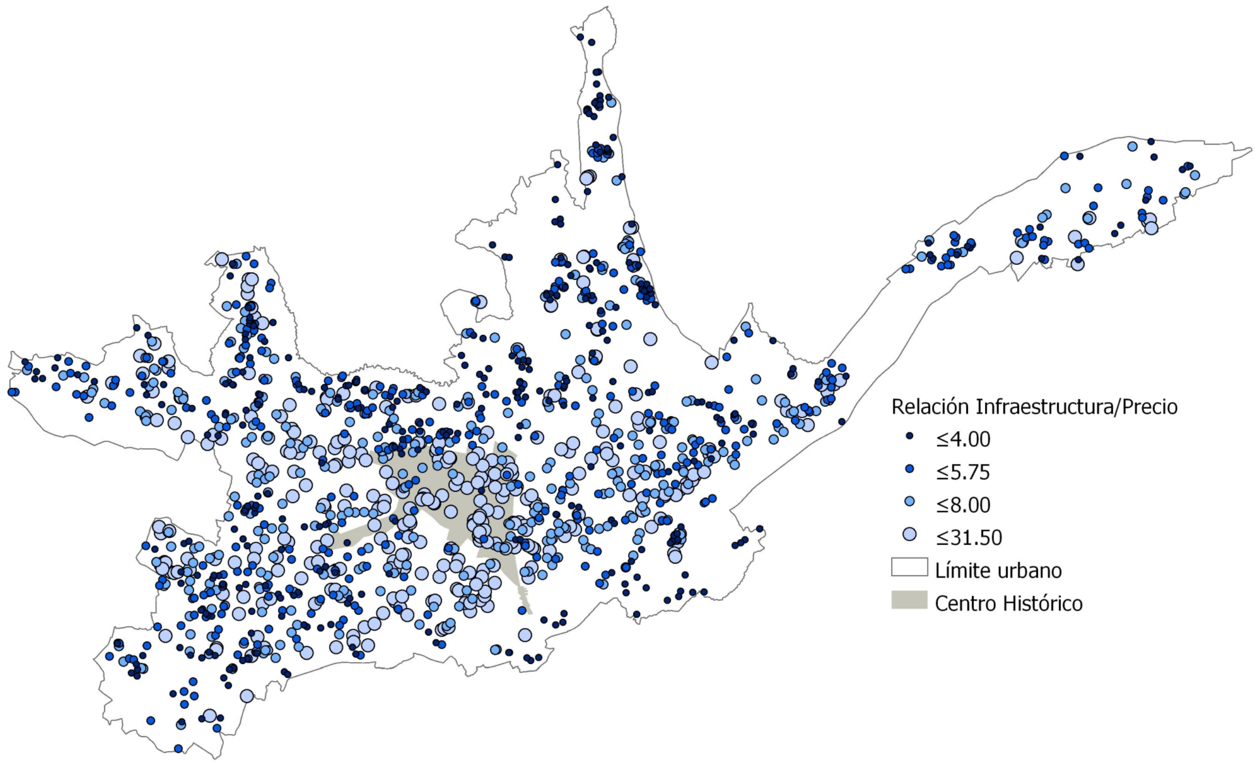

Figure 3. Spatial distribution of the relationship between the expected gain of lots and the capital incorporated in the infrastructure. Source: Preparation by the Authors.

Capital incorporated in basic infrastructure compared to the expected gain

The expected gain was obtained from the price given by the offer minus the capital incorporated and the base land value. The statistics of the relationship between the expected gain against the capital incorporated are shown in Table 3.

In this way, the expected gain, on average, is 6.35 times more than the capital incorporated by infrastructure, which represents 635%. The maximum case identified had a figure of 3,151% of expected gain, which, without a doubt, reveals extremely high valuations. On the other hand, three lots were identified whose capital incorporated represents a higher value than the expected price, where the values of the relationship were negative. These lots correspond to ones without buildings and on sheer sites, that indicate a very high slope. These are sites that are not suitable for building, marking them out as marginal land.

Figure 3 presents the spatial distribution of the relationship between the expected gain and the capital incorporated in basic infrastructure. The categorization is based on data quartiles.

According to the image, it can be stated that, in general, a specific spatial pattern of the potential gain in the city is not evident: a heterogenous distribution is seen in the entire urban area. However, it is possible to appreciate that the highest number of relations is present in the historic hub of the city, before then falling back on approaching the peripheries.

V. DISCUSSIONS

In Latin America, the impact of infrastructure works is more evident in the property value, due to the relative lack of lots with infrastructure, which implies an increase in the land price above the expense effectively made to provide services (Erba, 2007). From the results obtained here, it is seen that investment in infrastructure and the price expected by landowners, in several sectors of the city of Cuenca, show sizeable differences, namely, a very varied expected gain. In this way, it is determined that the values of the comparison between the expected gain and the capital incorporated by infrastructure is within the values reported by Borrero (2013), with higher expectations in commercial sectors, that reach values above 3,000%. Just like in the study of Ronconi et al. (2008), it is identified that the cost

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of providing infrastructure is substantially less than the average increase in the price expected by the owners. Even though the capital incorporated in services and land uses have an effect on the price, in this study, emphasis is only placed on the investment for infrastructure, considering that other external aspects are not direct investments made by the owner on the land. Likewise, certain services have a negative correlation compared to the sale price, for example, schools, supermarkets, pharmacies, among others (Aguirre-Núñez, Sandoval-Fernández & Alliende-Barberá, 2018).

In Cuenca, there is an important concentration of lots expecting very high values in the historic hub, possibly due to other factors involved, like land use, sociability, community, status, among others (Page, 2019), or the spatial (neighborhoods) or sectorial (specific elements) urban segregation, aspects which must be studied from a socioeconomic or cultural perspective to identify components related to materials and quality of life, just as Águila and Prada-Trigo (2020) suggest. In other sectors, there are high price lots, which can be attributed to their location vis-a-vis residential areas or commercial sectors. This information could lead to a future study to try to unravel the high asking prices, that are not solely attributable to investment for infrastructure. It is important to indicate that there is no direct explanation in most sectors about why adjoining lots have marked differences in the expected gains, which could constitute evidence of speculation, as there is no coherence between land prices, their infrastructure, and their location in the city. Sites with the same infrastructure (capital investment) are seen, although with totally different expected prices.

The disproportional increase of land price shows the need to prepare public policies in order to tax the undue transfer of wealth, through figures like the recovery of capital gains, as López Morales et al. (2019) also state, considering that property tax tends to regulate prices, as it looks to discourage speculation promoted by public works. In said sense, it would be positive that the local government undertook actions that directly impacted land speculation, like the regular publication of land value maps that reflect the reality of the market.

VI. CONCLUSIONS

The construction of infrastructure in cities contributes to their development, but at the same time generates increases in land prices. Based on the market prices of 1,393 urban lots in Cuenca, Ecuador, and the basic infrastructure provision, this work identified the contrast between the capital incorporated in infrastructure and the gain expected by the owners.

The asking prices contained lots with and without buildings and of horizontal property. It was seen, in this context, that there is a difference between the mean prices which depends on the type of lot under consideration: for lots without buildings, the mean sales price was US$384.17/m^2; for lots with buildings, it was 446.88; and for horizontal property, 560.34. The mean corresponding to all the lots represents a value of US$426.89/m^2. These high prices, compared to the income of the Ecuadorian population, limit access to the lots on sale or even restrict access to housing, motivating the search for lots available at a lower cost outside the urban area.

Likewise, the capital incorporated in lots by each type of infrastructure -drinking water, sewerage, electricity, telephone and road networks- was determined, bearing in mind their areas of coverage and construction prices. For 95% of the lots, the basic infrastructure investment was US$71.5/m^2. Road networks have the highest percentage of the capital incorporated compared to other infrastructures, being followed by sewers, drinking water, electricity, and telephones.

Considering the asking price, it was determined that the capital incorporated in infrastructure represents 22.4% or less of the price for 95% of the lots. This shows that the expected gain is significant, reaching as a mean, a value that is 6.35 times the capital incorporated, and reaching extreme values of 31.51 times. Infrastructure investments made by the local government have an impact on the land value, which leads to its higher valuation. Said valuation ultimately benefits the owners or real estate developers, as these are the ones who receive said gains. Because of this, adequately identifying these capital gains can help in the decision-making regarding tax collection for contributions towards improvements.

Regarding the spatial distribution of the comparison between the expected gains of lots and the capital incorporated in infrastructure, this allowed identifying that asking prices as a result of the offer, have high expected gains, with the prices given by the land market defying logic, leaving it clear that the social behavior of the owners is strongly speculative, while the high expected price dynamic is also evident. In fact, lots with capital incorporated in infrastructure that are very similar in value are seen; however, the prices the owners ask are illogical.

It is necessary to add that, although market prices are the values expected by the owners, at the end of the deal, what was proposed initially could end up falling. However, it is seen that the prices in question are subject, without any control whatsoever, to supply and demand, and without considering the social use of urban land either. Here is where the importance lies in that the State generates policies to control the land market.

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