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EFFECT OF DISTANCE TO TRAIN STATION AND MOBILE COVERAGE ON LAND VALUE: A CASE OF TAX VALUATION IN OREAMUNO, COSTA RICA

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Abstract. In Costa Rica, a land tax valuation model provided by the Technical Standardization Body (ONT) of the Ministry of Finance is used. This model considers homogeneous areas that include properties with similar characteristics and review factors that have not been recently updated. The objective of this article is to determine the effect of the distance to the train station and mobile coverage on the value of land in Oreamuno, Costa Rica, as a proposal to be included in the mass valuation model of the ONT. A multiple regression econometric model was used to establish the functional relationship between the value of the property and its characteristics, through the Ordinary Least Squares (OLS) method, using 10 variables applied to 200 references initially. The results allow demonstrating that other variables such as "Distance to the train station" and "Mobile coverage" are representative for determining the value of properties, in addition to those commonly used by the ONT model. The research allows concluding that the land valuation models should be updated periodically and should include variables related to improvements in technology and access roads, since these increase the market value of properties and improve the social development of localities in study.

Keywords: *Appraisal, land valuation, multiple regression, tax value.*
JEL Codes: *C50, Q15, R14*

INTRODUCTION

The Territorial Administrative Division of the Republic of Costa Rica establishes that the country is divided into provinces and cantons (Law 4366, 1969). Each canton is territorially administered by public entities known as Municipalities, with independent and autonomous powers that allow them to have their own budget and establish priorities in their operational and administrative management (Law 4366, 1969).

Land Tax Law (1939) gave way to the valuation of real estate and authorized the Tax Directorate of the Ministry of Finance to apply general, partial and particular valuations (Mayorga, 2008). Law 7509 (1995) created the Real Estate Tax, which is collected by local governments and levied on land, installations and fixed constructions. This law was amended by Law 7729 (1997), which establishes that the Technical Standardization Agency (ONT) of the Ministry of Finance is

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obliged to provide a tax valuation tool to local governments, in order to standardize and improve the inspection of real estate declarations.

The valuation model proposed by ONT integrates homogeneous areas, properties with similar characteristics and factors that influence the valuation of urban and rural land, such as: area of the property, length of frontage, slope, level between the surface of the property and the access road, location, type of access road, accessibility to public services, land regularity, land use and hydrography (Law 7729, 1997).

Costa Rican regulations require the ONT to determine the adjustment factors of the fiscal valuation model so that the local governments can use it and thus be able to collect territorial taxes. However, local government are allowed the freedom to suggest the incorporation of new factors that affect the fiscal value, especially if this contributes to an increase in tax collection to be used in improvements for the community.

In underdeveloped real estate markets like Costa Rica, it is common to find inconsistencies in the delimitation of properties with old and outdated cadastre, mainly in agricultural and forest lands (Forejt et al., 2020). On the other hand, despite the fact that the Oreamuno Municipality, (local government) in Cartago province, constantly updates the value of real estate, as suggested by Tomić et al. (2021), the proposal of the ONT valuation model no new factors has been included to explain the price of land.

This research aims to answer the question of the Oreamuno Municipality about the possibility that the land market value is explained by the effect of new factors, which would generate a more objective tax base for the local government and property owners. Therefore, the objective of this article is to determine the effect of the distance to the train station and mobile coverage on the value of land in Oreamuno, Costa Rica, as a proposal to be included in the mass valuation model of the ONT.

1. LITERATURE REVIEW

The traditional concept of urban and rural areas defines them as distinct entities, and their main connection in terms of land use is through flows of agricultural products from rural to urban areas (Seto et al., 2012). A study on the rural-urban dichotomy by land use argues that land should be characterised along a gradient from rural to urban and suggests the need for inclusive approaches (Van Vliet et al., 2020).

The implementation of public policies aimed at improving investment in infrastructure, productivity and cost optimization, both in the agricultural and commercial sectors, as well as reducing distances to the main markets, improving roads and promoting technological change, promote an increase in land prices (Soto, 2005).

Pioneering research in the area of land valuation is attributed to Haas (1922) and Wallace (1926), who used econometric and statistical methods to analyse the effect of factors such as size and distance to the centre of the city, the type of land and productivity, on the market value of agricultural properties in the United States

(Caballer & Guadalajara, 2005). Their contributions have been the basis for the elaboration of property valuation models and hedonic prices (Colwell & Dilmore, 1999).

Currently, the International Valuation Standards proposes income, cost and market approaches in the valuation of assets; it is also usual that comparative techniques are used to determine the value of the good based on other similar goods tradable in the market, of which price and features are known (IVSC, 2020).

The most relevant methods for the market comparison are the correction and multiple correction, valuation ratio, the Beta method and the econometric method (Aznar et al., 2020). The comparative method is based on homogeneous goods market data with information from recent transactions and uses several comparable goods according to their characteristics (Guadalajara, 2018). To determine the value of a good, the prices of comparable elements must be investigated and the indicator obtained will be its market value (Phoenix Valuation Institute, 2017; Robledo, 1998).

Econometric method has been widely used to determine the market value of a good based on a set of characteristics, it assigns objective values with greater efficiency and allows properly reasoning the weight of each explanatory variable on the property value (Hernández, 2016).

The choice of the method to determine the value of a good depends on the appraiser approach, as long as precise prices are established in the market to guarantee effective and efficient decision-making by economic agents (Usman et al., 2020).

In Spain, the land market value for agricultural use was studied with the econometric method and the incorporation of variables affecting productivity, such as land use, type of crop, availability of irrigation, temperature and rainfall level, in addition to other proxy variables that characterised the regional scope from the social, economic and geographic axes (Caballer & Guadalajara, 2005).

Based on a logistic regression model, Salem et al. (2020) pointed out that population growth and land value cause and drive change in land use and land cover in Egypt. These results demonstrate the importance of using variables from the social and economic sphere in relation to the quantification of the value and the use that is given to the land.

Regarding the high levels of urbanization, Beckers et al. (2020) mention that these lead to a continuous loss of agricultural land due to the appropriation of land and its use for non-productive rural activities such as recreation. Although this dynamic generates a reduction in the area of rural land, it can also lead to an increase in its value due to the accessibility and proximity of services available in urban areas.

Property tax is an important source of tax revenue in developed economies. Therefore, in countries with emerging real estate markets, it is essential to adopt mass appraisal models appropriate to the market structure and adapted to constant changes (Wang & Jing, 2019). These authors provide a mass appraisal model review applied to real estate, among which the multiple linear regression analysis stands out to predict the value of real estate (dependent variable) based on relevant attributes (independent variables) (Wang & Jing, 2019).

In Ireland, a mass valuation model was implemented for 2694 real estates with methods such as hedonic prices, linear regression analysis and artificial neural networks, which made it possible to measure the change in price from variables such as the size of property, the total number of storeys, the average travel to work time and ward location (McCluskey et al., 2013). Although the type of assets studied in this paper differs from the study by McCluskey et al. (2013), their research supports the implementation of mass appraisal models through a multiple regression analysis.

Regarding the use of value as a real estate tax base, Barańska (2013) determined that it was not uniform in developed countries of the European Union, United States and Canada, and a connection was generally established between the real estate tax system and the value of capital. However, the evidence emphasises the incorporation of common variables that allow the goods to be compared, such as physical characteristics (area of the property, quality in general, days the property was exposed to the market), location, market conditions, financing concessions and sales conditions (Benjamin et al., 2004).

At the end of the 80s, Coto (1986) analysed the spatial distribution of land value in Heredia province, Costa Rica, by a multiple regression analysis. The independent variables used were latitude, area, regularity and location of the land, the distance to the nearest commercial district, the front of the land, access to public and communal services, and the distance to the neighbouring property with higher value. According to Castro & de Obaldía (2004), the contributions of Coto (1986) were essential in the proposal of methodologies for the mass valuation for tax in Costa Rica and facilitated the territorial division of the study area.

In addition to the availability of the ONT valuation model in the field of fixed asset appraisals in Costa Rica, recent contributions support the use of other effective variables to quantify the land value in different areas of the country. Paniagua (2016 a,b; 2017) found that the distance to the beach and the sea view affected the value of land located in a coastal area, as well as the level of slope and the distance to urban centres. The use of this last variable is also supported by Álvarez et al. (2017) and Montero-Solís et al. (2019), who applied different approaches to value farms dedicated to agricultural production in Costa Rica.

2. DATA AND METHODS

Information was collected from 200 properties in urban and rural areas of Oreamuno, available on the market in the period of 2017–2019. The territory is subdivided into five districts and the main economic activities are developed in the commercial, service and agricultural (commonly vegetables crops) sectors.

Property prices were referenced to transaction prices. Properties included in the initial sample were verified with field visits and consultations with banks and mortgage appraisers. The sample was reduced to 149 observations with complete information required for the econometric analysis (Table 1).

Table 1. Variables Used in the Econometric Analysis

Variable	Code	Detail
Value	*V*	Land unit price per square meter, m^2
Extension	*AR*	Property total area, m^2
Front	*FA*	Property front length, m
Regularity	*RG*	Property shape
Slope	*SP*	Property slope level
Level	*LV*	Difference, m, between property level and land access road
Via	*RD*	Type of path to the property
Services	*SV*	Availability of basic services (water, electricity, landline, satellite television, internet and public lighting)
Location	*LC*	Property location in a georeferenced quadrant
Railway station	*TS*	Distance in kilometres between the property and the nearest railway station
Mobile coverage	*MC*	Accessibility, signal strength and type of mobile coverage

To establish the land value (V) with respect to its characteristics (X_i), econometric techniques were used through multiple regression models (Eq. 1). The regression parameters were estimated with the Ordinary Least Squares (OLS) method, which provided unique values for the regression coefficients and reduced the residual term (Gujarati & Porter, 2010).

$$V = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_k X_{ki} + \upsilon_i, \quad (1)$$

where

V is the dependent variable;
β_0 is the regression intercept;
β_1 to β_k are the regression coefficients of the independent variables X_i;
υ_i is the residual term.

The econometric model proposed is based on the ONT valuation model with the inclusion of new independent variables: distance to the nearest railroad station (TS) and the availability of mobile coverage (MC)[1]; which are proxy variables to measure the effect of accessibility to rapid interurban public transport and telecommunications services.

The properties included in the sample were spatially located with the Regulatory Plan, databases and current value platforms of the Oreamuno Municipality. This information was verified with the list of cadastral properties of Geographic Information System (GIS), risk maps of National Commission for Risk Prevention and Emergency Attention (CNE, 2019), aerial photographs and satellite images (Google, 2020).

[1] When the ONT model was developed, the effect of mobile coverage was not included as there was not a high degree of telecommunications network penetration (SUTEL, 2018).

The GIS was used to georeference the distance between the properties and the nearest railroad station. To categorize the mobile coverage (Table 2), the coverage map issued by the Telecommunications Superintendence (SUTEL, 2020) was used, based on the Regulations for the Provision and Quality of Services (2017) and resolution RCS-152-2017 (2017) derived from Law 8642 (2008).

Table 2. Signal Strength (x) by Technology and Type of Coverage (measured outdoors)

Scale	2G: Rxlev value, dBm[1]	3G: RSCP value, dBm[1]	4G: RSRP value, dBm[1]
Blue	$x \geq -75$	$x \geq -85$	$x \geq -95$
Green	$-75 > x \geq -85$	$-85 > x \geq -95$	$-95 > x \geq -105$
Yellow	$-85 > x \geq -95$	$-95 > x \geq -105$	$-105 > x \geq -115$
Red	$x \leq -95$	$x \leq -105$	$x \leq -115$

[1] Quality and coverage measurements in decibels relative to milliwatts, dBm.
Source: SUTEL (2018).

In areas with coverage levels and speed records from more than one telecommunications operator, a simple average of the available information was performed, assuming that any operator had the same coverage probability.

Breusch-Pagan and Lagrange Multiplier tests were used to test for heteroscedasticity and autocorrelation. The method of Generalized Least Squares (FLS) was applied as a correction measure to obtain unbiased and consistent estimators with minimum variance (Greene, 2003).

Logarithmic transformation was also applied to reduce the volatility of the data and different parameters were used to select the model with the best forecast fit, including adjusted coefficient of determination (R^2), Akaike and Bayesian information criteria (CIA and CIS) and U-Theil's.

To analyse the effect of the variables TS and MC (new factors included), we compared the prices obtained with the econometric model suggested in this research and the updated values of nine properties previously reported by the Oreamuno Municipality.

3. RESULT ANALYSIS

Five econometric models measuring the effect of different independent variables on land prices were performed (Table 3). All models have an acceptable R^2.

For model 1, the R^2 was 0.78, i.e., it has a predictive ability of 78 % on land price. However, the path variable (RD) does not have the expected sign in the regression coefficient. In model 2, the respective sign was corrected, although the presence of heteroscedasticity prevailed and the residuals did not fit the normality distribution.

In model 3, the same variables were used as in model 2 with the application of the FLS method to correct for heroscedasticity. The results suggest an improvement

of the adjusted R^2 and the U-Theil's parameter. However, the FLS method was not effective, since the null hypothesis is rejected at 1 % statistical significance.

In model 4, the variables "front" (FA) and "regularity" (RG) were excluded due to the absence of statistical significance and the FLS method was applied. This made it possible to correct the problem of heteroscedasticity, but the absence of normality persisted in the results.

To obtain the best model (model 5) that explains the land price Oreamuno, the FLS was applied with all the initial independent variables, except the GR variable. The regression coefficients of FA and SP (slope) are not significant at 10 %, but the probability value is acceptable to the researchers. The other regression coefficients have a statistical significance of less than 5 % and there is normality in the residuals, the error terms are uncorrelated and the error variance term is constant.

Thirteen outlier observations were eliminated in model 5, which were affected by speculation in the market, since in Costa Rica it was common for property owners to increase the value of properties when they were asked about the price and did not want to sell it.

Compared to the other models, model 5 has the lowest prediction bias according to the U-Theil's parameter and the highest adjusted coefficient of determination. The CIA and CIS parameters are higher than in models 1 and 2, but there is no heteroscedasticity or autocorrelation, so it is preferred over the other models.

Results suggest that the price is more sensitive to changes in the level of slope (SP) and moving range (CV), which are expressed as semi-elasticities. In this sense, for a one-unit increase in SP, the price of properties decreases by 46 %, while for a one-unit increase in CV, the price increases by 67 %. As for accessibility to rapid interurban public transport (TS), it can be assured that a one-unit increase in distance generates a 6 % reduction in the price of land. The interpretation of the other variables follows the same analogy.

Adjusted coefficient of determination confirms a simultaneous behaviour between the observed data and the prediction of the land unit price, and it can be assured that the independent variables explain 99 % of the changes in price. Figure 1 shows a dispersed distribution of the regression residuals, typical behaviour of a normal distribution, which is confirmed by the normality test (Table 3).

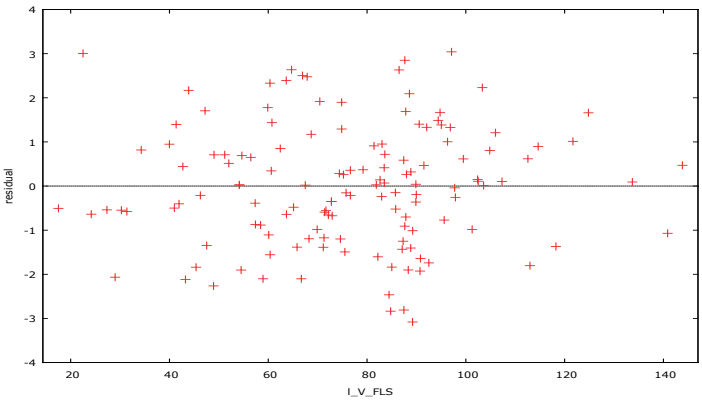


Fig. 1. Regression residuals model 5 with FLS.

Table 3. Summary of the Econometric Modelling with OLS of the Land Price in Oreamuno, Costa Rica

Independent variable	Model 1 (n = 149)			Model 2 (n = 149)			Model 3 (n = 149)			Model 4 (n = 149)			Model 5 (n = 136)		
	Depend. Var.: *l_V*			Depend. Var.: *l_V*			Depend. Var.: *l_VFLS*			Depend. Var.: *l_VFLS*			Depend. Var.: *l_VFLS*		
	Coef.	*p*-Value		Coef.	p-Value		Coef.	*p*-Value		Coef.	*p*-Value		Coef.	*p*-Value	
Intercept	9.37	1E-04	***	10.63	1E-04	***	11.17	1E-04	***	11.23	1E-04	***	11.74	1E-04	***
AR	–0.23[a]	1.E-04	***	–0.21[a]	1E-04	***	–0.19[a]	7E-04	***	–0.17[a]	1E-04	***	–0.22[a]	1E-04	***
FA	0.05[a]	0.49		0.10[a]	0.14		0.05[a]	0.43					0.06[a]	0.16	
SP	–0.34	0.06	*	–0.65	0.02	***	–0.53	0.18		–0.54	0.17		–0.46	0.11	
LV	–0.03	0.09	*	–0.07	0.08	***	–0.07	0.08	*	–0.07	0.08	*	–0.06	0.03	**
RD	1.7E-05	4E-03	***	–0.09	2E-03	***	–0.16	1E-04	***	–0.16	1E-04	***	–0.20	1E-04	***
SV	1.83[a]	1E-04	***	0.13	1E-04	***	0.12	1E-04	***	0.12	1E-04	***	0.11	1E-04	***
LC	–0.58[a]	3E-03	***	–0.06	0.14		–0.04	0.12		–0.06	0.02	**	–0.04	0.04	**
TS	–0.13[a]	4E-04	***	–0.06	1E-04	***	–0.06	1E-04	***	–0.06	1E-04	***	–0.06	1E-04	***
MC	0.58[a]	1E-04	***	0.91	1E-04	***	0.76	1E-04	***	0.75	1E-04	***	0.67	1E-04	***
RG	0.23[a]	0.28					0.16[a]	0.38							
R^2 Adjusted	0.78			0.79			0.99			0.99			0.99		
U-Theil´s	0.36			0.36			0.05			0.05			0.04		
CIA	126.91			120.20			632.23			629.56			488.83		
CIS	159.96			150.24			665.27			656.60			517.96		
Breusch-Pagan test	0.14			1E-10			0.01			0.42			0.99		
Autocorrelation LM test				0.86			0.96			0.84			0.96		
Normality test	0.06			3E-04			1E-04			7E-05			0.46		

[a] Independent variable with logarithmic transformation.

The econometric equation of model 5 that predicts the land price in Oreamuno, Costa Rica, is as follows:

$$l(V) = 11.74 - 0.22l(AR) + 0.06l(FA) - 0.46SP - 0.06LV -$$

$$-0.20RD + 0.11SV - 0.04LC - 0.06TS + 0.67MC \quad (2)$$

The main descriptive statistics of the observations used in model 5 are summarised in Table 4, for a final sample size of 136 observations (without outliers). The sample was characterised by an average unit price of 225.19 USD/m^2, with values fluctuating in a wide range, reaching up to 638.90 USD, possibly affected by the capital gain according to the level of urban development of the area where the properties are located.

Model 5 was used to estimate the prices of nine properties in Oreamuno and compare them with the values updated by the Municipality for tax collection. The properties were randomly selected from the sample and were located in different localities (Table 5).

In all cases of comparison, the proposed model presents differences greater than 100 % in the values per square meter, which represents significant increases in land value. Therefore, the incorporation of variables in the valuation model that measure the distance to the train and the availability of mobile coverage could strengthen the estimation of the price of real estate in Oreamuno in order to improve tax collection.

Table 4. The Main Statistics of the Properties with a Sample of 136 Observations

Variable	Mean	Median	Minimum	Maximum
V	225.19	221.99	10.18	638.90
AR	996.70	317.50	136.00	15900.00
FA	25.69	14.23	3.00	192.54
RG	0.92	1.00	0.50	1.00
SP	0.11	0.05	0.02	0.90
LV	0.18	0.00	–5.00	2.00
RD	4.03	4.00	2.00	10.00
SV	15.45	16.00	6.00	16.00
LC	4.90	5.00	3.00	8.00
TS	2.53	1.70	0.03	20.00
MC	0.86	1.00	0.15	1.00

Table 5. Differences in the Unit Price with Respect to the Values of the ONT Model and Model 5, for Nine Properties Located in Six Locations in Oreamuno, Costa Rica

Property	Location	District	Difference in price, %)
1	1	Potrero Cerrado	453 %
2	2	Cot	335 %
3	3	Potrero Cerrado	231 %
4	4	Cipreses	231 %
5	5	Santa Rosa	168 %
6	6	San Rafael	308 %
7	6	San Rafael	244 %
8	6	San Rafael	458 %
9	6	San Rafael	447 %

The properties with the highest value per square meter are located in the San Rafael neighbourhood (6), which has a higher level of urban development and is closer to the metropolitan area. The other localities are farther away and have a lower value per square meter. These results show a significant percentage increase in land value when applying the model suggested in this research, compared to the prices updated by the local government of Oreamuno based on ONT model.

DISCUSSION AND CONCLUSIONS

The results of this research demonstrate that the distance to the nearest train station and the level of mobile coverage are significant in explaining changes in land value, in combination with the other variables included in the ONT model.

This research highlights the importance of updating valuation models with the

incorporation of new factors, mainly when change in the economic development of communities is evident. Having a land valuation model at the regional level allows local governments to update the value of real estate in an accurate and objective manner, as long as variables specific to the area of interest are included.

In the case of Oreamuno, Costa Rica, valuation models could be strengthened by incorporating variables related to access to public services. Variables such as "distance" can be used when the delimitation of zones is not always done at the cadastral level, as it can cause inconsistency by locating the property in two or more homogeneous zones at the same time.

The explanation of land value in relation to the level of mobile coverage and access to interurban transportation suggests that, as access to these types of services improves in a specific geographic area, property values will increase, which will benefit property owners with lucrative activities and improve local government tax collection.

With the improvement of ONT methodology, local governments are encouraged to update their mass valuation models with the incorporation of proxy variables that measure the characteristics of the area under analysis. In addition, updating property values could mean an increase in property tax collection, which is consequently invested in the improvement of public infrastructure, benefiting the economic development of the localities.

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