Analysis of Impact of Introduction of Bus Rapid Transit on Land Price in Developing City - Case Study of Managua city, Republic of Nicaragua -

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Abstract

Most of the cities in developing countries are car-dependent, which causes traffic congestion. In order to decrease traffic congestion, Bus Rapid Transit (BRT) is introduced. In addition, it is not only necessary to convert demand from automobile-use but also to form urban corridors along the BRT routes and make significant changes to the urban structure. In that sense, it is also essential to estimate external effects such as urban development in the evaluation of BRT introduction. Therefore, in this study, we focused on changes in asset value as one of the external effects of introducing BRT and analyzed the impact of the introduction of BRT. This asset value is defined as land price. In analyzing the impact of its introduction, the land price data was collected from the website of real estate and a land price formula with explanatory variables such as the convenience of transportation, house quality, shopping convenience, and the Possibility of landslides, was derived by using the hedonic price approach. And then, the difference in land prices with/without the introduction of BRT was analyzed. As a result, land prices in the zones along BRT lines but also suburban zones have risen. This result means that was spread the impact of the introduction of the BRT system to the entire city. In conclusion, it was clarified that the introduction of BRT would have a substantial effect not only on the transportation market but also on the external market such as real estate and contribute to the development of the urban areas.

Keywords: Developing city, BRT, Land price, Hedonic price approach.

1. Introduction

Taking the success of Curitiba and Bogota as a precedent in many developing cities that depend on automobiles, in recent years, BRT was introduced to reduce demand from automobiles and the severe traffic congestion. Therefore, many existing studies on the introduction of BRT have analyzed the impact of passenger demands. For example, Bocarejo et al. [1] analyzed land use and population changes by the introduction of BRT in Bogota and evaluated from the viewpoint of urban. The study by Rodriguez et al. [2] estimated the impact on the real estate value in urban areas after BRT was introduced using the Hedonic Price Approach. However, in the cities where BRT has been successfully introduced, the demand conversion from automobiles and the city corridor centered on BRT line is formed, and the urban structure is mostly changed. In that sense, n the evaluation of the impact of BRT, it is necessary to measure not only the effects within the transportation market such as the alleviation of traffic congestion but also the outside market such as the urban development along BRT lines. In order to measure the impacts on the introduction of BRT, including these external effects, it is adequate to measure the fluctuation of asset value along BRT lines before and after its introduction.

Therefore, in this study, we derived the land price formula, including explanatory variables such as the convenience of transportation and calculated change of land price each zone with and without the introduction of BRT. Notably, the factors of the rise in land prices were considered from the view of the synergistic effects of the introduction of BRT and residential environment. This study selected Managua city, Nicaragua, where has the plan of the introduction of BRT [3] as a case study.

2. Literature Reviews

Many studies estimated the impacts of BRT from planning to the introduction. Many researchers have mainly discussed the benefits and issues related to cost and the environment of BRT and obtained much knowledge. In existing research, the impact of the introduction of BRT is enormous. Moreover, it has a significant impact on the environment along the BRT lines. In addition to existing studies, as stated in section 1, Estupinan et al. [4] analyzed the relationship between the built environment of BRT stations and BRT demand in Bogota. They found that pedestrians' environmental support and deterrents to car use was related to higher BRT demand.

On the other hand, in many studies, the hedonic price approach has been applied to understand the relationship between property prices and characteristics. "Hedonic price approach" was firstly proposed by Rosen [8]. The approach was implemented in the real estate industry. In other existing studies, the real estate price was estimated by using the hedonic price approach by the influences due to the introduction of transportation systems (e.g., train, Light Rail Transit, BRT) [9-16]. Furthermore, to understand the impacts of various natural disasters (e.g., flood risk, earthquake, landslide, etc.) on house prices, the relationship between flood damage and housing prices were analyzed [17-19]. These studies have clarified the impacts of changing environmental quality (e.g., the introduction of new transportation systems and flood risks, etc.) using the hedonic price approach.

However, these studies are not sufficient to analyze the fluctuations in house prices under the introduction of the transportation systems that positively affect housing prices and flood risk that negatively affects housing prices. Additionally, almost studies have not been analyzed the external effects such as real estate by synergistic effects of the introduction of BRT and residential environment. Thus, to clarify the impact of urban development along BRT corridor, it is essential to analyze the change of land price from the view of the effects of the introduction of BRT and residential environment.

3. Estimation of Land Price

3.1 Study Area

In recent years, residential areas for high - income people such as condominiums have spread in low density in the suburbs, and the urban area is gradually expanding. Since traffic congestion has become more severe due to the modal shift from public bus to passenger car use has increased. To tackle this problem, the government is planning four routes of BRT along the main roads in the city.

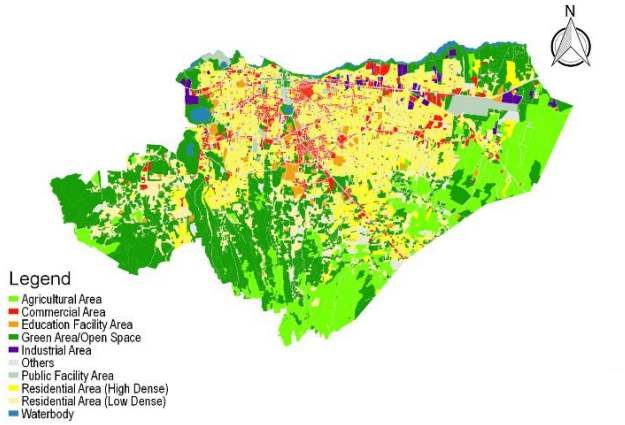

Fig. 1 Land Use in Managua (2016) [3]

3.2 Data Collection

In this study, we estimated the impacts of land prices by the opening of BRT on each zone, which divided into 27 zones based on the traffic analysis zone and four planned BRT routes (Juan Pablo II Line, Masaya Line, Saburbana Line, Panamerican Line), as shown in Fig. 2.

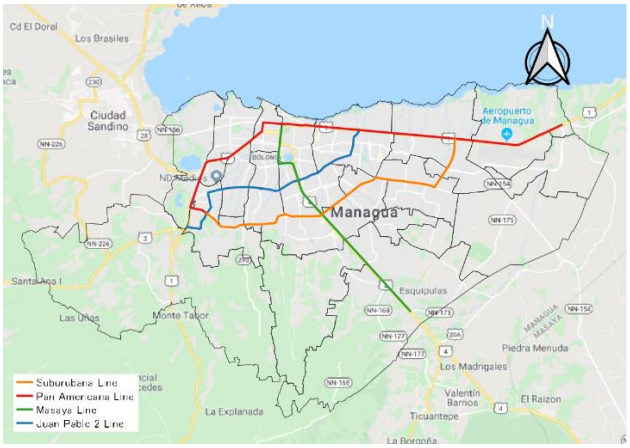

Fig. 2 27 zones and planned BRT routes

All land prices have to contain exact coordinates for analysis that the point belongs to which zone, and all zones should have at least a few points for estimation. In this study, 136 points of land price data were collected, as shown in Fig. 3.

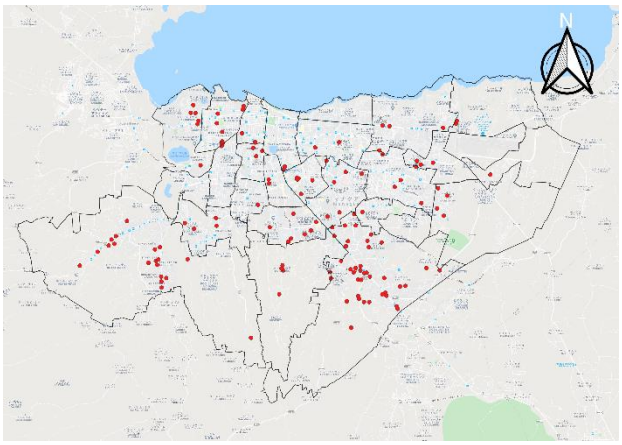

Fig. 3 The Data collection point of land price

3.3 Hedonic Price Approach

Hedonic Price approach is to understand the relationship between dependent variables and independent variables. The equation of the hedonic price approach could be written in the classical linear regression as follow:

$$Y_i = \beta_0 + \beta_1 X_{i1} + \mathrm{K} + \beta_k X_{ik} + \varepsilon_i \qquad (1)$$

Where,

Y= vector (n×1) of observations coresponding to dependent variable, X= matrix (n×k) of observations of k independent variables, β = vecotr (k×1) of regression parameters, and ε = vector (n×1) of random errors.

The hedonic price method is based on the theory of capitalization hypothesis. This hypothesis is that the flow effect is capitalized as a stock to a price. In this way, environmental improvement and social capital development are reflected in land prices and housing prices. In this study, we selected the variables that can be classified into five categories, BRT maintenance, facilities, disasters, location, and environment, to estimate the land price function.

Also, explanatory variables, such as the number of facilities and the city center's distance using the surrounding environment in the hedonic price approach, were collected from Google Maps and Geographic Information System (GIS). Details of the explanatory variable are shown in Table 1.

Table 1 Explanatory variables

Categories	Item	Range	Method
Locations	Distance from city central	Point	Google map
	House located in hill	Point	GIS
	Distance from nearest bus stop	Point	GIS
Environment	House quality	Point	Website
	Road pavement	Point	Google map
Disaster	Earthquake occurs possibility	Point	GIS
	Flood occurs possibility		GIS
	Landslide occurs possibility		GIS
	Earthquake occurs possibility	Within 500m	GIS
	Flood occurs possibility		GIS
	Landslide occurs possibility		GIS
	Earthquake occurs possibility	Zone	GIS
	Flood occurs possibility		GIS
	Landslide occurs possibility		GIS
Facilities	stores	Within 500m	Google map
	services		
	religion		
	medical		
	restaurant		
	recreation		
	school		
BRT	*No of route*	*Within 1km*	*GIS*
	Distance to line	*Point*	*GIS*

3.4 Variable Selection

As stated in the previous section, the hedonic price approach is a methodology that uses an explanatory variable to estimate a land price function. In this study, the variables which are not filled the criterion are gradually reduced using the p-value of each variable. And then, this process is repeated until all variables have p-values under 0.05. At first, 14 explanatory variables were set as variables of the land price formula of the case without BRT, as shown in Table 1. Finally, four explanatory variables (House location, House quality, Possibility of landslide and, number of stores) were narrowed down.

4. Results

First, the result (Coefficient, t-value, p-value) has shown the land price estimation before introducing BRT using the four variables. From this result, it was revealed that land price is greatly affected by the quality of housing and whether or not the residential land is on the hill (coefficient: 0.280, 0.435). On the other hand, the result of land price function, including some variables about the BRT has shown in Table3. This result has shown that variable of the number of BRT within 1 km has not filled with p-value (within 0.05). However, at this time, we estimated these parameter values for an understanding of the effects of introducing the BRT.

Table 2 Result of the case without BRT

	Coef.	t-stat	p-stat	Sig
β_0	10.266	69.126	5.9×10^{-105}	*
β_1	0.280	2.089	3.9×10^{-2}	*
β_2	0.435	3.815	2.1×10^{-4}	*
β_3	0.082	2.511	1.3×10^{-2}	*
β_4	0.023	2.407	1.7×10^{-2}	*
Adj. R^2		0.26		
N		136		

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i3} + \beta_4 X_{i4} + \varepsilon_i \quad (2)$$

Where,

y_i= land price of zone i, β = vector of regression parameters (1:hill, 2: house quality 3: the Possibility of landslides, 4: number of stores within 500m).

Table 3 Result of the case with BRT

	Coef.	t-stat	p-stat	Sig
β_0	10.226	69.126	5.9×10^{-105}	*
β_1	0.280	2.089	3.9×10^{-2}	*
β_2	0.435	3.815	2.1×10^{-4}	*
β_3	0.082	2.511	1.3×10^{-2}	*
β_4	0.023	2.407	1.7×10^{-2}	*
β_5	0.083	0.811	4.0×10^{-1}	*
Adj. R^2		0.265		
N		136		

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i3} + \beta_4 X_{i4} + \beta_5 X_{i5} + \varepsilon_i \quad (3)$$

Where,

y_i= land price of zone i, β = vector of regression parameters (1:hill, 2: house quality 3: the Possibility of landslides, 4: number of stores within 500m, 5: the number of line within 1 km).

R2 value is approximate 0.26. Generally, the accuracy of the estimation is high when R2 value exceeds 0.8. However, this estimation result was in low efficiency. It is considered that the collected data cause the reason for the bias.

Fig. 4 shows the land prices each zone before and after the introduction of BRT. Land prices in suburban zones along BRT lines tend to be higher than in other areas. This result means that it is inconvenient to access the city center by public transportation at present. Then it is expected that the rising land prices will be exceptionally high because the access to the city center is likely to improve after the introduction of BRT.

Besides, Fig. 5 shows the change in land prices before and after the introduction of BRT in different colors. Similarly, land prices of more than half of the zones along BRT routes were gone up. On the other hand, the land price of other zones without BRT routes was declined. Zone1 is the only central zone where the land price rises significantly. The reason is why the three BRT lines pass through in the zone, and the zone has high convenience of transportation and shopping. Hence, it is assumed that the land price will rise even more if the urban area along the line further developments due to the introduction of BRT.

On the other hand, the land price in zones much farther from BRT lines was declined because the number of BRT lines within 1km selected as an explanatory variable in the hedonic price approach. However, a few zones fell the land prices significantly, located near the city center, and passed BRT lines near the administrative boundary. This result is because the selected point of land price as an explanatory variable is further from the BRT lines. To solve this problem, It is thought that obtaining many samples and conducting analysis in smaller administrative units.

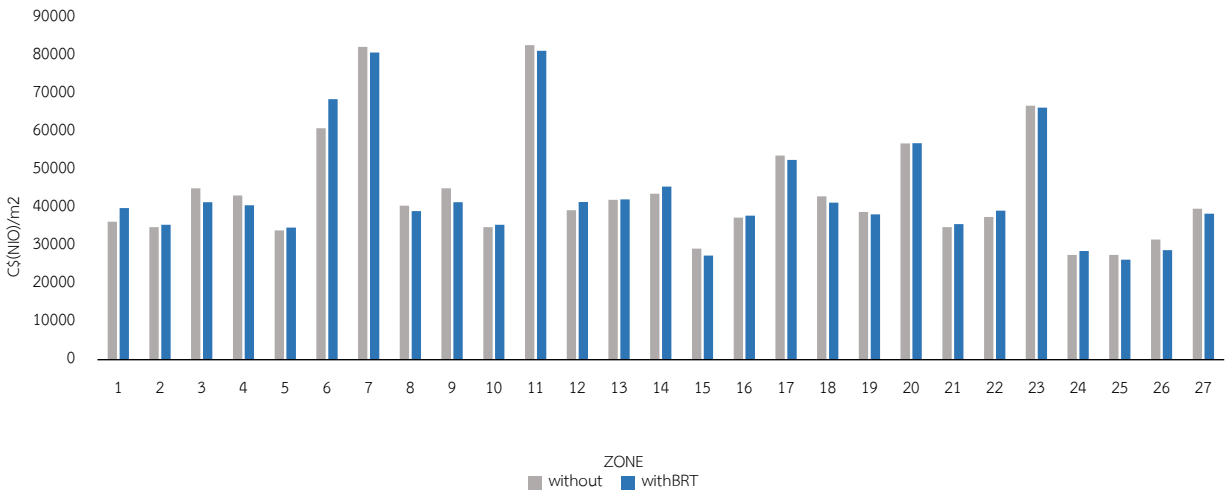

Fig. 4 Estimated land prices each zone

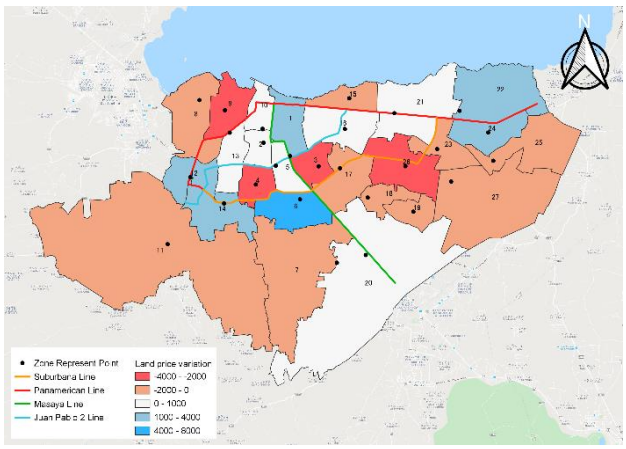

Fig. 5 Change of land price

5. Conclusions and Discussion

In this study, the difference in land prices was defined as the change in asset value. Moreover, the impact of the introduction of BRT was evaluated by using a land price formula which has explanatory variables such as the convenience of transportation, house quality, shopping convenience, and the Possibility of landslides. As a result, it was revealed that land prices would rise in most zones along BRT lines after its introduction. This result means that it is the impact of introducing BRT. In other words, the land price of the zones was fluctuated wildly depending on the introduction of BRT. The fluctuation range of the zones where land prices declined is average 4.3%, the range of the zone where land prices rose is 3.8%. The specific point is that the suburban zones along the BRT lines are most affected. This is why it is inconvenient to access the city center by public transportation in suburban zones at present, and access to the city center is expected to improve after the introduction of BRT.

In conclusion, it was found that the land price fluctuation, which is one of the external effects, spreads to the whole city by the introduction of BRT. Notably, the land price in the zones along the BRT lines has significantly risen. And then, it is assumed that the introduction of BRT would be contributed to the urban development along the BRT line. On the other hand, land prices in the zones without BRT would be declined. This result means that it is assumed that the difference in land prices would be increased in the city. Consequently, to lead to equable urban development in the city, it is necessary to cover the BRT network in a whole city.

For future studies, it is necessary to collect more realistic land prices because the land price on the real estate website, which was referred to in this study, is high estimation compared with its standard of Managua city.

References

[1] Bocarejo J P, Portilla I, Pérez M A. (2013). Impact of Transmilenio on Density, Land Use, and Land Value in Bogotá: *Research in Transportation Economics*, Vol.40, pp.78-86.

[2] Rodriguez D A, Mojica C H . (2009). Capitalization of BRT network expansions effects into prices of non-expansion areas: *Transportation Research Part A,* 43, pp.560-571.

[3] Japan International Cooperation Agency. (2017). Project for Urban Development Master Plan for Managua City in Republic of Nicaragua.

[4] Estupinan N, Rodoriguez D A. (2008). The relationship between urban form and station boardings for Bogota's BRT: *Transportation Research Part A: Policy and Practice*, Vol.42, pp.296-306.

[5] Nicaragua classifieds, Encuentra24.com (2019). https://www.encuentra24.com/nicaragua-en/classifieds.

[6] Living Wage Series – Nicaragua – January 2018 – In Cordoba Oro, per Month (2018). https://wageindicator.org/salary/living-wage/nicaragua-living-wage-series-december-2018.

[7] Rosen, S. (1974). Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. *Journal of Political Economy*, 81, pp.34-55.

[8] Tsutsumi M, Seya H. (2008). Measuring the impact of large-scale transportation projects on land price using spatial statistical models: *The regional science association international*, Vol.87, pp.385-401.

[9] Sasaki T, Sato T. (2016). The long-run impact of development of LRT on household distribution in Utsunomiya city, *Japan: Journal of the City Planning Institute of Japan*, Vol.51, No.3, pp.715-721.

[10] Suzuki K, Morioto A, Kanda M. (2012). Study on land use change along the railway line by introducing LRT: *Japan Society of Civil Engineers*, 45.

[11] Mochizuki A, Nakagawa D, Kasahara T. (2008). Analysis of the effectiveness of the improvement of service level of public transportation as city axis in Toyama city: *Journal of the City Planning Institute of Japan*, No.43-3, pp.805-810.

[12] Deng T, Nelson J D. (2010). The impact of bus rapid transit on land development a case study of Beijing China: *World Academy of Science, Engineering and Technology*, Vol66.

[13] Xue C, Ju Y, Li S, Zhou Q. (2020). Research on the Sustainable Development of Urban Housing Price Based on Transport Accessibility: A Case Study of Xi'an, China*: Sustainability*, 12(4), 1497.

[14] Dziauddin F M, Powe N, Alvanides S. (2014). Estimating the Effects of Light Rail Transit (LRT) System on Residential Property Values Using Geographically Weighted Regression (GWR): *Applied Spatial Analysis and Policy*, 25pp.

[15] Dziauddin F M, Alvanides S, Powe N. (2013). Estimating the Effects of Light Rail Transit (LRT) System on the Property Values in the Klang Valley Malaysia: A Hedonic House Price Approach: *Journal Technology* 61 (1), pp.35-47.

[16] Speyrer, F J. and, Ragas, R. W. (1991). Housing Prices and Flood Risk: An Examination Using Spline Regression, *Journal of Real Estate Finance and Economics*, 4, pp.395-407.

[17] Isamail H N, Karim A Z M, Basri H B. (2019) Hedonic Analysis of the Impact of Flood Events on Residential Property Values in Malaysia: A Study of Willingness to Pay: *Malaysian Journal of Economic Studies*, 56(1), pp.63-84.

[18] Egbenta I R, Udo G O, Otegbulu A C. (2015). Using Hedonic Price Model to Estimate Effects of Flood on real Property Value in Lokija Nigeria: *Ethiopian Journal of Environmental Studies & Management,* 8(5), pp.507-516.