The Empirical Study of Rail Transit Impacts on Land Value in Developing Countries: A Case Study in Bangkok, Thailand

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The three existing rail transit lines in the Bangkok, the so-called BTS Skytrain, Bangkok, MRT Subway, and Airport Rail Link, have been launched in 1999, 2004, and 2010 respectively. The extensions of other lines are currently under development. That development of rail transit brings the large benefit and drives the changes of land value.

However, to what exactly drives up the land value as it has strongly been influenced by rail transit development is still less investigated in a city of developing countries. The purpose of this study is to examine the impact of rail transit development on the land value with the real evidence in the Bangkok. A context of regression framework is applied to interpret the value of land on the basis of independent variables. Among the independent variables, they are mainly classified into three categories: location factors, neighborhood attributes, and land use attribute. The hypothesis used is that rail transit development significant benefit to the surrounding area.

Key Words : Land value, Urban rail transit, Regression model, Bangkok

1. INTRODUCTION

Since 1960, Bangkok has rapidly grown from being a small compact city located on the eastern area of the Chao Praya River to a large sprawling urban area in accordance with the emphasized plans of transportation infrastructures such as bridge and road network that accelerate urban development to the outside areas. However, the commercial and employment zoning are still in the inner core of the city. Such an urban structure brings a huge amount of travel demand and the increasing commuting distance. Therefore, it is hardly to keep away from the traveling by private car in order to reduce the travel time and get around conveniently. This gradually converted Bangkok into a car dependent city and made the city face critical traffic congestion.

Recently, the urban rail transit system has been introduced to alleviate the traffic issues. In December 1999, the first 23.5-kilometer elevated rail transit, the so-called BTS Skytrain, has started its service with two initial green lines: the 22-kilometer of Sukhumvit line and the 8.5-kilometer of Silom line. Five years later, the second 20-kilometer Bangkok Mass Rapid Transit (Chaloem Ratchamongkhon line or MRT Subway Blue line) was launched at underground level in July 2004. The third 28.5-kilometer Suvarnabhumi Airport Rail Link, also known as Airport Link has opened in August 2010. Nowadays travel by rail transit in Bangkok has increasingly obtained interest due to its safe, punctual, as well as

convenient service.

In the fact that land use and transportation has closed relationship, so it is claimed that development of rail transit unavoidably impacts on the area along the corridors. There are some attempts in Bangkok, property price and the number of building stock along BTS Skytrain corridor has remarkably increased in the research of Vichiensan et al (2011). It was concluded that the premium of transit accessibility adding to the property value is approximately $10 for every meter closer to station of BTS Skytrain as mentioned in Chalermpong (2007).

The benefit due to rail transit development also impact on the areas which is announced future extension. The objective of this study is to examine whether the urban rail transit investment has an impact on the land price. More specifically, the variations of the influences on the land price are clearly presented by incorporating the spatial effect, namely, spatial heterogeneity, so as to reveal the relationship that might vary across space. This relationship will valuable to the public agencies to tax the direct beneficiaries of their investments in the affected districts.

2. LITERATURE REVIEW

Many previous studies summarized and interpreted the association between land price or property value and transportation development using a regression framework.

Simple model is employed in Seoul and indicated that distance to Line-5 subway station has less impact than other factors such as quality of school district, proximity to high-status sub-center, and accessibility to recreational resource (Bae et al. 2003). Pan and Zhang (2008) showed the land value premium of proximity to train station in Shanghai.

The simple model assumes that relationship is constant over space. However, the relationship often might vary across space because the attributes are not the same in different locations. Recently, literatures in urban studies have shed light to the location variation of the impact by incorporating spatial heterogeneity: a situation that the measurement of a relationship depends in part on where the measurement is taken (Fotheringham et al. 2002). It is therefore useful to speculate on the relationship that might not be constant over space. And the statistical test for spatial heterogeneity was based on the geographically weighted regression model (GWR).

A study in Tyne and Wear Region, UK also employed GWR and found that the variation existing in the relationship between transport accessibility may have positive effect on land value (Du and Mulley, 2006).

3. STUDY AREA

This study is to examine the impact of urban rail transit on land price in Bangkok Metropolis. The city of Bangkok with the total area of 1,568.74 square kilometers, also known as a capital of Thailand, is divided into 50 districts and 154 sub-districts and governed by Bangkok Metropolitan Administration (BMA). The districts are divided into three groups based on the settlement of community: inner city (22 districts), urban fringe (22 districts), and suburb (6 districts). The population increased from 2.14 million in 1960 to 6.36 million in 2010 with an average annual population growth rate of 3.6% (National Statistical Office) and produces 44.2% of the country's GDP. This shows that the Bangkok is a major economic center of the country.

4. MODEL SPECIFICATION

In this study, two types of model specification are presented. Global regression model is a reference model and geographically weighted regression model is to shed light on the spatial effect vary across space.

(1) Global Regression

Regression analysis is used to interpret the relationship between one (or more) dependent and a number of independent variables. The global regression equation of land price can be written as follow:

$$Y = \beta_0 + \beta_1 X_1 + ... + \beta_k X_k + \varepsilon \qquad (1)$$

Equation (1) can be written more compactly as:

$$\mathbf{Y} = \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon} \qquad (2)$$

Where Y is the land price of observation, X is the attributes of the land price of observation, ε is the random error term of observation and β is the coefficient parameters of each attribute.

Classical ordinary least squares (OLS) is obtained by assuming the errors to be normally distributed with an expected value of 0 and the solution for the coefficients is obtained as:

$$\boldsymbol{\beta} = (\mathbf{X'X})^{-1}\mathbf{X'Y} \qquad (3)$$

(2) Spatial Regression

Geographically weighted regression (GWR) is the term used to describe a family regression model in which the coefficients, β, are allowed to speculate on the relationship that might not be constant over

space. (Fotheringham et al., 2002)

The regression model in Equation (2) may be re-written for each local model at observation location i at the coordinates u, v as follows.

$$Y_i = \beta_0(u_i, v_i) + \beta_1(u_i, v_i)X_1 + ... + \beta_k(u_i, v_i)X_k + \varepsilon_i \quad (4)$$

Equation (4) can be written more compactly as:

$$\mathbf{Y} = \mathbf{X}\boldsymbol{\beta}(\mathbf{i}) + \boldsymbol{\varepsilon} \quad (5)$$

Where the sub-index i indicates an observation point where the model is estimated. The coefficients are determined by examining the set of points within a well-defined neighborhood of each of the sample points. This neighborhood is essentially circle, radius r, around each data point. However, if r is treated as a fix value in which all points are regarded as of equal importance, it could be include every point (for r large) or alternatively no other points (for r small). Instead of using a fixed value for r it is replaced by a distance-decay function (De Smith et al. 2007).

A simple function may be defined such as f(d)=exp(-d^2/h), where d is the distance between the focus point and other points, and h is a parameter, so-called bandwidth.

Using the function and bandwidth, h, a diagonal weighted matrix, W(i) where is the geographically weighting of each of the n observed data for point i, may be defined for every sample point, i, with off-diagonal elements being 0. The parameters β(i) for this point can be determined following the framework of global regression, the local parameter estimates can be obtained:

$$\boldsymbol{\beta}(\mathbf{i}) = (\mathbf{X'W(i)X})^{-1}\mathbf{X'W(i)Y} \quad (6)$$

5. LAND PRICE MODELING

This section consists of two subsections. The first subsection is to describe the dependent and independent variables which will be used in the estimation. Next, the second subsection is to summarize and interpret the results of land price model for Bangkok Metropolitan Area.

(1) Dependent and independent variables

The variables in this study, which were obtained from the various sources, are summarized in Table 1.

Land price data was obtained from the assessed land value reports, which were published by The Treasury Department, Thailand. The period time of land price is during the year 2008 and 2011.

Location factors, in term of transportation and centers of activities accessibility including distance to rail transit station, main road, expressway ramp (as in entrance ramp), shopping center, and the central business district (CBD), were measured by the straight line distance. As a difficulty to identify the boundary of the CBD, hence, Siam Square was assigned to be the CBD of Bangkok Metropolis because there are the centers of activities, e.g., shopping center and employment area. For the location, the hypothesis is the shorter distance, the more valuable they are.

Table 1 Description of variables

Variables	Description
Dependent variable	
PRICE	Land price (baht/sq.m)
Independent variables	
Location factors (Straight line distance)	
DIST_RSTA	Distance to the nearest railway station (km)
DIST_MR	Distance to the nearest main road (km)
DIST_CBD	Distance to CBD: Siam Square (km)
DIST_SHP	Distance to the nearest shopping center (km)
DIST_EXP	Distance to the nearest expressway ramp (km)
Neighborhood attributes	
POP_DENS	Population density (persons/sq.km)
M_INC	Median income (baht)
H_DENS	Household density (households/sq.km)
EM_DENS	Employment density (positions/sq.km.)
Land use attribute	
RES	Residential use (1/0)

Employment density, obtained from the transportation model of Bangkok Metropolitan Region as known as e-BUM, was chosen to determine the effect of neighborhood attribute.

Finally, the land use attribute is presented by a dummy variable. The value is set to 1 if that land parcel is used as residential type, and set to 0 otherwise. Residential type in this study means a single house and townhouse, combines with the high-rise building for residence, both condominium and apartment. As mentioned, these four types of housing are grouped into residential type. Other types are grouped into non-residential type, for example, an office building, recreation, leisure, and so on.

(2) Results of land price model

The two types of land price models, i.e., OLS and GWR were calculated. The results summarized in Table 2.

The OLS model is estimated where the resulting coefficients are global meaning that the coefficients are constant over the study area.

Table 2 Results of land price models

Variable	OLS		GWR		
	Coef.	t-stat	Min	Max	Mean
Explanatory variables					
Location factors (Straight line distance)					
ln(DIST_RSTA)	11.942	6.666	-370.591	14.163	-3.408
ln(DIST_MR)	-14.220	-12.077	-51.482	1,044.308	-6.801
ln(DIST_SHP)	11.724	6.095	-344.720	13.259	-2.007
ln(DIST_EXP)	6.999	3.836	-479.134	2,641.687	0.631
ln(DIST_CBD)	-59.656	-16.938	-2,396.841	292.360	-16.749
Neighborhood attributes					
EM_DENS	7.431	5.419	-56.930	761.699	-0.046
Land use attribute					
RES (1/0)	-14.727	-3.780	-100.579	76.724	-8.246
R^2		0.507		0.805	
Residual sum of squares		3,299,515		1,305,361	
Number of observation		1,368		1,368	

a) Effects of location factors

The OLS model shows that the distance to main road and the central business district (CBD) have negative sign indicating that the shorter distance from each land parcel to those sites, the more valuable it is. As mentioned above, it claimed that the land parcel with greater accessibility is more expensive due to convenience to commute and travel. Nevertheless, the distance to rail transit station, shopping center, and expressway ramp have positive coefficient. Although, the distance is too far, the land price is not decrease.

b) Effects of neighborhood attributes

Let notice the table, the coefficient of employment density has positive sign, indicating that the high-density of employment location influences on the land price uplift.

c) Effects of land use attribute

The model result shows the residential land type has negative sign indicating negative impact. Not surprisingly, residential land parcels are less valuable than non-residential land parcels.

The goodness-of-fit is evaluated by the coefficient of determination (R^2) and residual sum of squares which are measured of how well the models are.

Next, based on the hypothesis that spatial effect, spatial heterogeneity, is present in the data. The spatial heterogeneity is examined by geographically weighted regression model (GWR). On the other hand GWR estimated a model at each data point.

Since, the GWR model gives local parameter estimates for each observation points, i.e., a total of 1,368 sets of estimates are obtained. However, in Table 2 shows only minimum, maximum, and average values. The estimation framework is the same trend as global regression (OLS model). The Fig. 1 to Fig. 4 show the coefficient at each observation point in this study that obtained from the GWR model. In addition, three of these figures present only the variables that are not have the intuitive sign in the OLS model. Another one present the land attribute variable.

Firstly, in Fig. 1 shows the distribution of the distance to rail station coefficient relationship to the

land price. It found that the coefficients are negative in red color until in light-orange color. In the figure, the orange color and light-orange color are located along the area near the rail transit network meaning that the areas where there are located near the rail transit corridor are the higher price than other areas. On the other hand, it found the positive coefficient in green color meaning that although the distance to be large, the price is not decreasing because the distance to station is too far. It is, therefore, the distance to station is not the primary influencing factor on the land price, for example, the green points in the top of figure is the area where the high-price of villages are located. The price is high because of the demand.
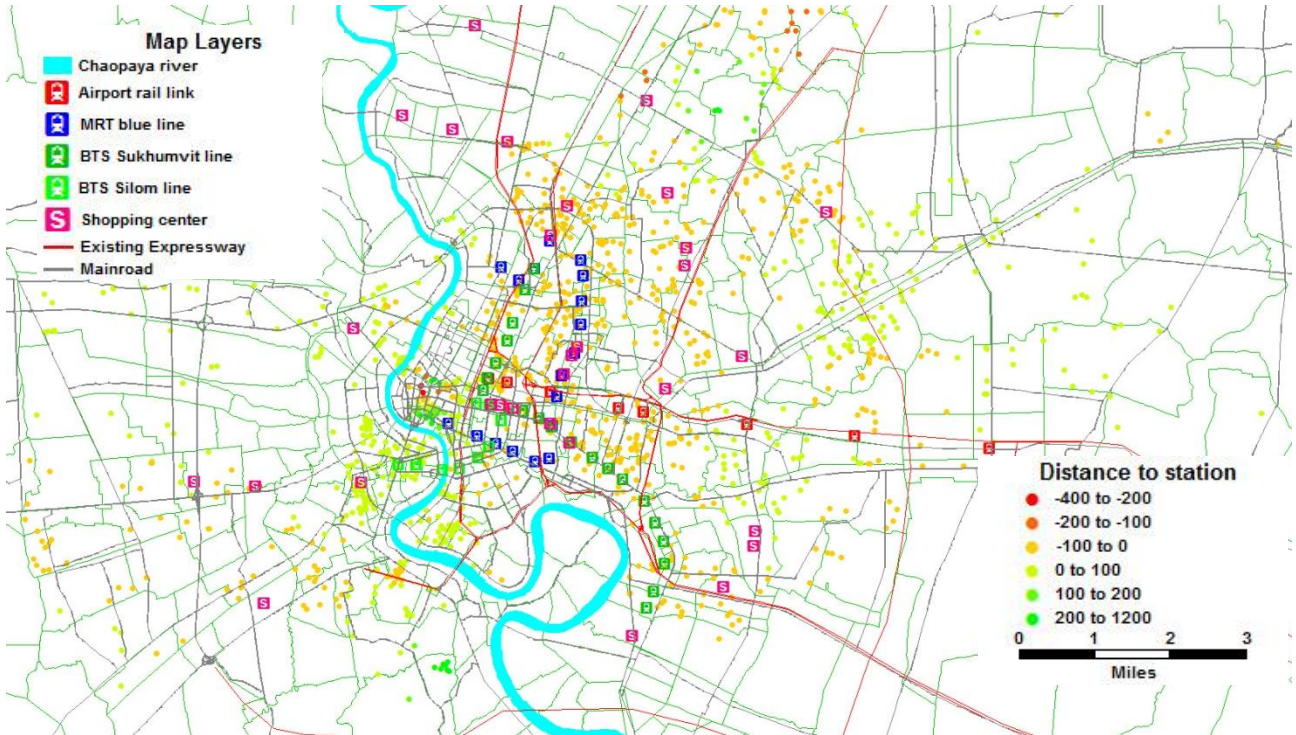

Fig. 1 The coefficient of distance to rail transit station
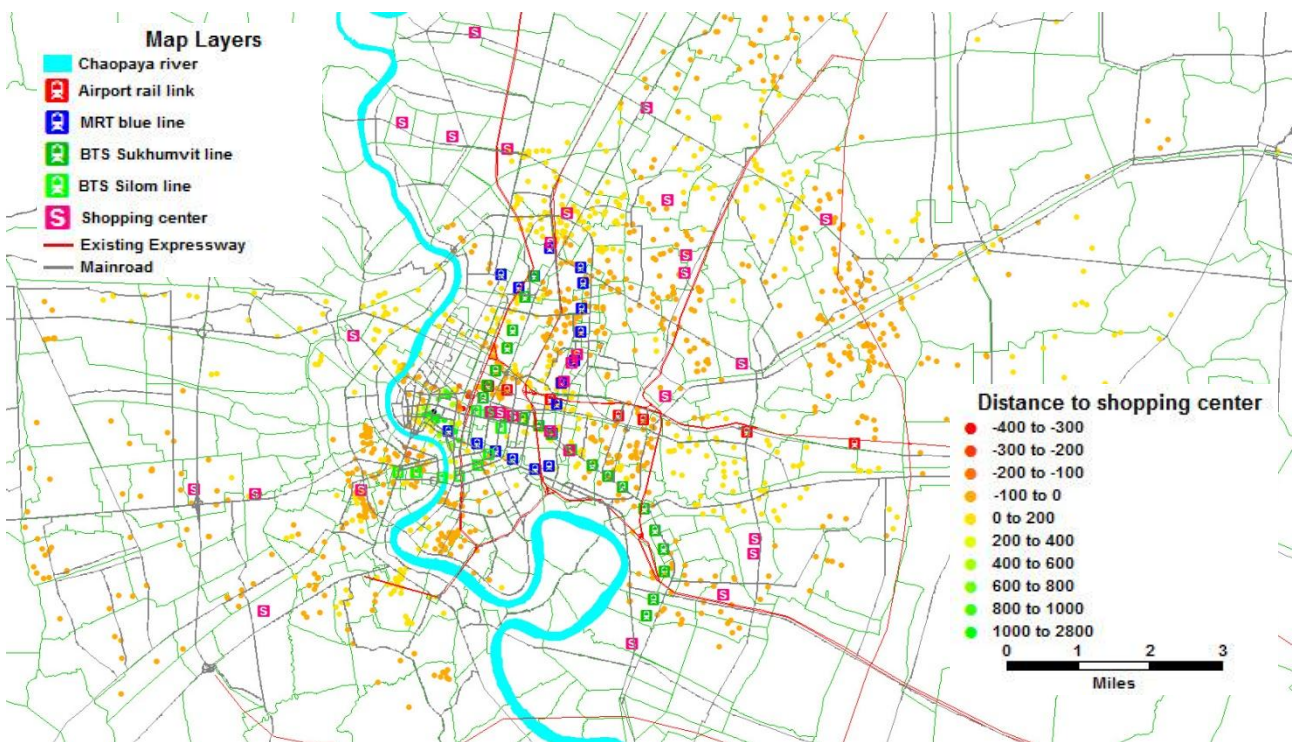

Fig. 2 The coefficient of distance to the shopping center

For the coefficient of the distance to shopping center, it has negative sign in red color until in orange color. Those colors are being located near the shopping centers in study area as can be seen in the figure. The shopping centers' mark is in pink color. By visual inspection in Fig. 2, land parcels where there are located surrounding each shopping center are negative sign meaning that short distance to shopping center, the higher price they are. More specifically, the coefficient in green color meaning than the price is not decreasing because the distance to shopping center is too far. The area in green color is known as
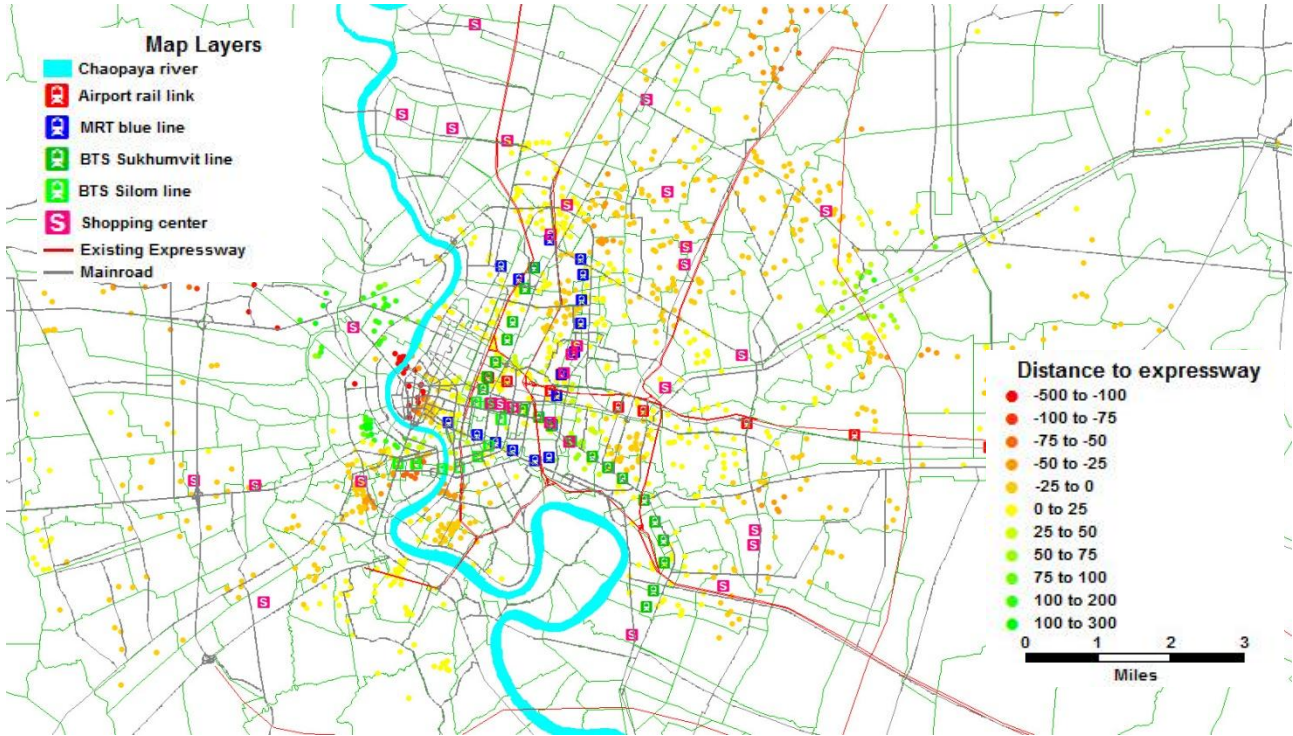

Fig. 3 The coefficient of distance to the expressway ramp (entrance ramp)
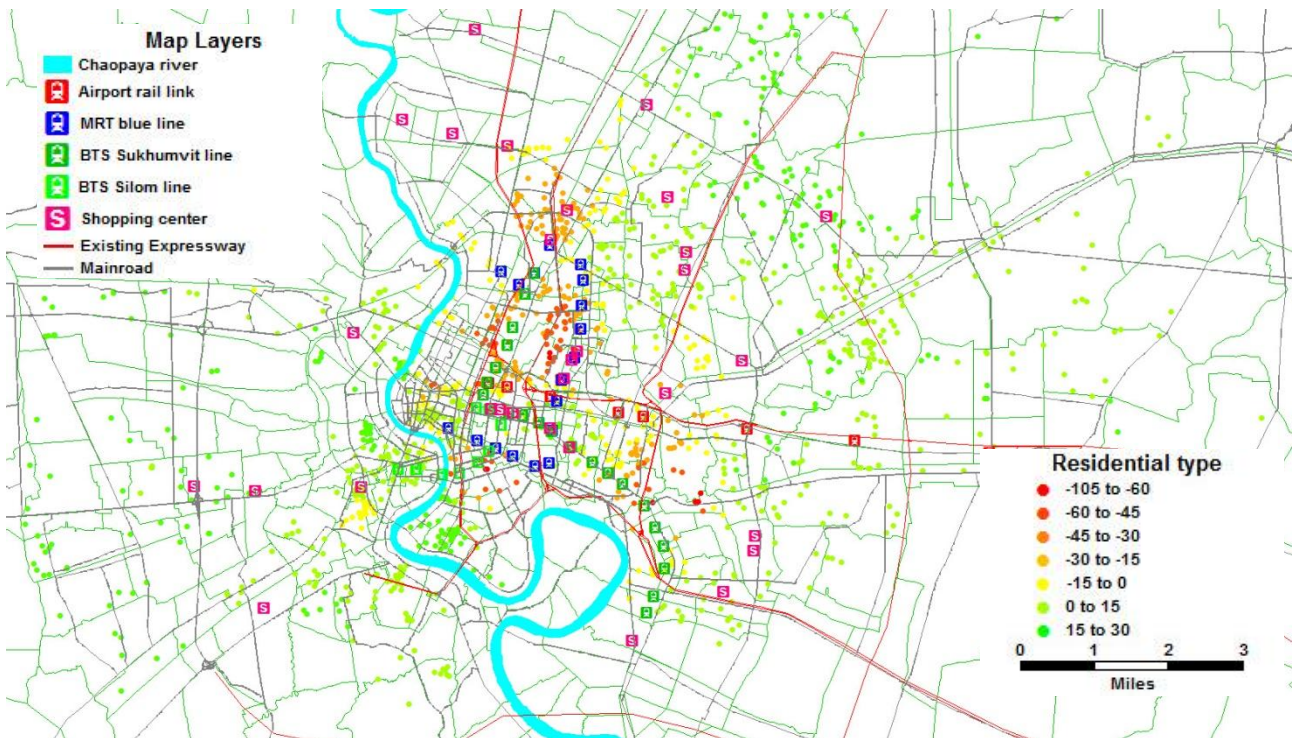

Fig. 4 The coefficient of residential type (dummy variable)

an old business center. There are many small streets and alleys full of shops and vendors.

Next, the coefficient of the distance to expressway entrance, it found that the coefficient is negative in red until light-orange where there are located in urban fringe and suburbs and also known as a high-density residential zone in Fig. 3. Due to the fact that most of people in Bangkok get around by their private car, hence, using the expressway is the best way to reduce the travel time to CBD. Whereas the coefficient is positive in yellow and green where there are located in CBD and served by rail transit. These results could be indicating that if the rail transit network is served, the mode choice will be shifted to public transport.

In Fig. 4 shows the coefficients variation in the relationship between land price and residential type. Let notice, the green color has positive sign meaning that it has the positive impact to the land price in these area. In contrast, it has negative impact to the land price in orange and red color. It is, probably due to the benefit of rail transit service, the price of land in its adjacent areas will be more valuable if they are used for non-residential type such as office building, recreation, and so on.

In term of goodness of fit is also evaluated using the coefficient of determination (R^2) and residual sum of squares. Let notice in table, it found that the GWR model is more outstanding than the OLS model indicating that the effect of each factor to land price spatially varies in the study area.

6. CONCLUSION

This study is to investigate whether the urban rail transit investment has an impact on the land price in the Bangkok Metropolis. The results is estimated and obtained using the context of regression framework. It is, furthermore, accommodating the spatial effect, i.e., heterogeneity which is estimated based on the geographically weighted regression model.

The findings in this paper clearly showed that the influence of rail transit impacts and other factors on the land price is not constant over space. The global regression provides information in selecting the independent variables. The local GWR model clearly points out the variations of the relationship between land price and distance to urban rail transit station. The price of land parcels is strongly influenced by the proximity to the rail transit station in the adjacent area. In contrast, rail transit proximity is not the primary influencing factor on the land price in the further area.

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