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Hedonic pricing and economic valuation of green spaces in the city of La Paz,Bolivia

Precios hedónicos y valoración económica de áreas verdes en la ciudad de La Paz, Bolivia

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Abstract

Several environmental services and goods (e.g., green spaces) are not formally commercialized in markets, which has significant consequences for public policy and private decision-making. This study allows valuing the green spaces of city of La Paz (Bolivia), based on empirical evaluation of the impact of *green spaces* on the price of housing, period 2015, An indirect method of environmental valuation was used, called "Hedonic Pricing Model", which is based on determining the effect -on housing prices- of variables, such as *"units of green spaces", "structure of housing", location",* among others, which finally allows giving economic value to green areas of the city. Results reveal that a 100% increase in the determining variable *"green area vegetation units"* would increase by 7.04, the price per square meter of housing. Also, an increase of 100% in the *"distance between green spaces and housing"* would cause a decrease in the unit price of houses by 6.80%. The *Willingness to Pay* (by owners) for the conservation of green spaces, by housing and per year, was US$. 134.02 per square meter.

Keywords: environmental economics, economic valuation of environmental effects, government policy, econometric modeling.

JEL Codes: Q50, Q51, Q58, C59

Resumen

Varios servicios y bienes ambientales (v.g. áreas verdes) no se comercializan en mercados formales, con consecuencias importantes en políticas públicas y la toma de decisiones privadas. Este estudio permite valorar las áreas verdes de la ciudad de La Paz, Bolivia, en base a una evaluación empírica del impacto de áreas *verdes* en el precio de las viviendas, periodo 2015. Se usa un método indirecto de valoración ambiental, denominado "Modelo de Precios Hedónicos", que se basa en determinar el efecto -en los precios de la vivienda- de variables como *"unidades de espacios verdes", "estructura habitacional", "ubicación"*, entre otros, lo que finalmente permite dar valor económico a las áreas verdes de la ciudad. Los resultados revelan un incremento del 100% en la variable determinante *"unidades de vegetación de área verde"*, eleva el precio por metro cuadrado de la vivienda, en 7,04. También un incremento del 100% en la característica *"distancia entre área verde y vivienda"*, ocasionaría una disminución del precio unitario de la vivienda, en 6.80 %. La *Disposición a pagar anual,* por la conservación de áreas verdes, por m^2 de vivienda, fue de US $. 134.02

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Palabras claves: economía ambiental, valoración económica de efectos ambientales, política pública, modelamiento econométrico.

Clasificación JEL: Q50, Q51, Q58, C59

1. Introduction

Green spaces play an essential role for urban society, as they provide a set of functions in the area where they develop their quotidian activities: improvement of the air quality, and the urban landscape, protection of catchment spaces, land restoration, among others, generating a positive impact on the whole population (Sorensen *et al.,* 1997). Within the framework of development and implementation of public policies, the aforementioned uses can generate economic benefits for society. Often such benefits are received for free, but because they belong to the sector of the use of public goods, there is a problem to establish the monetary measure of said benefits (Pearce and Turner, 1995). For the subject in question, it is crucial to approach the value provided by green spaces, considering their character of public goods and, therefore, making use of some valuation technique of non-market goods.

On the other hand, La Paz (Bolivia) has shown significant urban growth since the late 1990s. In the period 2001-2015, the increase in urban dispersion (decrease in green spaces) corresponds to a total of 3,242 hectares, that is to say, an increase of 55%. The spaces or neighborhoods of the city that showed the most growth in the period are Achumani, Irpavi, and Ovejuyo. Also, in the same period, there has been a vertical growth of the city, as a result of the proliferation of buildings in some areas, such as Miraflores, Sopocachi, Obrajes and Calacoto (Ministerio de Obras Públicas, Servicios y Vivienda, Bolivia, 2014).

The World Health Organization (2013) considers establishing a minimum parameter of 9 square meters of urban green spaces per inhabitant and an optimum of 12 square meters of urban green spaces per inhabitant. For La Paz, said indicator, in 2014, determined 2.42 square meters per inhabitant. Although air pollution is not yet a relatively severe problem (compared to other cities in the region), the problem of air pollution does merit the design of urban public policies for the increase and proliferation of green spaces, as a preventive measure to alleviate possible problems derived from air pollution. In this regard, a support mechanism of great importance is to have a monetary measure of its possible social benefit, through which public policy alternatives become more cost-efficient for scarce public resources.

Until the end of the nineties, on the national and international scene, thevisual reference of La Paz was given by a set of earth-colored hills and slopes, as well as a jungle of gray cement. Until then, there was no place in the collective imagination that in this city, at 3,600 meters above sea level, there could be green spaces that would transform the quality of life of its inhabitants. Back then, a million people who inhabit it also have maintained a spirit of disinterest in their city. There was no possibility of generating and developing large tracts of land to green the city.

On February 19, 2002, a hailstorm hit the center of the city of La Paz. It is a common meteorological phenomenon in the rainy season (December-March). However, at that time, the rise of somewhat more humid air than during the rest of the year, favored by the warmer average temperatures of the Andean summer turned out to be very strong, forced locally by the topography of the ravine with abrupt slopes where the agglomeration of La Paz unfolds between 3,200 and 4,100 meters high.

That day the cloud mass over La Paz was 10 kilometers high and fed a hailstorm that lasted an hour and a half, during which the average temperature on the ground went from 13 to 8 degrees Celsius. That day, the total volume of recorded rainfall reached a height of 41 mm, 39.4 mm in just one hour. It is the most critical event recorded since 1976, the date on which the volume had reached 32 mm (Servicio Nacional de Meteorología e Hidrología – Bolivia, 2002).

The hailstorm caused floods and landslides in the agglomeration of La Paz, causing significant havoc. It was possible to list at least 69 dead — most of the street vendors from the informal sector — 130 wounded and 50 missing. Structural damages were valued at 10 million dollars (damage to communication routes, vehicles, public and private buildings such as the "Consultatory Health Center" of the National Health Fund on Manco Kapac Avenue), in addition to the interruptions of power supply in electricity and drinking water that aggravated the dysfunctions of the emergency phase. Besides, approximately 200 families were forced to abandon their damaged homes (Servicio Nacional de Meteorología e Hidrología - Bolivia, 2002).

With this incident, only then the authorities became aware of these types of problems that demonstrated the vulnerability of the city to these weather phenomena, and, after attending to the emergencies, they began to work on a permanent risk management policy within the municipality.

Within the policy, the increase and generation of green areas in the city were since considered. If the city parks and green spaces are located in areas with a high probability of flooding of rivers, streams or other systems of natural drainage, it is possible to increase the permeable surface available for water absorption, as well as reduce the velocity rates of the currents (compared to surfaces without vegetation, such as asphalt). In this way, eliminate damage to buildings or human settlements, which would otherwise have been built in the area.

This article presents the quantification of a monetary measure of the economic value of green spaces in city of La Paz, based on the estimation of a hedonic pricing mathematical model, and the specification of an implicit demand equation for green spaces. It provides an approximation to the monetary value of green areas from the introduction and use of a new key variable in the model: "Vegetation units", which refers to the total number of plants and trees found in a given green space. A specific green space can have more or less vegetation units of different species (such as plants, shrubs, flowers, etc.). Different plant species have different capacity to capture atmospheric CO2 and also different photosynthetic processes to metabolize it, and obtain sugars and other compounds required for the normal development of its life cycle. In this sense, this new variable helps to better capture the contribution of green areas in fixing CO2 from the atmosphere; its use in the hedonic price model is relevant insofar as it allows for a solid unit of measurement for the most important (environmental) variable of the model.

There are no hedonic studies related to the economic value of green areas in La Paz. There is no literature on hedonic price studies in Bolivia, referring specifically to the valuation of environmental attributes through the housing market. What was done has been to use similar studies in other countries such as Spain, Colombia, Mexico, and Chile, to give context to the present study.

This article contains five sections, including the introduction. The second section presents a characterization of the green spaces in city of La Paz. The methodology, including the mathematical model, is presented in the third section; then, in the fourth section, the results obtained from the used regression model and its discussion and analysis, are shown. Section five presents the conclusions drawn from the analysis of results.

2. Urban Green Spaces in the city of La Paz

Until the end of the 1990s, in the national and international panorama, the visual reference of city of La Paz was a set of hills and earth-colored slopes and essential quantities of gray cement. Until then, it was unthinkable that in this city, at 3,600 meters above sea level, there could exist green spaces that impact the quality of life of its inhabitants. In 2003, after an unfortunate period known as "Black February", due to the overflow of several rivers in the city.[1] The Municipal Government presented the creation of the first municipal company for the management of green spaces (EMAVERDE), intending to generate and develop large unutilized spaces to gradually improve the quality of life of its citizens and improve the image of the capital city.

The EMAVERDE company advanced in the current categorization of the green spaces of city of La Paz, into four categories of parks: (1) large central parks, (2) district and neighborhood parks, (3) town squares, and (4) city gardens. Figure 1 presents the composition of green spaces according to the classification established by the municipal company of La Paz.

The category that includes "great central parks" of city of La Paz occupies approximately 55% of the total surface of green spaces in the city. Secondly, the "city squares" occupy 23%; and thirdly, the "district and neighborhood parks" which, although they occupy a vast area, are no more than three in number.

To carry out this study, it was used the variable "vegetation units", which, according to the previous classification, presents a different scenario to that posed by the distribution of the surface. "Vegetation units" is collectively understood as the total number of plants and trees in a particular green space. A specific green space may have more or fewer vegetation units from different species (such as plants, shrubs, flowers, etc.).

In highland cities, there are typical areas of vegetation, such as *Tola* and *Vareta*, that correspond to native species of those areas. These plant species are commonly referred to as green areas by the inhabitants. However, in the case of the study, the Municipal Green Areas Company (EMAVERDE), has managed to quantify different plant species (different from those initially mentioned) as its coverage of the parks. In this sense, it is important not to discard this data and include it as part of the study.

The most significant number of "vegetation units" is concentrated in the "town squares" with 44%, followed by "large central parks" with 35%, and to a lesser extent, "city gardens" with 13%. One can see the low degree of vegetation coverage in the city, with a low level of land utilization compared to the bulk of the surface area predetermined for vegetation cover.

3. The Hedonic Pricing Model

The hedonic pricing model can be described as a competitive equilibrium in a multidimensional plane where house buyers and sellers are located (Freeman, 1993). For example, Mingie, Poudyal, Mc Donall (2004) used the two-stage hedonic structure to derive demand functions for public green space, privately owned green space, comparison of consumer surplus estimates for private and public green space.

Consumers obtain utility from the consumption of a differentiated good represented by a vector $Z=(z_1,z_2,\ldots..z_n)$, which corresponds to the *"i"* structural characteristics contained in the property (e.g., number of rooms, square meters of surface space, square meters built, number of bathrooms, etc.) and also a vector $A=(a_1,a_2,\ldots..a_n)$ of neighborhoods and/or environmental attributes (for example, proximity to urban parks or green spaces, noise level, emission of odors, etc.). In this way, the price of a house can be expressed as a function of the characteristics and attributes of it:

$$P=P(Z,A) \qquad (3.1)$$

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[1] As a result of a fierce hail storm that made evident the vulnerability of the city.

The hedonic equilibrium is reached from the optimization processes carried out by consumers and by producers, and the interaction they carry out in the market. In particular, a price $P(Z) = P\ (z_1, z_2, z_3, \ldots, z_n)$ is defined at each point in the plane and guides the localized decisions of choice, for buyers and sellers, concerning purchasing houses.

In turn, the choice of a specific household implies the choice of an A vector of attributes and a Z vector of the characteristics of the household. Likewise, individuals choose a compound good X, that includes all the other goods that are part of their consumption. Therefore, given the budget constraint of households, which is limited by their income M, the choice that maximizes consumer welfare will be distributed between housing expenses or expenditures on the compound good *X*.

Also, each household exhibits different socioeconomic characteristics that are represented through a vector $\alpha = (\alpha_1, \alpha_2, \ldots \alpha_n)$. In this way, households' preferences can be represented by a utility function: $U(Z, A, X; \alpha)$, which is assumed strictly concave.

The proposition of maximizing the utility of the consumer can be represented in the following way:

$$U(Z, A, X; \alpha) \text{ subject to } P(Z, A) + X = M \tag{3.2}$$

For simplicity, the price of the compound good is set at 1, which allows us to measure the income *(M)* in terms of the units of *X*. From the solution to this proposition, we obtain the function of the consumer's payment (or position function), which represents the willingness to pay that the individual has for a good that has a vector of *Z* characteristics and a vector of attributes A, $(Z, A, M, U; \alpha$ taking as given the levels of income and utility.

If the position function is proposed as $U(Z,\ A,\ M - \varphi =)\ u$, then it is possible to appreciate that a change in income will cause a change in the position. On the other hand, the derivative of the position function concerning a particular characteristic is given by $\frac{(Z,A,M,u;\alpha)}{z_i}$ which represents the rate at which a household would be willing to modify its housing expenditure due to a change in characteristic *i*, its utility level remaining unchanged.

The first-order conditions of the household maximization proposition state that the marginal rate of substitution between one of the characteristics “Z” and the compound good “X” is equal to the marginal (hedonic) price of the characteristic *i*:

$$\frac{U_{zi}(Z,A,X;\alpha)}{U_x(Z,A,X;\alpha)} = P_{zi}(Z, A) = \frac{\partial\varphi(Z,A,M,u;\alpha)}{\partial z_i} \quad \text{with } \boldsymbol{i} = 1,2,3,\ldots n \tag{3.3}$$

That is, the marginal rate of substitution between an attribute and the compound good is equal to the price of that attribute, which in turn is equal to the marginal position or marginal bargain for the attribute.

For the producers (builders of houses), they face the choice of both the type and quantity of houses or apartments that they will build. A producer (builder) has a cost function that we will represent as $C(Z,A,N; \beta)$ where N is technological the number of produced units and β represents a vector of given technological conditions and production factor prices. With these considerations, the proposition of profit maximization of the producer that is the price taker is given by:

$$\pi = P(Z, A) - C(Z, A, N; \beta) \tag{3.4}$$

The solution to this proposition gives us the supply function $\rho(Z,A,N; \beta)$, which represents the equilibrium price that a producer (in this case, a builder or property seller) can accept for a house that exhibits certain characteristics Z and attributes A.

First-order conditions require that the marginal price of each characteristic be equal to the marginal cost per unit of that characteristic:

$$\frac{P}{Z_i} = \frac{C}{Z_i} \tag{3.5}$$

In equilibrium, functions of supply and demand (position) will be tan-gent, and the function of hedonic pricing will be constituted in the envelope of the supply and position curves that are tangent (Palmquist 1984). The implicit marginal price of a characteristic can be found from:

$$\frac{P}{z_i} = P_{zi}(Z, A) \tag{3.6}$$

This expression indicates the increase in the cost of housing required to obtain a house unit with an additional unit of the characteristic zi, as long as there are no changes in the other variables. If the marginal implicit function is linear in zi, then it is not possible to identify a demand curve for zi; when observing the price, it is appreciated that it is the same for all individuals. On the other hand, if the function of hedonic pricing is non-linear, each individual selects different baskets of characteristics, so that it will have different marginal prices implicit for *Zi* (Rosen, 1974).

4. Methodological Application

In matrix form, the hedonic pricing method can be thought of as follows:

$$Y = X\hat{\beta} + \hat{\mu} \tag{4.1}$$

Where:
Y = target variable: housing transaction price (US$)
β = vector of parameters of the model.
X = matrix of independent variables, which includes the key environmental variable.

Model Specification

By allowing the generation of positive externalities, this research seeks to statistically demonstrate that green spaces lead to a gain in value in the houses of city of La Paz, and allow us to obtain a measure of the benefit, useful in terms of public policy, and based on benefit-cost relationships.

From a sample of the total number of registered households in city of La Paz, regressions were run with different functional forms relating the price to the household's attributes and characteristics. Variables were combined to "capture" the effect of interactions; since one of the characteristics of the collected information corresponded to a set of dichotomous variables. For this purpose, it was necessary to characterize the market's real state into the urban perimeter.

Before proceeding with the estimation of parameters, the normality of the variables was analyzed. Also, interaction variables were constructed, and collinearity of several of them also was tested according to standard arguments of Econometrics (Gujarati and Porter, 2010). The use of Box-Cox transformation did not provide greater utility given the large number of dichotomous variables included in the database.

This research seeks to demonstrate, statistically, that green areas, by allowing the generation of positive externalities, lead to a value gain for houses in La Paz, Bolivia. This aspect can be used in policy formulation. To test this hypothesis, the hedonic price economic valuation method, developed in the previous chapter, was used. From a random sample of the total number of dwellings registered in the city of La Paz, four regressions were estimated with different functional forms that relate the price to the attributes and characteristics of the dwelling. Variables were combined to “capture” the effect of interactions, given that one of the characteristics of the information collected responded to a set of dichotomous variables. The variables used in the estimation are shown in Table A1 (see Annex).

The areas included in the regression (Achumani, Sopocachi, Calacoto) are mainly the residential areas that, due to their characteristics, contain more green areas, where this hedonic attribute is appreciated and, therefore, more valued than the rest of the others. Calacoto, for example, is the most expensive residential area in La Paz and with a large number of green areas. Since the city of La Paz is located in an arid zone, the presence of green areas is valued by individuals. Apartments that mostly have two or three rooms were considered.

The estimated hedonic pricing function was represented, in a general way and with significant variables, by the equation:

$$\begin{aligned} PSU_i &= \beta_0+\beta_1\ TRES\_HABIT\_CENTRO_i+\beta_2\ UVGA\_CALACOTO_i+\beta_3 SOPOCACHI_i+\beta_4 CENTRO_i \\ &\quad +\beta_5 TRES\_HABIT\_ACHUMANI_i+\beta_6 ACHUMANI_i+\beta_7\ UVGA_i+\beta_8 UVGA2_i+\beta_9 D01_i+\beta_{10} GA_i+\varepsilon_i \end{aligned} \tag{4.2}$$

The selection of the variables, which were part of the final estimated equation, was made after ruling out the violation of assumptions. In the same way, when making the respective regressions, care was taken in the sign of the parameters and their statistical significance.

Database and sources

The primary data of the study were obtained from the database of a real estate agency of the city. The data of the green spaces were obtained from the Municipal Government of La Paz. All the data correspond to the 2015 year and include real transactions of purchase and sale of real estate.

The real estate agency provided a total of 618 data, corresponding to housing transactions, from which residential use was selected, distributed among houses and apartments. This sample was taken within 39 areas of the city (out of a total of 94). The study is conditioned, therefore, to the transactions registered in said real estate agency. This method was used because there is no information available for this type of study or other research for purely academic purposes in Bolivia.

The 39 zones were considered since they are the most representative in terms of the provision of green areas, and, therefore, there is greater availability to pay for them. In the peripheral areas, the lack of green areas has been verified, given the topography prioritizing construction versus environment attributes.

This study includes the estimation of the hedonic pricing function and the derivation of the implicit marginal prices. From equation 4.2 it was possible to obtain a function of the implicit demand for units of vegetation per green space. In other words, the prices depend on the level reached by some characteristic or specific environmental variable; in this case, the units of vegetation per green space. The observations were imputed to the corresponding green spaces from the distance measurement.

5. Results

Achieved results were those shown in Table 1.

Table 1 presents the results of the four models estimated using Ordinary Least Squares. In the quadratic model (final selected model), most of the estimated coefficients show a significant *"t"* statistic for a confidence level of 95% and two that were significant at 90%. About the other three models, this selected one presents the largest number of estimated parameters that are statistically significant independently to explain variations in the dependent variable.

Table 1 Result of the estimates

	Quadratic [1]	*Double Log*	*Log-Lin*	*Lin-Log*
Dependent Variable[2] →	Housing price by constructed meter (PSU)			
Intercept	746.501 (17.47)***	7.004 (83.81)***	6.583 (120.48)***	1068.306 (16.38)***
UVGA	52.574 (3.29)***	Omitida	0.071 (3.46)***	Omitida
UVGA2	-5.156 (-2.85)***	0.018 (2.07)**	-0.007 (-2.99)***	12.103 (1.81)*
D01	-0.054 (-6.75)***	-0.064 (-5.95)***	-0.0000715 (-7.01)***	-48.603 (-5.82)***
UVGA_CALACOTO	94.770 (6.35)***	0.108 (5.65)***	0.099 (5.18)***	102.072 (6.82)***
SOPOCACHI	55.023 (1.70)*	0.041 (1.09)	0.066 (1.60)	37.081 (1.26)
CENTRO	322.276 (3.86)***	0.374 (3.44)***	0.382 (3.59)***	316.067 (3.72)***
ACHUMANI	72.958 (2.97)***	0.083 (2.61)***	0.097 (0.002)***	62.517 (2.53)*
TRES_HABIT_ACHUMANI	-251.396 (-2.24)**	-0.298 (-2.03)**	-0.285 (-1.98)**	-262.026 (-2.28)**
TRES_HABIT_CENTRO	45.782 (1.65)*	0.044 (1.21)	0.054 (1.52)	38.193 (1.36)
GA	64.575 (2.11)**	0.091 (2.27)**	0.078 (1.99)**	73.986 (2.37)*
R^2	0.243	0.190	0.225	0.212
F	19.490 (0.00)	15.800 (0.00)	17.640 (0.00)	18.190 (0.00)

[1] The best selected functional form was the quadratic one, chosen based on: (i) the largest number of estimated parameters that were statistically significant, in explaining the dependent variable, (ii) the relatively better specification and goodness of fit.

[2] The *t*-statistic appears in parentheses and indicates: ***statistical significance at 99%; **idem at 95%; *idem at 90%

[3] Some other important diagnostic tests of the quadratic regression model are: White test for heteroscedasticity - X^2 = 52.73 (0.0699); Ramsey test for specification error- *F*=1.68 (0.17); Variance Inflation Factor for collinearity (average)= 4.23 (it doesn't consider the quadratic term).

Source: Own elaboration.

Checking the goodness of fit of the linear model, the determination coefficient R^2 yields a value of 0.2431, that is, 24% of the variations observed in the price variable per square meter built, are explained by the variations of the explanatory variables considered by the model. The low value of the R2 coefficient is typical of cross-sectional models due to the high number of explanatory variables and the high degree of variability.

The F statistic for the linear model reaches a value of 19.49 with a probability of zero. In other words, all the estimated coefficients together are significant to explain the model.

To detect heteroscedasticity in the quadratic model, the White test was used where the null hypothesis proposes the fulfillment of the assumption of homoscedasticity, compared to an alternative hypothesis of violation of the assumption of homoscedasticity, that is, the presence of heteroscedasticity. The chi-square statistic gives a value of 52.73 with a probability of 0.0699, which is why it is concluded that there is not enough evidence to reject the existence of homoscedasticity.

To test the correct specification of the quadratic model, the Ramsey test was applied. The null hypothesis refers to the fact that the model had not omitted variables, compared to an alternative hypothesis that the model had omitted variables. The F statistic reaches a value of 1.68, with a probability of 0.1696, then the null hypothesis cannot be rejected; that is, there is not enough evidence to believe that the model has omitted variables.[2]

Multicollinearity is problematic in any regression model because it can increase the variance of the regression coefficients, which would make them unstable and difficult to interpret. Variance Inflation Factors (VIF), which measure the extent to which the variance of the estimated regression coefficients has been inflated, helps us describe how much multicollinearity (correlation between predictors) exists in a regression analysis. In this case, the VIF values for the model show that there is not enough evidence to believe in the existence of multicollinearity, given that the signs given by the coefficients estimated by the quadratic were between 1 and 2 (limit is a maximum of 5).

The objective of the research seeks to demonstrate that the existence of vegetation units per surface of green area, in the vicinity of a home, generates an increase in the price per square meter of it (UVGA). This objective is corroborated with the positive sign of the coefficient of said such variable. In other words, green areas have a positive impact on the price of homes. Pablo de Frutos Madrazo and Sonia Esteban Laleona (2003), Aurelia Bengochea Morancho (2005), found a positive effect but using the surface of the green area as an explanatory variable.

However, although the existence of vegetation units per surface of green area in the vicinity of a house, generates an increase in the price per square meter of it, this increase is less and less, that is, it is decreasing and, therefore, it has a limit, given by the variable vegetation units per green squared area surface (UVGA2). This fact could not be contrasted with another study since those reviewed did not use vegetation units as an explanatory variable.

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[2] Two tests were performed to check endogeneity. For this purpose, the UVGA variable (vegetation units per green area surface) was taken, and the SUPGA (green area surface) as an instrumental variable; that is, the surface of the park or square near the house. Indeed, the result shows that it is not possible to reject the null hypothesis of the non-existence of endogeneity. UVGA is a variable that is obtained by the quotient between the existing vegetation units (in a green area) concerning its surface. However, when performing the hedonic regression by replacing the UVGA variable directly with SUPGA, the results show total contradiction against the belief or hypothesis raised in the present work; that is: as the green area surface increases, the price per square meter of housing decreases. In this sense, the introduction of the variables UVGA and UVGA2 was justified.

As the distance from a house to a green area increases, the price of it decreases. The variable D01 shown a negative sign. This fact confirms that distance becomes a mechanism for excluding green areas by negatively impacting the price of housing. As these areas move away from housing, individuals will have less incentive to visit those areas. (RA43). This fact was also obtained by Aurelia Bengochea Morancho (2005). For each additional meter of increase in distance, that is, a house that is located one hundred meters from a green area will be worth 300,000 pesetas (US $ 2,067.07). The present study finds that due to a 100% increase in the characteristic distance to the closest green area to the dwelling, (D01), the equilibrium price per constructed square meter of the dwelling decreases by 6.80%.

A three-bedroom house in the city center has a negative impact on the price of the house. This is because a family, instead of choosing a house with three rooms in the city center, prefers to choose one in another area with more comforts and amenities. Thus the price per square meter decreases.

Variable ACHUMANI presents a positive sign. Since it is the area with the highest growth in housing solutions, people are looking for homes in that area with a higher preference, so the impact on the price per square meter is positive. There is an increasing demand for real estate in the area so that as demand increases, the price rises.

CALACOTO presents a positive sign (UVGA CALACOTO). Calacoto is a residential area par excellence. In this sense, vegetation units per green area surface in Calacoto have a positive impact on the price per square meter.

SOPOCACHI presents a positive sign. The traditional residential area of the city. The houses are listed in the same; for this reason, a house in the said area has a positive impact on the price per square meter.

The variable CENTER showed a positive sign. Houses in the central area of the city are highly-priced, because of commercial premises or offices. For this reason, there is a positive impact on the price per square meter.

Variable "Existence of apartments with three rooms in the Achumani area" (TRES HABIT_ACHUMANI) had positive impacts on the price; that is, individuals more value to this attribute.

If a house has a garage, the impact on the price per square meter is positive. Indeed, GA showed a positive sign. Likewise, the signs shown by the rest of the estimated coefficients are those expected. Notably, in the case of the variable *"vegetation units per surface of green area"*, the results show the expected behavior: A positive marginal effect on house prices, but at a decreasing rate as the units of vegetation per square meter of green area.

Demand Estimation by Green Areas

From the estimated equation (4.2), the marginal effect is derived given by the equation

$$\frac{\partial PSU}{\partial UVGA} = 52.57 - 10.31(UVGA)$$

$$Elasticity = \frac{\partial PSU}{\partial UVGA} * \frac{\overline{UVGA}}{\overline{PSU}}$$

$$Elasticity = [52.57 - 10.31(UVGA)] * \frac{\overline{UVGA}}{\overline{PSU}}$$

Results obtained from the estimation of the hedonic price equation were used to calculate the marginal effect and the average elasticity:

Table 2 Marginal effect and elasticity

Variable	*Average Value*	*Average Marginal Effect*	*Average Elasticity*	*Per 100 %*
UVGA	3.057	21.0510	0.0704	7.04
D01	1,155.36	-0.0538	-0.0680	-6.80

Source: Own elaboration.

Table 2 measures the impact of green areas and distance on the equili-brium price of the housing market in the city of La Paz. The implicit average price of a square meter of a surface is 3.057; the average marginal effect vege-tation units is US$. 21.1; however, this is not a constant value since the price depends on the level of the property. On average, due to a 100% increase in the characteristic vegetation units per square meter of a green area (UVGA), the equilibrium price per built square meter of the house increases by 7.04% (Assuming that everything else remains constant).

On average, due to a 100% increase in the characteristic distance to the closest green area to the dwelling, (D01), the equilibrium price per cons-tructed square meter of the dwelling decreases by 6.80% (Assuming that everything else remains constant).[3]

Derivation of the implicit Demand for green areas

The marginal effect of vegetation units per green area surface (UVGA) on the equilibrium price of housing per built square meter (PSU), is the implicit demand equation for green areas (by vegetation units per green area surface). This is given by:

$$\frac{\partial PSU}{\partial UVGA} = 52.57 - 10.31(UVGA)$$

$$P_{UVGA} = 52.57 - 10.31(UVGA)$$

Since the price per square meter of constructed area and the variable unit of vegetation per green area is not linearly related, the marginal effect, that is, the partial derivative of the price per square meter concerning the unit of vegetation per area surface green represents the demand for vegetation units per square meter of green area.

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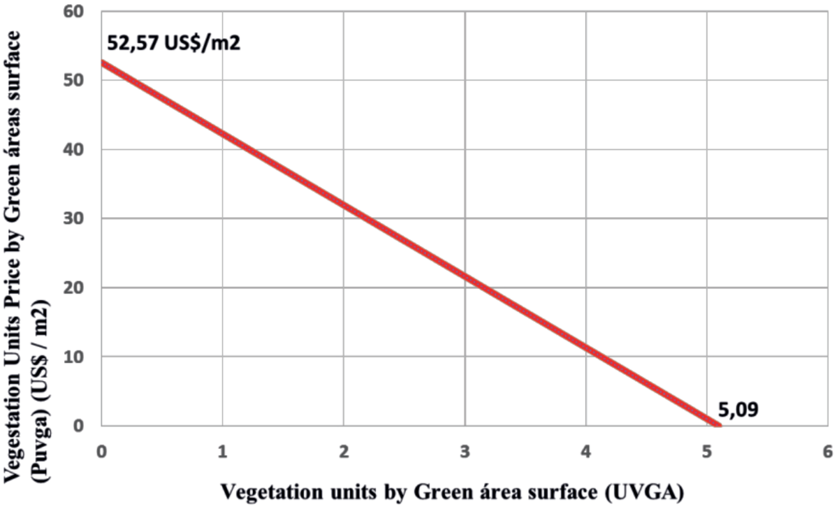
[3] It is assumed that the average number of vegetation units per green area surface increases by 100%; that is 3.05.

For the sample data, the corresponding graph is as follows:

Figure 1 Demand by Vegetation Units by the surface of a green area (per year)



Source: Own elaboration.

The relationship between the price per unit of vegetation per green area and the variable unit of vegetation per area of the green area is linear and inversely proportional as in a demand equation. The maximum availability to pay for a vegetation unit in one square meter of green area amounts to the sum of US $. 52.57, which can be considered high value and which could vary depending on the type of vegetation unit, an aspect that is beyond the limits of the present investigation. For its part, the maximum number of vegetation units per surface of green area that the inhabitants of La Paz are willing to pay is 5.09. That is, from this value, the willingness to pay is zero or negative.

6. Conclusions

A hedonic pricing function has been built to capture the value of urban green areas in housing prices of La Paz, Bolivia, from an environmental perspective. Said function, for its construction, taking into consideration information referring to the structural characteristics of the house, location attributes (areas), and environment attributes (proximity of green areas). The variable "units of vegetation per square meter of the green area" was used for measuring the relationship between green areas and the price per square meter of housing built in the hedonic price model. The way of measuring this variable is relatively new and shows the behavior that supports the hypothesis. It is significant, and its effect is positive on the price per meter of housing built, that is, it represents a positive externality. Said impact depends on the level of the characteristic vegetation units per surface of the green area.

From the hedonic price equation, the demand for green areas was estimated as the derivative of the price per square meter of constructed area concerning the variable vegetation units per green area surface. The derivative represents the implicit price of the feature. This demand shows that, as the number of vegetation units per square meter of green area increases, the impact is less and less on the price of the property; that is, it is decreasing until it reaches a maximum number of vegetation units per square meter of green areas. Another significant variable in the study was the "distance from the house to urban green areas", with a negative impact on the price; that is, the higher the distance, the lower the price of the house.

Two areas of city of La Paz have a strong influence on the hedonic price function. One is the central zone of the city, which shows the trade-off bet-ween the use of a property for housing and its use for an office; this variable has a negative effect on the price. The other area is *Achumani* residential, and constantly growing, with a positive price effect.

Policy implications

The results of the research can contribute to defining criteria (to the Municipal Green Areas Company) for the establishment of green areas in some regions of the city of La Paz. This is discussed below.

Total willingness to pay (WTP)

The total willingness to pay by homeowners was estimated by the area under the demand curve for green areas, between 0 and 5.09, the largest number of vegetation units per green area, that is counted at the time of the study (city of La Paz). It represents the owners' willingness to pay to conserve green spaces.

The estimated result for the WTP by green areas, by housing, per year, for the city of La Paz, is US$. 134.02 per one square meter, with 5.09 vegetation units. Considering that, in the city, there is a total of 322,982 square meters of green areas, the total WTP was estimated in US$ 43,286,967.3, which represents the economic value for homeowners (private benefit) of the urban green areas of city of La Paz.

The result, obtained from the WTP for green areas, constitutes a first approximation to the value of the private benefit, which allows some comparisons to be made with figures from the municipality's public investment. In the case of green areas and parks, according to information from the Municipal Government of the city (GMLP), for the year 2018, the increase in the budget go from four million in 2017 to seven million Bolivians by 2018 (around million dollars) for construction of new parks and green areas. On the other hand, for 2018, the maintenance budget for green areas amounts to twenty million Bolivianos (about three million dollars), including the maintenance of closed parks. In this context, the WTP, in theory, covers these budgets; however, it is important to think and propose the way of collection or transmission mechanism of this amount for investment in green areas.

Estimated data from EMAVERDE information shows that US$ 24.15 is the average cost of maintaining green areas (per square meter), which, compared with the estimated US$ WTP 134.02, shows the feasibility of investing in improvements and maintenance of green areas.

It is key to consider that the fiscal dependence of EMAVERDE concerning the financial budget of the Municipal Government of city of La Paz, has been decreasing, going from 85% in 2014 to 55% in 2018 (GAMLP in Table A2, Annex). On the other hand, revenues from services provided to the private sector have increased from 15% to 38% in the same period. These indicators allow concluding that the profitability that services derived from maintaining green areas can generate; this importance has grown, on average, by 20.43% annually.

Also can be seen that the value obtained from the total Availability to Pay (WTP of US$ 43.3 million) is much higher than EMAVERDE's income (30.5 in 2018). This fact may open up the possibility of self-financing its activities (EMAVERDE), through some financial mechanism that makes sustainable, over time, the maintenance and increase of green areas in the city.

The current policy of the Municipal Government of La Paz, referring to green areas, theoretically is framed in the purposes of EMAVERDE: "To preserve, conserve, restore and contribute to the protection of the environment, natural resources and places of public recreation, as well as building, managing parks, squares, etc. and other green areas, … for the benefit of the population". However, due to the amount assigned to green areas, it can be inferred that it is not a real priority of the local government. Likewise, it has been not possible to determine the criteria for the establishment of green areas in city of La Paz, Bolivia.

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Annex

Table 1A Description of the used variables

Variables	*The expected sign of the relationship with the dependent variable*	*Description*
Price (dependent or objective variable) (psu)		The transaction price of the house (expressed in US $ per built square meter)
Three rooms downtown (tres_habit_center)	Negative	The dichotomous variable that takes a value of 1 if the house has three rooms in the central area of the city and 0 otherwise
Vegetation Units Calacoto (uvga_calacoto)	Positive	The variable that represents *the vegetation units per green area surface* (in square meters), located in the Calacoto area
Vegetation Units (uvga)	Positive	Amount of vegetation species in the green area closest to the house, comprising trees, shrubs, and flowers.
Distance (D01)	Negative	Distance in meters between the house and the nearest green area
Sopocachi (Sopocachi)	Positive	The dichotomous variable that takes the value of 1 if the house is in the Sopocachi area, and 0 otherwise
Downtown (center)	Positive	The dichotomous variable that takes the value of 1 if the house is in the central area of the city, 0 otherwise.
Three rooms achumani (tres_habit_Achumani)	Positive	The dichotomous variable that takes value one if the house has three rooms and is located in the Achumani area, 0 otherwise.
Achumani (Achumani)	Positive	The dichotomous variable that takes the value of 1 if the dwelling is located in the Achumani area, and 0 otherwise
Garage (ga)	Positive	The dichotomous variable that takes the value of 1 if the house has a garage and 0 otherwise.

Table 2A EMAVERDE income and dependency of the Local Government of La Paz ($ thousands of Bolivianos)

Año	*2014*		*2015*		*2016*		*2017*		*2018*	
Description	*Amount*	*Depend. index*	*Amount*	*Depend. index*	*Amount*	*Depend. index*	*Amount*	*Depend. index*	*Amount*	*Depend. index*
Operation Incomes	55,256.6		51,093.6		43,363.1		47,907.3		51,461.2	
To EMAVERD	47,164.0	85%	41,793.3	76%	30,849.8	58%	30,849.8	56%	30,500.0	55%
To other Costumer	8,092.5	15%	9,300.3	17%	17,057.5	20%	17,057.5	31%	20,964.2	38%