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On the Use of Hedonic Price Indices to Understand Ecosystem Service Provision from Urban Green Space in Five Latin American Megacities

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Received: 7 October 2017; Accepted: 23 November 2017; Published: 5 December 2017

Abstract: Latin American (LA) megacities are facing enormous challenges to provide welfare to millions of people who live in them. High rates of urbanization and limited administrative capacity of LA cities to plan and control urban growth have led to a critical deficit of urban green space, and therefore, to sub-optimal outcomes in terms of urban sustainability. This study seeks to assess the possibility of using real estate prices to provide an estimate of the monetary value of the ecosystem services provided by urban green space across five Latin American megacities: Bogota, Buenos Aires, Lima, Mexico City and Santiago de Chile. Using Google Earth images to quantify urban green space and multiple regression analysis, we evaluated the impact of urban green space, crime rates, business density and population density on real estate prices across the five mentioned megacities. In addition, for a subset of the data (Lima and Buenos Aires) we analyzed the effects of landscape ecology variables (green space patch size, connectivity, etc.) on real estate prices to provide a first insight into how the ecological attributes of urban green space can determine the level of ecosystem service provision in different urban contexts in Latin America. The results show a strong positive relationship between the presence of urban green space and real estate prices. Green space explains 52% of the variability in real estate prices across the five studied megacities. Population density, business density and crime had only minor impacts on real estate prices. Our analysis of the landscape ecology variables in Lima and Buenos Aires also show that the relationship between green space and price is context-specific, which indicates that further research is needed to better understand when and where ecological attributes of green space affect real estate prices so that managers of urban green space in LA cities can optimize ecological configuration to maximize ecosystem service provision from often limited green spaces.

Keywords: Urban green space; real estate prices; Latin American megacities; Google Earth; hedonic price indices

1. Introduction

Between 1700 and 2000, 55% of the Earth's ice free land cover was transformed by human activities, leaving less than 45% of the terrestrial biosphere natural or semi natural [1]. Also, humans have changed the way they use the environment and their distribution within it. World population has gone from living mainly on semi natural lands in 1700 [2], to living mostly in dense settlements (cities) by 2016 [3]. Nowadays, cities are home for more than half of the world's population [4], and cities are expanding on average at twice the rate of the human population [5–7].

In Latin America (LA), three-quarters of the population already lives in cities [8], making it one of the most urbanized regions in the world. Moreover, LA cities, and megacities increasingly play a key role in the economies of the region [9]. However, LA cities can also be characterized by deep social and spatial segregation, crime, income inequality, and poverty [10]. High population densities and the high concentration of human activity in LA megacities have led to a number of negative environmental impacts [11] and there are significant challenges in terms of meeting the demand for new physical infrastructure, which is often achieved at high social and/or-environmental costs [12].

Many city planners and policy makers consider urban green space and vacant lots as potential land to be converted to infrastructure [13,14] without taking into account the fact that cities depend on the ecosystem services that urban green space provides to sustain human well-being [15,16]. Urban green space, defined as vegetated natural and human-modified outdoor spaces [17] including parks and urban forests, greenways, trails, community gardens, street trees, cemeteries, and others [18], occurs as patches embedded in the urban matrix, where its connectivity and continuity is often endangered by other land allocation priorities [19]. Thus, cities in Latin America are characterized by a critical deficit of urban green space [8], which impairs human well-being [20].

Urban green spaces provide both environmental and social benefits, as they help to ameliorate several problems that occur in cities by supplying numerous ecosystem services. Ecosystem services are the direct and indirect contributions to human well-being, in this case, from urban ecosystems and their components [15] and their provision is related to an increased quality of life [21] and urban resilience [22]. Urban green spaces may improve air quality by filtration of pollutants, regulate water flux and urban temperature, reduce the heat island effect generated by concrete and combustion motors as well as reduce noise pollution [23,24]. Urban green space also improves the mental and physical health of citizens, and supports social interactions [18,25–27].

However, these benefits have a non-market price, so that they cannot be traded in an existing market [28], leading to insufficient consideration of green spaces in public urban-planning policies.

One of the main challenges that LA urban planners face in order to achieve welfare for millions of urban residents in LA megacities is related to large, uncontrolled and informal urban development that places pressure on the provision of basic services, increases a city's vulnerability and has a number of negative environmental consequences [29–31]. This informal growth also tends to occur independently and apart from formal urban expansion which leads to the consolidation of spatial segregation socioeconomically [32]. Green spaces are important in urban areas as they support ecological integrity of cities, provide ecosystem services, and improve the livability of cities [18,24,25], which clearly needs to be taken into account in urban planning activities [33,34]. If the economic value of urban green space could be demonstrated through a premium on real estate, the importance of the ecosystem services provided by urban green space would be reinforced in the political decision-making process [35]. This is important because financing public infrastructure and public services depends heavily on governmental institutional arrangements [36].

One approach to quantify the value of ecosystem services is through the use of hedonic price indices [37]. Hedonic price indices are based on correlations between prices in existing markets (i.e., the real estate market) and specific ecosystem services (i.e., air quality) or bundles of ecosystem services, as, for example, provided by urban green spaces [18,25]. An open question for the LA region is whether hedonic price indices can be used to estimate the value of ecosystem service provision from urban green space in its megacities. Another open question for LA cities is how the ecological attributes of urban green space might impact the capacity of urban green spaces to provide ecosystem services. Here, we provide some insight into these two issues for LA cities. We specifically test the following hypotheses: (1) hedonic price indices can provide reliable estimates of the value of ecosystem service bundles generated by urban green space across Latin American megacities, and (2) the information that we can obtain from hedonic price indices may be context specific and vary across cities.

2. Methods

2.1. Characteristics of the Cities Used in the Comparison of Hedonic Price Indices Across Cities

This study is focused on LA megacities (as opposed to cities more generally) due to the high concentration of the LA population in megacities compared to other regions of the world [38]. According to UN Habitat (2012), there are eight megacities in LA: Buenos Aires, Mexico City, Rio de Janeiro and São Paulo (with more than 10 million inhabitants) and Belo Horizonte, Bogota, Lima and Santiago (with populations approaching 10 million) [8]. Among these eight we were able to obtain real estate prices at district level for the following five megacities: Bogotá in Colombia, Buenos Aires in Argentina, Lima in Peru, Mexico City in Mexico and Santiago in Chile (Appendix A).

Although these five megacities present common urban development challenges, the intensity of specific aspects related to sustainability and resilience changes from one city to another [10] (Table 1).

Bogotá is located in the center of Colombia, on the eastern flank of the Andes, at 2625 m above sea level [39]. The city has an extension of 1637 km^2 [40] and is politically divided into 20 *localidades* [26]. Bogota has an annual population growth rate of 1.3%, with a mean population density of 4876 inhabitants/km^2 [41]. It has a relative compact structure with high consolidation of population density, with an increased concentration of informal development in peripheral areas [42]. Growth of informal settlements and pronounced income inequality levels are the most important challenges in Bogota. The estimation of green space per inhabitant is 10 m^2 [43].

Buenos Aires is located in the central-eastern region of the country, on the western shore of the La Plata river, on the Pampean plain, at 25 m above sea level [44]. The city's extension is 204 km^2 [45]. Buenos Aires is officially divided into 48 *barrios*; however, the political and administrative management of the city is distributed across fifteen *comunas* that, in most cases, cover more than one Buenos Aires *barrio* [44]. It has an annual rate of population increase of 1.5%, with a mean population density of 14,970 inhabitants/km^2 [45]. Buenos Aires presents pronounced socio-spatial differentiation with a strong suburban and peri-urban growth [29]. Growth of informal and precarious housing, poverty, inequality, and crime are the most urgent challenges in Buenos Aires [10]. The estimation of green space per inhabitant is 6 m^2 [44].

Lima is located on the coast and in the center of the country, on the shores of the Pacific Ocean and is limited by the coastal desert and formal construction of the city, which has occurred mostly on ex agricultural land on flood plains of three rivers: Chillón, Rímac and Lurín. Lima is 154 m above sea level [46]. The city has an extension of 2812 km^2 and is divided into 43 *distritos* [47]. Lima's annual population growth rate is 1.6% [48] and its population density is 3328 inhabitants/km^2 [49]. Lima is a highly segregated metropolitan agglomeration with deep contrasts between high income and low-income sectors of the population [50]. In Lima there is a large amount of informal urban growth and an unsatisfied demand for basic services like drinking water, transport, and housing [10]. The city has 3 m^2 of green space per inhabitant [51].

México City is located in the Mexican Valley at 2240 m above sea level [52]. The city has an extension of 1485 km^2 and is divided into 16 *delegaciones* [53]. Mexico city's annual population growth rate is 0.3% and its population density is 5967 inhabitants/km^2 [54]. Growing insecurity, social-spatial fragmentation and precarious housing conditions are the most important social challenges in Mexico City [10]. Mexico City has 13 m^2 of green space per inhabitant [55].

Santiago is located in the Santiago valley surrounded by the Andes, at 520 m above sea level [56]. The city has an extension of 640 km^2 and is politically divided into 32 *comunas* [57]. It has an annual population growth rate of 1.0% and a population density of 2304 inhabitants/km^2 [58]. Santiago's housing policies have reduced informal housing issues; nevertheless, these policies have led to profound social segregation [10,59]. Santiago has 4 m^2 of green space per inhabitant.

Table 1. Selected Latin American megacities and respective relevant information.

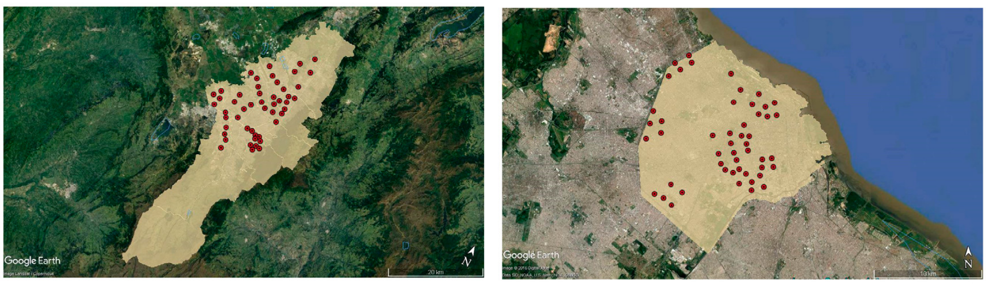
	Bogota	Buenos Aires	Lima	Mexico City	Santiago
Country	Colombia	Argentina	Peru	Mexico	Chile
Mean altitude (AMSL)	2625	25	154	2240	520
Extension (km^2)	1637	204	2812	1485	640
City administrative divisions	20 localidades	48 barrios	43 distritos	16 delegaciones	32 comunas
Green space (m^2/inhab)	10	6	3	13	4
Mean annual precipitation (mm)	818	1040	16	749	390
Mean annual temperature (°C)	13.5	16.8	18.8	15.7	14.4
Population growth rate (%)	1.3	1.5	1.6	0.3	1.0
Most Significant Challenge	Informal settlement growth	Insecurity	Lack of basic services	Insecurity	Spatial-Social segregation

2.2. Green Space Quantification across the 5 Megacities

LA megacities occupy different amounts of physical space and have been built over different types of original land cover. Thus, three characteristics were considered to define the districts included in this study: (1) percentage of rural population; (2) location; and (3) size.

Districts that had more than 50% rural population and/or were predominantly rural or adjacent to the sea shore were excluded. Within and between the five megacities, districts sizes are different. San Telmo in Buenos Aires is the smallest district with an area size of 1.2 km^2; and Tlalpan in Mexico City is the largest district with 312 km^2. Districts smaller than 3 km^2 and/or larger than 100 km^2 were excluded. To create a comparable sample, ten districts per city were randomly selected from the districts that were larger than 3 km^2 and smaller than 100 km^2.

Google Earth Pro (version 7.3) was used to obtain land cover data with images from 2013. Total area sampled per district was 2.5 km^2, divided into five randomly selected polygons of 0.5 km^2, which accounted for the majority of the area in the majority of the districts sampled. In summary, this study considered five polygons per district equivalent to 50 polygons per city, with a total number of 250 polygons (Figure 1). Green space measurements were established at an altitude of 500 m above ground level. Urban green spaces were defined as areas covered with any type of vegetation as described by Wolch et al. (2014) [18]. Thus, all types of vegetation cover were sampled inside all polygons, from single trees to urban forests to measure the total availability of green space including public and private spaces.



(a) (b)

Figure 1. *Cont.*

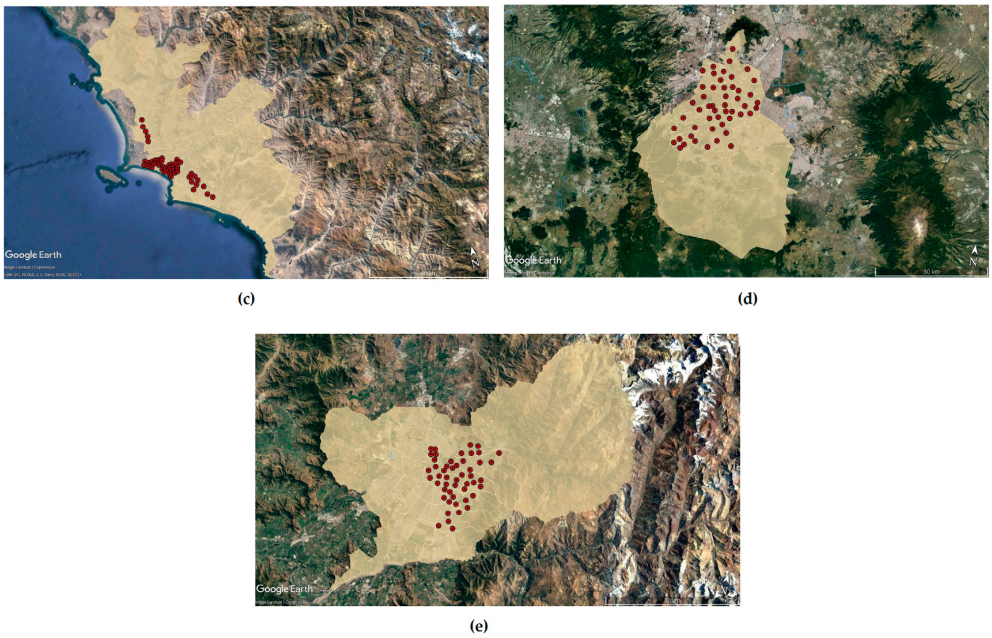


Figure 1. 250 sampled polygons distributed within five megacities. (**a**) Bogota; (**b**) Buenos Aires; (**c**) Lima; (**d**) México City; (**e**) Santiago. Image Landsat/Copernicus downloaded Google Earth.

2.3. Socio-Economic Variable Estimation across the Five Megcities

Population Density: This variable was estimated as the number of inhabitants per km^2 of each district area in 2013 (Appendix B). This variable was included in the analysis across cities because Garcia & Riera (2003) have shown that individuals are willing to pay in order to live in less densely populated suburbs [60]. Other studies also have shown that people prefer neighborhoods with low population density and low dwelling-unit density [61,62].

Business Density: This variable is the ratio resulting from dividing the total number of businesses by total district area in 2013 (Appendix B). This variable shows the probable relationship between a more economically active area and willingness to pay to live in said area. According to Des Rosiers et al. (2000) and Yu et al. (2012), there is a positive relationship between real estate prices and proximity to shopping centers, suggesting that the attractiveness of commercial facilities impacts on households' decisions and translates into a higher demand, and therefore higher prices and rent [63,64].

Crime Density: This variable is calculated as the number of crimes recorded per km^2 in each district in 2013 (Appendix B). Previous findings suggest that there is an important relationship between crime rates and property values. Ihlanfeldt & Mayock (2010) suggest that home buyers are willing to pay nontrivial premiums for housing located in neighborhoods with less aggravated assault, robbery and crime [65]. Indeed, crime rate reduction has an immediate benefit on real estate prices but also, benefits that are derived over a 4–6 year period [66].

2.4. Case Study: The Effect of Landscape Ecology Variables on Hedonic Price Indices

Buenos Aires and Lima were chosen as case studies for a more profound analysis in which we assessed how landscape ecology variables (mean patch size, patch connectivity, etc.) affect real estate prices in an effort to obtain a deeper understanding of how and when differences in the ecological attributes of green space can impact the potential for ecosystem service provision from urban green space. In this dataset, Buenos Aires and Lima represent the extremes of climatic conditions with the lowest mean annual precipitation in Lima (16 mm) and highest in Buenos Aires (1040 mm).

Satellite images of Buenos Aires and Lima from March 2013 were downloaded from Google Earth Pro (Version 7.3, Google Inc., Mountain View, CA, USA) and processed in ArcGIS 10.3 (ESRI, Redlands, CA, USA). Images were first georeferenced and projected in geographic form, and then areas of interest were extracted from the previous five randomly selected polygons of 0.5 km^2 per district. We used the Segment Mean Shift from the Spatial Analyst toolbox to segment the images into objects of at least 10 pixels. We then manually selected objects that corresponded to our definition of urban green areas or "green patch" within the areas of interest. The area of each patch was calculated using the calculate geometry function in the attribute table of ArcGIS. Average Nearest Neighbor distance between green patches were calculated using Euclidean Distance in the Spatial Statistics toolbox.

2.5. Statistical Analysis

To homogenize data and simplify interpretation for the analysis of hedonic price indices across cities, independent and dependent variables were normalized prior to statistical analysis with the following transformation:

$$X_i^* = X_i / X_{max}$$

where X_i^* is each dependent variable after normalization. X_i is the variable prior to normalization and X_{max} is the maximum value obtained for the variable in the respective city.

For the case studies (Lima and Buenos Aires) no normalization of data was performed before analysis since differing scales are not an issue within single cities.

Transformed and non-transformed data were analyzed using multiple linear regression using XLStat (Version 2014.5, Addin Soft, Paris, France).

3. Results

3.1. Comparison of Hedonic Price Indices across the Megacities

From a multiple regression with four independent variables, we obtained a model with admissible accuracy (R^2 = 0.62; Table 2A; Figure 2). The η^2 values indicate that urban green space was the most important predictive variable explaining 52% of the variability in real estate prices across the megacities considered in this analysis. Business density also had a modest influence on real estate prices with a η^2 value of 10, whereas crime rate and population density had non-relevant impacts (Table 2). However, there was also considerable error with unexplained variability accounting for 39% of the sum of squares; therefore, a complete understanding of the factors that determine real estate pricing was not obtained from the analysis across cities.

Table 2. (A) Summary statistics for the multiple regression models in which (A) real estate prices were correlated with four variables: green space, population density, business density and crime rate, (B) green space and green patch attributes vs. real estate prices in Lima, and (C) green space and green patch attributes vs. real estate prices in Buenos Aires. Variables: Av/at = green space/total area, TGS = Total green space, TNP = Total number of patches, MPS = Mean patch size, LPS = Largest patch size, ANN = average nearest neighbor, PopDen = Population Density, BusDen = Business Density, CrimDen = Crime Rate.

Source	df	SS	MS	F	Pr > F	η^2
(A) Analysis hedonic price indices across cities						
AV/AT *	1	1.14	1.14	60.16	<0.0001	51.5
Pop Den *	1	0.00	0.00	0.03	0.87	0.0
Bus Den *	1	0.22	0.22	11.5	0.002	9.8
Crim Den *	1	0.00	0.00	0.24	0.63	0.2
Error	45	0.85				38.5
Corrected Total	49	2.21				100

Table 2. *Cont.*

Source	df	SS	MS	F	Pr > F	η^2
(B) Analysis of green space and patch attributes vs. real estate prices in Lima						
TGS	1	2,663,521.6	2,663,521.6	42.9	0.0	83.8
LPS	1	223,703.7	223,703.7	3.6	0.1	7.0
TNP	1	18,053.0	18,053.0	0.3	0.6	0.6
MPS	1	21,708.4	21,708.4	0.3	0.6	0.7
ANN	1	2851.4	2851.4	0.0	0.8	0.1
Error	4	248,443.6	62,110.9			7.8
Corrected Total	9	3,178,281.6				100.0
(C) Analysis of green space and patch attributes vs. real estate prices in Buenos Aires						
TGS	1	213,044.0	213,044.0	1.7	0.3	12.5
LPS	1	393,208.9	393,208.9	3.1	0.2	23.0
TNP	1	88,816.9	88,816.9	0.7	0.5	5.2
MPS	1	131,095.6	131,095.6	1.0	0.4	7.7
ANN	1	375,692.7	375,692.7	3.0	0.2	22.0
Error	4	508,002.4	127,000.6			29.7
Corrected Total	9	1,709,860.5				100

df, degrees of freedom; SS, sum of squares; MS, mean squares; F, F-test; Pr, probability, η^2 percentage of variation of the R^2 explained for each independent variable, η^2 is obtained from the SS partial value between the SS total value per 100. * Variables after transformation (normalization) used for multiple regressions for first analysis. Normalization: $X_i^* = X_i/X_{max}$. X_i: variable prior to normalization. X_{max}: maximum value obtained for the variable in the city in which the district occurs.

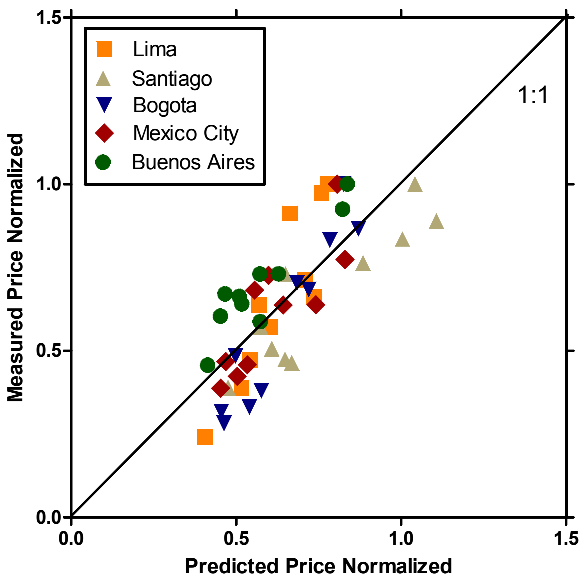


Figure 2. Relationship between measured prices and predicted price at district level. Predicted values obtained via multiple regression: Predicted Price Normalized (NOR) = 0.35 + 0.71*av/at NOR − 0.053*Population Density NOR + 0.34*Business Density NOR − 0.061*Crime Density NOR. See Table 2 for details. Diagonal line indicates the 1:1 relationship. The normalized data used in this analysis adhere closely to the 1:1 line (which indicates close correspondence between the measured and predicted values and shows the robustness of the multiple regression model.

3.2. Case Study: The Effect of Landscape Ecology Variables on Hedonic Price Indices

Results from the case studies (Lima and Buenos Aires) provided a strong hint that the effectiveness of hedonic price indices for constraining the value of the ecosystem services provided by urban green space can be context specific.

The Lima data showed a strong relationship between the amount of green space and real estate prices, in which the amount of green space explained 83.8% of the variability in real estate prices (Table 2B). The positive and significant impact of total green space (TGS) further confirmed that the amount of urban green spaces is strongly valued by Lima's residents. Largest patch size (LPS) of green space in Lima had a minor impact on real estate prices ($\eta^2 = 7$), whereas mean patch size (MPS), total number of patches (TNP) and the average nearest neighbor (ANN) or connectivity between patches were irrelevant.

In contrast, for Buenos Aires, the most important variables for explaining variation in real estate prices was largest patch size (LPS) with a η^2 value of 23 (Table 2C), followed by the average nearest neighbor (ANN) or connectivity with a η^2 value of 22. Total green space (TGS) had a modest impact explaining 12.5% of variance in real estate prices. Mean patch size (MPS) of urban green space in Buenos Aires also had a small impact explaining 7.7% of the variance in real estate prices. In Buenos Aires, there was a considerable error with unexplained variability accounting for 29.7% of the variance. In contrast the error term for Lima was 7.8%.

4. Discussion and Conclusions

4.1. General Considerations

The results of this study reinforce prior findings showing that urban green space is an important determinant of real estate prices [35,67–69], and that hedonic price indices can provide a robust estimate of the value of the ecosystem services provided by urban green spaces across LA cities. However, the unexplained variability in the multiple regression model for the analysis across cities (38.5%) was also significant and could be related to a variety of factors which were not taken into account in this study. Some social variables such as economic status perceptions [26], income dynamics [70], school quality [71] and/or cultural—spiritual values like sense of place, social cohesion [24,72] may provide further insights into the underlying factors that impact real estate prices.

In addition, the use of landscape ecology variables in the case study of Lima and Buenos Aires demonstrates that despite regional similarities, the relationship between green space and real estate prices is context-specific, and that the ecological attributes of green space can impact strongly the potential for ecosystem service provision. These preferences could be related to several factors like city growth tendency, government policy or, as we suspect, the physical environment. It seems logical that amount of green space should be more highly prized in a hyper arid city like Lima than in a city like Buenos Aires where rainfall is sufficient to support growth of rainforest. This we believe can explain why we see a more nuanced valuation of green spaces in Buenos Aires focused on spatial patterns of the green space, specifically related to the size of green spaces and the connectivity. However differences in the quality of city planning may also be important in this specific comparison between Buenos Aires and Lima [50,73] and a larger analysis that includes data from more cities could provide further insight.

Also, the relevance of ecosystem services differs according to the specific environmental and socio-economic characteristics of a city [24]. For example, urban green spaces can buffer extreme weather events like floods, which may be important for cities like Buenos Aires, but for cities like Lima with little to no rainfall, this ES is not important. Air quality regulation is critical for all megacities, but possibly most important in cities like Santiago and Mexico City where topography favors the concentration of aerosol contaminants. Urban forests stabilize slopes, preventing damage from natural hazards, which is crucial for Bogota, but not important for Buenos Aires, located on a coastal plain. A context-specific classification of ecosystem services in LA urban areas is needed to secure resilience-oriented planning [74] as it will be important to consider the role of culturally specific features of people-nature relationships for increasing the quality of life of LA city residents [26].

4.2. Methodological Reflections

Urban planners require up-to-date and accurate spatial data at a city scale to understand urban dynamics and processes [75]. In Latin America, robust data at city and local scale are difficult to obtain due to limited interest and investment in preliminary research and there is little effort to ensure open access of relevant data.

Our results demonstrate the important role that hedonic price indices can play in helping us to understand how green space generates ecosystem services in different situations (i.e., Buenos Aires vs. Lima). Further research is needed to better understand how when and why ecological attributes of green space impact real estate prices so we can optimize the way we invest in and manage green spaces in LA cities so that our investments in urban green space generate the maximum amount of ecosystem services possible. However, our ability to achieve this will depend heavily on data availability and a common frame for comparisons as we have attempted here across the LA megacities. Improving quality and quantity of data acquisition and availability could significantly improve urban planning processes for Latin American cities, which would be directly in line with the United Nations Sustainable Development Goals aiming to improve good health and well-being and supporting development of sustainable cities and communities (http://www.un.org/sustainabledevelopment/sustainable-development-goals/, accessed on 3 November 2017).

4.3. Relevance of the Results for Urban Planning Strategies

High rates of urbanization in Latin America continue to pose direct threats to the preservation of urban green space [76] due to limited administrative capacity in LA cities to plan and control urban growth causing conversion of urban green space into houses and infrastructure. Further, creating new urban green space is becoming increasingly problematic due to a high levels of urban land consolidation [77] and overlapping demand of land for multiple purposes (e.g., urban green space vs. infrastructure) [78].

On the other hand, green space planning is not only guided by urban theories but also from the values people assign to green spaces [79]. Our results demonstrate that the people living in LA megacities value green space significantly, expressing their preferences through the real estate market. However as the case study clearly shows there is significant scope to conduct new research that will enable us to better understand how when and why the ecological attributes of urban green space can help to ensure, maintain or even enhance a range of different ecosystem services [80]. Being able to do more with less in terms of ecosystem service provision from urban green space is especially important for the urban poor in LA cities who generally live in the metropolitan peripheries with critical deficits of urban green space.

Acknowledgments: We want to thank the Cámara Peruana de Construcción, Portal Inmobiliario, Cámara Colombiana de la Construcción, Metros Cúbicos, and Reporte Inmobiliario for their collaboration in providing essential data. We acknowledge support from the Publication Funds of Cientifica del Sur University. We also thank the editorial team and the peer reviewers who provided a wealth of constructive feedback that has significantly improved the quality of this paper.

Author Contributions: B.L. conceived the research idea. U.L.d.M. obtained the real estate data and measured urban green space availability. B.L. and U.L.d.M. carried out the statistical analysis. B.L. supervised the whole research process and the findings of this work. S.D. processed climatic variables information and provided the maps. N.B. and R.A.L.R. provided critical feedback and helped shape the analysis and manuscript. B.R.Z. defined and performed the GIS analysis for case study section. U.L.d.M. wrote the paper with authors inputs.

Conflicts of Interest: The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

Appendix A

Table A1. Real Estate Data: US$/m^2 at district level (2013).

Country	City	Neighborhood	Price (US$)
Colombia	Bogotá	Antonio Nariño	870
Colombia	Bogotá	Barrios Unidos	1493
Colombia	Bogotá	Bosa	570
Colombia	Bogotá	Engativa	1228
Colombia	Bogotá	Fontibon	1263
Colombia	Bogotá	Kennedy	682
Colombia	Bogotá	Rafael Uribe Uribe	506
Colombia	Bogotá	San Cristobal	594
Colombia	Bogotá	Suba	1555
Colombia	Bogotá	Teusaquillo	1794
Argentina	Buenos Aires	Almagro	1830
Argentina	Buenos Aires	Caballito	1993
Argentina	Buenos Aires	Mataderos	1648
Argentina	Buenos Aires	Nueva Pompeya	1245
Argentina	Buenos Aires	Palermo	2523
Argentina	Buenos Aires	Parque Chacabuco	1749
Argentina	Buenos Aires	Parque Patricios	1603
Argentina	Buenos Aires	Recoleta	2730
Argentina	Buenos Aires	Saavedra	1995
Argentina	Buenos Aires	Villa Devoto	1809
Perú	Lima	Jesus Maria	1679
Perú	Lima	Los Olivos	1113
Perú	Lima	Miraflores	2293
Perú	Lima	Pueblo Libre	1345
Perú	Lima	San Borja	2148
Perú	Lima	San Isidro	2355
Perú	Lima	San Miguel	1504
Perú	Lima	San Juan Miraflores	914
Perú	Lima	Surquillo	1559
Perú	Lima	Villa María del Triunfo	568
México	Mexico City	Alvaro Obregon	1824
México	Mexico City	Miguel Hidalgo	2358
México	Mexico City	Azcapotzalco	1103
México	Mexico City	Benito Juarez	1712
México	Mexico City	Coyoacan	1502
México	Mexico City	Cuauhtemoc	1504
México	Mexico City	Gustavo A. Madero	998
México	Mexico City	Iztacalco	915
México	Mexico City	La Magdalena Contreras	1607
México	Mexico City	Venustiano Carranza	1081
Chile	Santiago	Vitacura	2795
Chile	Santiago	Santiago	1325
Chile	Santiago	Providencia	2333
Chile	Santiago	Peñalolen	1599
Chile	Santiago	Ñuñoa	2041
Chile	Santiago	Macul	1416
Chile	Santiago	Las Condes	2486
Chile	Santiago	La Reina	2134
Chile	Santiago	La Florida	1297
Chile	Santiago	Independencia	1089

Appendix B

Table A2. Independent social variables used in the study (2013). All data were divided between the area of each district.

Country	City	Neighborhood	Population (Inhabitants) *	Business (Number of Businesses) **	Security (Number of Crimes Recorded) ***
Colombia	Bogotá	Antonio Nariño	108,607	4660	1428
Colombia	Bogotá	Barrios Unidos	236,433	15,932	1502
Colombia	Bogotá	Bosa	612,754	11,803	1725
Colombia	Bogotá	Engativa	858,935	29,469	3327
Colombia	Bogotá	Fontibon	362,167	15,909	2153
Colombia	Bogotá	Kennedy	1,042,080	28,787	3889
Colombia	Bogotá	Rafael Uribe Uribe	376,767	8196	1520
Colombia	Bogotá	San Cristobal	408,477	5646	1285
Colombia	Bogotá	Suba	1,120,342	36,856	4669
Colombia	Bogotá	Teusaquillo	149,166	13,266	2316
Argentina	Buenos Aires	Almagro	93,571	2437	1062
Argentina	Buenos Aires	Caballito	183,662	5171	1837
Argentina	Buenos Aires	Mataderos	55,633	1176	797
Argentina	Buenos Aires	Nueva Pompeya	62,791	1142	1012
Argentina	Buenos Aires	Palermo	255,358	10,771	5751
Argentina	Buenos Aires	Parque Chacabuco	109,541	2423	1550
Argentina	Buenos Aires	Parque Patricios	62,791	1142	1012
Argentina	Buenos Aires	Recoleta	187,141	8987	2267
Argentina	Buenos Aires	Saavedra	49,910	1157	561
Argentina	Buenos Aires	Villa Devoto	49,443	1163	512
Perú	Lima	Jesus Maria	71,439	13,634	1021
Perú	Lima	Los Olivos	360,532	32,874	7929
Perú	Lima	Miraflores	83,649	27,303	2364
Perú	Lima	Pueblo Libre	76,743	9877	1114
Perú	Lima	San Borja	111,688	16,424	2634
Perú	Lima	San Isidro	55,792	19,445	1019
Perú	Lima	San Miguel	135,226	15,408	3565
Perú	Lima	San Juan Miraflores	397,113	26,725	4323
Perú	Lima	Surquillo	92,012	14,293	2318
Perú	Lima	Villa María del Triunfo	433,861	21,023	2542
México	Mexico City	Alvaro Obregon	734,290	20,170	10,902
México	Mexico City	Miguel Hidalgo	380,608	23,724	11,013
México	Mexico City	Azcapotzalco	410,475	16,928	8561
México	Mexico City	Benito Juarez	397,446	24,293	12,042
México	Mexico City	Coyoacan	618,265	22,142	11,826
México	Mexico City	Cuauhtemoc	536,086	66,587	26,542
México	Mexico City	Gustavo A. Madero	1,180,559	46,007	21,980
México	Mexico City	Iztacalco	380,259	16,955	7825
México	Mexico City	La Magdalena Contreras	242,355	6094	2385
México	Mexico City	Venustiano Carranza	424,962	30,763	10,337
Chile	Santiago	Vitacura	87,792	14,519	1382
Chile	Santiago	Santiago	331,325	56,651	16,459
Chile	Santiago	Providencia	144,169	44,699	4998
Chile	Santiago	Peñalolen	240,304	8690	4319
Chile	Santiago	Ñuñoa	212,163	15,328	4347
Chile	Santiago	Macul	122,966	5533	2389
Chile	Santiago	Las Condes	279,760	51,167	4893
Chile	Santiago	La Reina	101,358	6327	1633
Chile	Santiago	La Florida	387,352	15,696	8939
Chile	Santiago	Independencia	80,476	4868	1899

* Secretaría de Planeación—Alcaldía Mayor de Bogotá (Colombia), Dirección General de Estadística y Censos—Gobierno de la Ciudad Autónoma de Buenos Aires (Argentina), Dirección Técnica de Demografía e Indicadores Sociales del Instituto Nacional de Estadística e Informática—INEI (Peru), Consejo Nacional de Población—CONAPO (Mexico), Instituto Nacional de Estadísticas Chile—INE (Chile); ** Cámara de Comercio de Bogotá—CCB (Colombia), Subsecretaria de Trabajo, Industria y Comercio—Ministerio de Desarrollo Económico (Argentina), Instituto Nacional de Estadística e Informática—INEI (Peru), Instituto Nacional de Estadística y Geografía—INEGI (Mexico), Departamento de Estudios Económicos y Tributarios—Subdirección de Estudios del Servicio de Impuestos Internos (Chile); *** Observatorio de Seguridad en Bogota (Colombia), Instituto Superior de Seguridad Publica (Argentina), Observatorio Nacional de Seguridad Ciudadana—OBNASEC (Peru), Dirección General de Politica y Estadística Criminal—Procuraduría General de Justicia del Distrito Federal-PGJ DF (Mexico), Carabineros—Instituto Nacional de Estadísticas Chile—INE (Chile).

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