Analyzing the impact of accessibility on property price by using hedonic-price modelling for supporting urban land management towards TOD in Hanoi, Vietnam

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Abstract. Land and property price are determined by a number of characteristics, such as house-related characteristics and neighborhood-related characteristics. Accessibility to urban services and infrastructure is considered as an attribute group with a strong influence on this value. These impacts are diverse and complex, inconsistent, depending on each case study. The paper desires to use the linear regression method to evaluate the impact of accessibility to urban services and transportation on property prices in Hanoi. Some models were set up based on our assumptions on the relationship between accessibility-related attributes and estimated for 4 zones in the south of Hanoi and use them to compare the differences among these zones. Conclusions about the relationship between property prices and accessibility to transit, car-accessibility and accessibility to public amenities will help to enhance many ideas in managing land development in new centers established from Urban Mass Rapid Transit (UMRT) interchanges under the TOD concept - compact development, mixed land use, and easy accessibility.

1. Introduction

The idea of our article comes from the urban development initiatives associated with the public transport system (which is known as Transit–Oriented Development - TOD) and the land value capture (LVC) in the area around transit stations. A compact and diverse city with the support of public transport will make its neighborhood more accessible, easier to walk, and more complete [1]. In other words, the TOD model focuses on the construction of an urban established by a mass rapid transit in combination with the development of multi-functional economic and service centers in the surrounding area around transit stations. Tax revenue from the increase in land value due to improvements in infrastructure is considered a viable financial instrument to compensate for initial infrastructure investment costs. This measure has been effectively implemented in many developed countries such as the United Kingdom, Australia, and Denmark to collect taxes and fees from land development activities in the affected areas of railway stations and transit hubs. LVC has become a powerful tool to support local managers in promoting TOD strategies and initiatives.

The basis of LVC is based on evaluating the relationship between the value of land (or property) and their characteristics which are considered as the attributes of these special "commodities". Based on the traditional method of "hedonic-price modelling", there are two groups of characteristics, including attribute group associated with the property (describing the housing itself) and attribute group describing the area around the property such as location, density, accessibility to services and transportation... Many studies have shown that the relationship between property value and its characteristics is very complex, diverse, and varied in many cases.
Accessibility is considered as an attribute group affecting land and property prices. Accessibility characteristics may include access to the city center where many comprehensive services have already existed; accessibility to public transport and accessibility by private transport. According to TOD design principles, the affected area within a radius of 500 - 1000 meter around transit stations and hubs have good accessibility to public transport and services, diverse land use, high population, and employment density. Therefore, land and property prices in this affected area are often strongly influenced by the characteristics of TOD.

Hanoi and other major cities of Vietnam are now promoting projects to construct an urban mass rapid transit system such as urban railways, BRTs, and metros. Evaluating the attributes affecting the change of land and property price in areas with the support of public transport will help the city government control and develop the strategy to capture this added value and use that to support the city infrastructure reinvestment.

This paper focuses on analyzing the relationship between property prices and their accessibility characteristics in the context of Hanoi where the urban railway system is now under construction and the BRT service is limited. Using the log-log regression model method to evaluate the association of the property value function to the corresponding independent variables will help Hanoi’s policymakers to clarify some questions such as:

i. In the case of a private-vehicle dependent city, does accessibility to public transport such as buses have a positive impact on property value?

ii. Does accessibility to public facilities be an advantage and have a positive impact on property value in their service areas?

iii. In the tendency of replacing by the commercial centers, supermarket chains, and retail stores invested by large economic groups instead of small-scale or household business, whether access to business conditions will still strongly affect the property value as seen in commodity economy with many small-scale or household businesses?

This paper is considered as initial research on evaluating the impacts on land/property value in Hanoi according to TOD in the future. For a more comprehensive evaluation, it is necessary to expand the study analyzing all characteristic groups affecting land/property prices in areas around urban railway stations.

2. Literature review

In theory, housing itself has been considered as a “multi-dimensional commodity”, a “composite demand for a flow of services embodying a variable mix of characteristics” [2] and thus, these characteristics will decide the value of this house. A large number of studies have investigated the factors influencing the land and property price since the 1960s. The most frequently used method in these studies is the Hedonic price method, which has a long, established history for more than 50 years ago. One of the most famous and earliest studies from [3], who provided “a theoretical framework for analyzing a market for a single commodity with many attributes” [4]. In this paper, he defined hedonic prices as the implicit prices of attributes and be expressed by the economic values along with the specific amounts of characteristics. These characteristics are various, which can be the characteristics of the “commodity” itself or the characteristics of the external impacts affecting this “commodity”. The attractiveness of the “commodity”, in other words, the house value will be determined through the characteristics that will affect the attractiveness of the house. Therefore, when analyzing the hedonic price at the same time, the effects of market volatility can be eliminated, and by analyzing the hedonic price at many random locations, the hedonic price of housing properties can be revealed and then be used to estimate market value within the study area.

In hedonic-price modelling based on multiple regression analysis, explanatory variables can be divided into two types of characteristics, including those related to the structure built on the land and those related to the land location [5]. Structural-related factors include number of floors, direction, building material, etc., while determinants related to the house’s neighborhood consist of the house’s location such as the width of the road in front of the house or distance from the house to the main road.
and characteristics of surrounding areas such as population and employment density, street density, number of public facilities in the nearby area... [6]. It can be said that the house-related characteristics be considered as “static” attributes – quite consistent, while neighborhood-related characteristics are considered as “dynamic” attributes - easy to change according to the changes of the surrounded neighborhood. Therefore, when an area is renovated or has a newly investing infrastructure system, land and property value in this area will be influenced, normally in an increasing trend, and thus local government and investors can capture revenue from this extra value.

Accessibility characteristics can be categorized into three aspects: distance to the city center, transit accessibility, and automobile accessibility. CBDs have been considered as the most accessible and concentrated the highest number of urban amenities. Distance to CBD thus reflects the accessibility to the largest number and variety of activities. Many studies have shown many evidences about the significant inverse impact of distance to CBD on land price – the shorter the distance to the CBD, the higher the land values [5]. The relationship between property price and its distance to CBD has been studied in many developing countries and followed the same trend as in many developed countries [7]. In addition, with the trend of developing multi-centric cities based on public transportation, there is more and more research about the relationship between property price and its accessibility to new centers - transit hubs.

Generally, attributes evaluating the accessibility to public transport include distance to the nearest station or transit hub, number of stations, transit hubs which can be accessed within a 5-minute walking distance, variables evaluating the public transport service such as trip frequency, commercial services in the station, passenger satisfaction... Many empirical studies have shown that the effect of proximity to transit stations on land value has mixed impacts. [8] showed that commercial property prices increased when they located within 400-meter radius around a station and the increasing value not only depending on the distance to the station but also the type of transit technology. This research suggested that light rail systems had a “disamenity” zones, caused by noise, vibration or crime, outweighed the accessibility advantages. It is these “negative” points that can affect and diminish the positive effects of this public transport system. Meanwhile, [9] found that properties located within the first quarter-mile (about 400 meters) from a station in Atlanta were discounted by 19 percent compared to those located 3 miles (about 5 kilometers) away, while the properties within 1 to 3 miles (about 1.5 to 5 km) around the station had significant price premium. Similarly, [10] also concluded that housings located too close to the railway tracks had to suffer the price reductant. On the other hand, in the context of developing countries, [5] concluded the opposite result as in the above-mentioned research. Her research in Bangkok prove that the shorter distance to station, the more valuable properties are. In addition, the premium is approximately 15,000 baht/sq.m per kilometer or US$ 500 per kilometer closer to the station in Bangkok.

Accessibility to public services is considered as one of the attribute groups reflecting the diversity of land use and closely related to land and property prices. Mixed land use is represented by the full range of services within the walking radius around the house. Some researchers often use some attributes such as distance to the nearest open space [11], distance to urban utilities (shopping centers, parks, etc.), the proportion of urban facilities in the study area [12].

In order to comprehensively evaluate the impact of land-use diversity in TOD’s affected on land and property prices, researchers also based on some estimated attributes which can be use to evaluate the land-use mix such as Balance Index (calculating the balance between land types, or between labor and population), Dissimilarity Index (calculating the difference in land use with surrounding areas), Entropy Index (calculating the land-use mix)... [12, 13, 14, 15], but these attributes are not considered in this study.

In Vietnam, Dr. Hoang Huu Phe carried out a research project on methods of evaluating location based on the theory of Position - Quality [16]. Data for the study were selected randomly, within 8 wards (out of 84 wards in 1993). 243 samples were selected for detailed interviews and surveys. The data collected was divided into 7 categories, including household characteristics, housing characteristics, people's attitude to home improvement, location characteristics, planning impacts,
characteristics of the surrounding area, and the priorities and preferences of the locals. In detail, the variables used for this research consist of variable evaluating the accessibility to the main street, the variable of location within French Quarter, the variable evaluating the distance to the city center, the variable about the site area and the variable about the number of floors. Although the results indicated that most of these variables are statistically significant, however, the researcher also mentioned that although the Position - Quality method has the concept of “Location” but determining what factors establish this concept is the most important.

Another research by [17] is one of the first researchers analyzing the determinants of housing values in Hanoi. They adopted a hedonic price analysis with more than 1,500 samples collected by the Hanoi Authority of Finance and covered 10 districts in Hanoi urban core (within Ring road 3). They divided Hanoi into 5 sub-divisions regarding the history of Hanoi urban development, with a set of determinants including housing characteristics, neighborhood characteristics, and accessibilities. Specifically, the variable regarding housing location was scored from 1 to 4 with 1 as a house located along a street, and 4 as a house located inside a small lane with its width below 2 meters. They found that housing location to the street was the most influencing factor, while other factors such as distance to CBD, accessibility to public transport, which generally is considered as main determinants of housing values, only appeared significantly in 1 out of 5 sub-divisions. One of the reasons may be due to the division of Hanoi into 5 zones and calculating the explanatory variables in a zone-based scale, thus, it made the calculated explanatory variables may be subjective or not fully reflect the area.

In this study, the relationship between property prices and their accessibility attributes will be analyzed and evaluated based on linear regression analysis. By comparison among these zones, we hope to give some findings of the differences in the relationship between property prices and accessibility, and then give policy recommendations for urban land development in areas around transit stations.

3. Materials and methods

3.1. Study area

Our study area is in the south of the Hanoi Metropolitan Area, which consists of eight urban inner districts and two suburban districts. All districts located in the south side of Red River, which are the most developed areas in Hanoi Metropolitan. According to HPC, in 2016, the survey area had a population of about 2,705,100 in an area of approximately 195.92 km2 in total. Figure 1 below shows the study area and sample distribution. We divided the study area into 4 zones, including Urban core, Within RR2, from RR2 to RR3, Outside of RR3. This division is based on the developing process of Hanoi and the specific characteristics of each zone.
3.2. Methodology

In this study, we use a log-log regression model to investigate the factors that affected the housing values. The property price functions are assumed by using the following formula:

\[
\ln(p) = \beta_0 + \sum \beta_i \times \ln(X_i) + \sum \beta_j \times D_j + \varepsilon
\]

Where: \(\ln(p)\) – dependent variable - is the natural logarithm of the property price; \(\ln(X_i)\) is the natural logarithm of continuous independent variables that affected the price; \(D_j\) denotes the dummy explained variables; \(\beta_i, \beta_j\) indicates the coefficient of independent variable \(X_i\) and \(D_j\), respectively; \(\beta_0\) is the constant term; \(\varepsilon\) is an error term.

Using a logarithm scale for price functions makes interpretation easier than other methods [18]. When the prices are expressed as logarithm, the coefficient \(\beta_i\) can be interpreted as the percentage change in price caused by an additional unit changing in the independent variables. For dummy variables, the coefficient \(\beta_j\) can be interpreted approximately as the percentage difference in price between properties with the attribute and those without. [19].

In this study, the dummy variables include Car Accessibility, Inside Old Quarter, Historical Premium and Business Advantage. The continuous independent variables include Number of Floors, Street density, Number of street intersection, Bus frequency, Distance to the nearest bus stop, Distance to Hoan Kiem lake, Distance to the nearest water space, Number of public facilities. These variables are divided into two groups, including variables related to housing characteristics and variables related to neighborhood and housing accessibility.

Due to the purpose of our study which focuses in accessibility and the shortage of data availability, not all housing characteristics variables are introduced in our function. Housing characteristics variables include: “Number of floors” is defined as the total floors of the building; “Car accessibility” is defined as 1 if the width of the street/alley in front of the house is wider than 4 meters, and 0 otherwise.
otherwise; “Historical premium” is defined as 1 if the house located in front of or nearby famous historical places such as Hoan Kiem lake, Van Mieu… and 0 otherwise; “Inside old quarter” is defined as 1 if the house located inside the old quarter, and 0 otherwise.

To investigate the association between property price and accessibility, the accessibility variables can be divided into 3 groups: accessibility to public transportation (bus), automobile accessibility, and accessibility to urban facilities. For evaluating the accessibility to transit, “Bus frequency” and “Distance to nearest bus stop” are used; for evaluating the automobile accessibility, “Car accessibility”, “Street density”, and “Number of street intersection” are used; and for evaluating the accessibility to urban facilities, we used various attributes including: “Distance to Hoan Kiem lake”, “Distance to nearest water space”, and “Number of public facilities”. Because of the high correlation among these variables, one model can test only one or two independent variables. Therefore, to cover all three groups of accessibility evaluation, we need to construct 2 or 3 models for each zone.

3.3. Data characteristics of property price
As mentioned above, the property price per square meter per floor is set as the dependent variable. The price we used in this study is offer-price from property owners instead of property prices issued by the government due to the big gap between state-price and market price. Many previous studies in Vietnam also adopted the similar price system for their hedonic price analysis (Ducksu Seo, You Seok Chung and Youngsang Kwon, 2018). We use the property price data of the year 2017 collected by three local real estate companies. This database is obtained from past research conducted by the writer (Chi, Kato, 2018). Due to the limitation of data availability, offer-price from the property owners is used instead of the successful transaction price. More than 1,200 samples were randomly distributed within our study area, covered both detached houses and apartments which were being for sale at that moment. The number of samples collecting in each zone are 106 samples in Urban core, 215 samples in Within RR2, 584 samples in From RR2 to RR3, and 219 samples in Outside of RR3.

Figure 2. Property price distributions of sample data [20]

Figure 2 describes the property price distribution of sample data with zone-based share, including 5 zones: Urban core, Within RR2, From RR2 to RR3, Outside of RR3. The figure reflects the wide range between housing values in different areas, from less than 20 million to more than 250 million VND per square meter per floor and mainly focused in the range of less than 50 million per square meter per
floor. It also showed that the prices for apartments are lower compared to detached houses located in the same area.

3.4. GIS-based data and other variables for property price function

Table 1 shows the variables used in the estimation of properties price functions, including two above-mentioned independent variables’ groups.

For the calculation of neighborhood and accessibility variables, a GIS-based database was originally created by the authors’ study team using geospatial data sources from Hanoi Urban Zone Planning, which was developed in 2010. The GIS-based database enabled us to produce five dimensions of BE measures: density, diversity, design, distance to transit and destination accessibility. However, in this study, we only focused on three BE dimensions which are related to accessibility, including “design” – is represented by street density and number of 4-way street intersection, “distance to transit” – is represented by bus frequency and distance to the nearest bus stop, “destination accessibility” – is measured by the number of public facilities inside the buffering area. Buffering distance 1,000 meters around each house location was chosen for BE’s measurement. The reason for choosing a 1,000-meter buffering is based on Hanoians’ living habits depending on motorbikes (we assumed that this is the distance we can reach within 5 minutes using motorbikes). Another reason for our buffering distance is based on the result of our past research. In this research, we compared property functions in different buffering scales. The results showed that the functions computed in the 1,000-meter scale had better model fitness compared to those in the 500-meter scale.

[20]

Street density examines how long the network spreads over a buffer area.

Number of 4-way (or more) street intersection is used to measure the street connectivity and accessibility for automobile users. It is calculated by counting the total number of 4-way or more street intersections within a buffer area.

Because of the lack of data in Hanoi, data about bus stops is created by the writer based on the bus stop map provided by Hanoi – Transerco – the local bus operator in Hanoi. All bus stops are pointed in ArcGIS for further analysis. Bus frequency is calculated based on the bus schedule provided by the local bus supplier (Hanoi Transerco). Distance to bus stop is defined as the walking distance from the house to the nearest bus stop.

Number of public facilities is calculated by counting the total number of public facilities such as hospitals, department stores, markets and so on within a buffer area.

Distance to water space is defined as the straight distance from the house to the nearest water body such as lake, river, and tunnel. Distance to the city center is defined as the straight distance from the house to Hoan Kiem lake.

| Table 1. Definitions of variables used in the estimation of properties price functions. |
| ----------------- | ----------------- | ----------------- |
| Variables | Definitions | Data sources |
|-----------------|-----------------|-----------------|
| Housing characteristics | | |
| Floor | Number of floors | Survey |
| Car accessibility | Width of the street/ lane in front of the house | Survey |
| Historical premium | Locate in front of historical places | Survey |
| Inside the old quarter | Locate inside the old quarter | Survey |
| Price | Property price (Millions VND/m2 per floor) | Survey |
| Accessibilities | | |
| Street density | Total street length in buffering area (m/m2) | GIS |
| Number of 4-way street intersection | Total number of 4-way street intersections | GIS |
| Distance to bus stop | Distance to nearest bus stop (m) | GIS |
| Bus service | Bus frequency | Transerco + GIS |
| Distance to city center | Distance to the Hoan Kiem lake (m) | GIS |
| Water spaces | Distance to the nearest water space (m) | GIS |
| Public areas | Number of public areas | GIS |
4. Results

4.1. Result 1: Descriptive statistics analysis of all dependent and independent variables

Table 2 shows the descriptive statistics of all variables used in property price functions in different zones in Hanoi.

First, it shows that more than half of the properties in the dataset in every zone have the streets/lanes accessing them wider than 4 meters, which means they can be accessed by car. The number of samples with accessing street/lane wider than 4 meters is higher in Urban core and Urban periphery than the remaining area.

Second, “Number of floors” varies in a wide range, from 1 to 9 floors and with the average value is from 2.6 floors in Urban core to 3.2 floors in Within RR2 area.

Third, “Historical premium” is defined to be 1 if the house locates in front of famous historical areas such as Hoan Kiem lake, Van Mieu Pagoda… and 0 otherwise. This attribute is only mentioned in two study zones, including Urban core and Within RR2 as a high number of famous historical places located here. However, the result shows that few properties contain this advantage even in our historical inner city. The average value is 0.02 for Urban core, and 0.009 for Within RR2 zone.

Fourth, the variable “Inside the old quarter” appears only in Urban core, with its average value is 0.28, which means nearly 30% of our sample in this zone is inside the old quarter area.

Fifth, “Distance to the city center” varies from 208m to 10,619m, with an average of 1,185m in Urban core; 3,575m in Within RR2; 5148m in From RR2 to RR3; and 8,291m in Outside of RR3. As the dataset covers major Hanoi Metropolitan Area, the maximum distance of about 10km means that the urbanized area is quite compact in Hanoi.

Sixth, the average of “Distance to water space” is 206.39m to 436.25m. This attribute gets higher value in Urban core and Outside of RR3, while less value appears in Within RR2 and From RR2 to RR3. It indicates the unbalance distribution of water space among zones.

Seventh, “Number of public facilities” varies from 2 to 272, with the average value is 165 in Urban core, 51 in Within RR2, 33 in From RR2 to RR3, and 18 in Outside of RR3. The value gets the highest number in Urban core, then decreases from Within RR2, From RR2 to RR3, to Outside of RR3. The reason might be in the urban periphery, there are many new development areas and now are in the process of completion of facilities compared to the historical area which had developed a long time ago and very stable.

Eighth, “Street density” varies from 0.35 to 2.1m per square meter, with the average value is 1.42 in Urban core, 1.29 in Within RR2, 1.5 in From RR2 to RR3, and 1.14 in Outside of RR3. Note that all the streets which are equal and wider than 2 meters are accounted for in this variable. It is remarkable attention in zone 3 – From RR2 to RR3 that the far difference between min and max value. The reason may be this area contains a high number of urban villages with a high density of the cul-de-sac system. Besides, there are new residences that have bloomed and interleaved among villages. In the new residential areas, the street network is not designed as dense as in the old village areas. So that is the reason why there is a big gap between the lowest and the highest value in zone 3.

Ninth, the average value of “Number of 4-way street intersections” is 64.51 in Urban core, 16.85 in Within RR2, 13.22 in From RR2 to RR3, and 9.69 in Outside of RR3. Note that all the collector/distributor streets are taken into account. Inner-city of Hanoi owns a higher density street system because it has a long time developing process – since the French colonial – than other zones where this infrastructure was newly built around 3 decades ago.

Tenth, “Distance to nearest bus stop” varies from 20 to 1431m, with the average value is 190.31 meters in Urban core, 275.3 meters in Within RR2, 353.75 meters in From RR2 to RR3, and 383.22 meters in Outside of RR3. It reflects that our dataset has good bus coverage.

Finally, the average value of “Bus frequency” is 989.41 trips per day in Urban core, 618.08 trips in Within RR2, 537.74 trips in From RR2 to RR3, and 396.03 trips in Outside of RR3. It reflects the unbalancing distribution of bus service in Hanoi.
## Table 2. Descriptive statistics of variables used in property price functions in each zone

| Variables                     | Type      | Mean (1) | Mean (2) | Mean (3) | Mean (4) | Min (1) | Min (2) | Min (3) | Min (4) | Max (1) | Max (2) | Max (3) | Max (4) | Median (1) | Median (2) | Median (3) | Median (4) | Standard Deviation (1) | Standard Deviation (2) | Standard Deviation (3) | Standard Deviation (4) |
|-------------------------------|-----------|----------|----------|----------|----------|---------|---------|---------|---------|---------|---------|---------|---------|----------|---------|---------|----------|------------------------|------------------------|------------------------|------------------------|
| **House characteristics**     |           |          |          |          |          |         |         |         |         |         |         |         |         |          |         |         |          |                       |                       |                        |                        |
| Floor                         | Cont.     | 2.6      | 3.2      | 3.09     | 2.93     | 1       | 1       | 1       | 1       | 8       | 9       | 9       | 9       | 2.5      | 3.5      | 3.5      | 3         | 1.63                  | 1.71                  | 1.78                  | 1.78                  |
| Car accessibility             | Dummy     | 0.76     | 0.51     | 0.64     | 0.71     | 0       | 0       | 0       | 0       | 1       | 1       | 1       | 1       | 1         | 1         | 1         | 1         | 0.43                  | 0.5                   | 0.48                  | 0.45                  |
| Historical premium            | Dummy     | 0.02     | 0.009    | -        | -        | 0       | 0       | -       | -       | 1       | 1       | -       | -       | 0         | 0         | -       | -         | 0.013                | 0.09                  | -                     | -                     |
| Inside old quarter            | Dummy     | 0.28     | 0.01     | -        | -        | 0       | 0       | -       | -       | 1       | 1       | -       | -       | 0         | 0         | -       | -         | 0.45                  | 0.11                  | -                     | -                     |
| Price                         | Cont.     | 110.69   | 51.42    | 34.05    | 30.08    | 9.52    | 4.93    | 2.55    | 8.33    | 727.75  | 550.24  | 249.9   | 168.53  | 75.69    | 26.13    | 21.34    | 112.25               | 60.24                 | 28.26                 | 19.58                 |
| **Accessibilities**           |           |          |          |          |          |         |         |         |         |         |         |         |         |          |         |         |          |                       |                       |                        |                        |
| Distance to Hoan Kiem lake     | Cont.     | 1185.7   | 3755.65  | 5148.9   | 8291.1   | 208     | 941     | 2187    | 1365    | 2461    | 6640    | 8360    | 10619   | 1068     | 3581     | 5106     | 8348                 | 510.47                | 1268.3                | 246.2                 | 1183.7                |
| Distance to water spaces       | Cont.     | 436.25   | 228.51   | 206.39   | 301.79   | 12.25   | 2.63    | 6.65    | 15      | 853.45  | 826.36  | 950     | 972.72  | 443.9    | 169.94   | 175.72   | 257.45               | 193.29                | 182.2                | 159.1                 | 213.43                |
| Number of public facilities    | Cont.     | 165      | 51.25    | 32.99    | 17.86    | 32      | 17      | 6       | 2       | 272     | 176     | 104     | 129     | 167      | 45       | 29       | 17       | 53                    | 27.67                 | 18.54                | 11.7                  |                       |
| Street density                | Cont.     | 1.42     | 1.29     | 1.5      | 1.14     | 0.86    | 0.76    | 0.35    | 0.49    | 1.75    | 1.78    | 2.1     | 1.9     | 1.39     | 1.26     | 1.58     | 1.14     | 0.13                  | 0.22                  | 0.33                  | 0.3                   |                       |
| Distance to bus stop           | Cont.     | 190.31   | 275.3    | 353.75   | 383.22   | 20      | 20      | 20      | 30      | 663     | 1263    | 1431    | 1195    | 183      | 235      | 285.5   | 340      | 109.36               | 172.59                | 246.3                | 232.39                |
| Bus frequency                 | Cont.     | 989.41   | 618.08   | 537.74   | 396.03   | 233.5   | 0       | 0       | 0       | 2446    | 1820.9  | 1798    | 1396    | 983      | 564.5    | 502.5   | 322      | 435.53               | 350.83                | 413.7                 | 339.2                 |
| Number of street intersection  | Cont.     | 64.51    | 16.85    | 13.22    | 9.69     | 11      | 0       | 0       | 0       | 111     | 76      | 62      | 48      | 68.5     | 13       | 9       | 9        | 19.05                | 15.3                  | 11.6                 | 7.6                   |

Notes: (1) means Urban core; (2) means Within RR2; (3) means From RR2 to RR3; (4) means Outside of RR3; Cont. means Continuous variable; Dummy means 0/1 variable.
4.2. Result 2: Estimating the impact of Accessibility on property price

Table 3 summarizes the estimation results of property function with the introduction of accessibility factors in different zones in Hanoi, including Urban core, Within RR2, From RR2 to RR3, and Outside of RR3.

| Attributes                      | Urban core | Within RR2 | RR2 to RR3 | Outside of RR3 |
|---------------------------------|------------|------------|------------|----------------|
|                                 | Model 1    | Model 2    | Model 3    | Model 1        | Model 2    | Model 3    | Model 1    | Model 2    | Model 3 |
| Intercept                       | 3.13**     | 2.21**     | 1.88.      | 3.74***        | 7.36***    | 3.91***    | 2.92***    | 3.04***    | 3.06*** |
| Number of floor                 | -0.28**    | -0.28**    | -0.27*     | -0.45***       | -0.45***   | -0.46***   | -0.27***   | -0.28***   | -0.26*** |
| Car access                      | 0.54**     | 0.61***    | 0.59***    | 0.36***        | 0.35***    | 0.43***    | 0.26***    | 0.28***    | 0.25*** |
| Historical premium              | 1.28**     | 1.25*      | 1.14*      | 1.05**         | 1.05**     | 1.28**     | -          | -          | -       |
| Inside the old quarter          | 0.49**     | 0.36*      | 0.37*      | -             | -          | -          | -          | -          | -       |
| Distance to bus                 | -0.16 (1.634) | -         | -0.13*     | -0.15*         | -0.02      | -          | 0.06       | 0.05       | 0.04    |
| Bus frequency                   | 0.25 .     | -          | -          | -0.02          | -          | 0.01*      | -          | -          | 0.0007  |
| Number of intersection          | -          | 0.45*      | -          | -              | 0.008      | 0.03**     | 0.03***    | -          | 0.01    |
| Street density                  | -          | -0.29      | -0.43      | -              | -          | 0.44***    | -          | -          | -       |
| Distance to city center         | -          | -          | -0.31**    | -              | -          | -          | -0.41**    | -0.4**     | -       |
| Distance to water space         | -          | -          | -0.03      | -              | -0.016     | 0.03.      | 0.04.      | 0.04       | -0.002  |
| Number of public facilities     | -          | 0.45*      | 0.25**     | -              | 0.11**     | -          | -          | -          | 0.05    |
| Sample                          | 106        | 106        | 106        | 215            | 215        | 215        | 584        | 584        | 584     |
| Adjusted R2                     | 0.3513     | 0.3469     | 0.3464     | 0.4115         | 0.4224     | 0.3771     | 0.2452     | 0.2417     | 0.242   |

Significant code: ***: p < 0.001, **: p<0.01, *: p<0.05, : : p < 0.1.
5. Discussions
First, the results indicate that most of the estimated coefficients are statistically significant in any models with the acceptable model fitness ranging from 0.2068 to 0.4224.

Second, signs and magnitudes of all estimated coefficients of house-related characteristics are consistent across the models. “Number of floors” has a negative impact on property values, which means, houses with fewer floors will be more expensive. It somehow reflects the height restriction policy of the Hanoi government in Hanoi inner city, such as housing in the ancient quarter must be below 3-storey while housings in this area are the most expensive. Besides, it also suggests that housing characteristics such as the height are not an important determinant of property value compared to neighborhood characteristics.

Third, “Car accessibility” has a strong positive association with property prices in all models and in all areas of Hanoi, varies from 0.26 to 0.61. It means that housing with better accessibility for cars will have a price premium than others. However, compared to the results in other zones, the attributes “Car accessibility” in Urban core zone have slightly lower significant levels than those in other zones, which means that these attributes have a stronger impact on property price in Within RR2, From RR2 to RR3 and Outside of RR3 than in Urban core. The reason might be the affection of car-limitation policies was reduced in those areas comparing to areas in Urban core. Besides, it also suggests that newly developed areas are preferable for car-users.

Fourth, the results also show that “Historical premium” has a significantly positive association with property values with the estimated coefficient varies from 1.05 to 1.28. This is because historical areas usually attract many tourism and entertainment activities, which may lead to economic agglomeration in surrounded areas, thus lead to higher profit for those who own or run a private-own shop here.

Fifth, “Inside the old quarter area” has a positive impact on property values, with the coefficient varies from 0.36 to 0.49. It is reasonable because property prices in this area are usually considered as the most expensive area in Hanoi for a long time. It suggests that the reason why the ancient quarter has the most expensive land values may be more influenced by historical preferences and lifestyle of old Hanoians than other BE variables. On the other hand, economic benefits from tourism may be another reason for the top land value in the ancient quarter.

Sixth, the results reflect that automobile accessibility has a statistical significant impact on property price in all zones, however, its sign and magnitude is different among these models. “Number of street intersection” has a positive statistically significant association in housing price in urban core and areas from RR2 to RR3, which means a house which locates in areas consisting of a higher number of street intersection will have a higher price. Note that only the 4-way and more than 4-way street intersection are counted while estimating this variable. By only counting this type of intersection, only major street network is taking into account, and we can exclude the small traditional “fish-bone” street network. In the context of Hanoi, street network in urban core, and new urban areas (from RR2 to RR3) is mostly grid design, which is a popular street-design in many automobile-dependent cities in the world. On the other hand, the attribute “Number of intersection” falls to have a statistical significant impact on housing prices in areas locating Within RR2 and areas in Outside of RR3. In Within RR2 zone, there are a number of collective residential areas that were constructed in the half of the 20th century, along with many villages that are now becoming urban wards in the process of urbanization. The street network design of these two structures mostly consists of T-joint nodes, which be eliminated in the “Number of intersection” variable. In the case of Outside of RR3 zone, the urban structure here is mostly a mixture of many old craft villages, urbanized villages and new urban areas. Moreover, the structure of traditional villages is mostly based on “fish-bone” street design rather than other street network design such as grid-network. Therefore, it might be the reason why this attribute falls to have an impact on property prices in this zone.
The association of “street density” and housing value is more complex. The results show that the coefficient has no statistical impact in Urban core, a negative statistically significant impact in Within RR2 zone and a positive impact From RR2 to RR3 and Outside of RR3 zones. In Within RR2, it reflects that housing locating in an area with a higher level of street density will have a lower price. This result is unexpected, however, it somehow reflects the negative impact of an ineffective infrastructure system happening in this zone such as terrible traffic jams or air pollution… negatively affect the property price here. Besides, considering the area of 1000 m around the samples of high street density, the street networks here consist of mainly alleys and cul-de-sac branches. It also reflects that the value of a house might decrease as it locates deep into an alley. In areas From RR2 to RR3 and Outside of RR3, housing with a higher level of street density will have a higher price. These results are quite reasonable because people tend to prefer the house if it is easier to access.

Seventh, the results show that accessibility to public transportation has positive statistically significant impact on housing values in Urban core, Within RR2 and From RR2 to RR3, while it has no statistically significant impact on housing values outside of RR3. The reason may be the poor transit service in urban. In Urban core and areas from RR2 to RR3, “bus frequency” has a positive association with property price, which means areas with a higher level of bus service will be more expensive, while “Distance to nearest bus stop” has no statistically significant impact on housing values. However, the t-value of this variable in model 1 in Urban core is 1.634, nearly reach the significant level (1.645) and with the negative sign of this coefficient, it means the shorter the distance to the bus stop, the higher housing value. On the other hand, “Distance to the nearest bus stop” appears to have a positive association with property price, while “bus frequency” has no statistically significant impact on those in areas within RR2. It reflects that a house located near a bus stop will have a higher value than those located farther. The reason might because the street density in this area is the lowest among three zones, and it consists of a dense concentration of the cul-de-sac and narrow alleys, where are difficult to operate bus service. Therefore, houses locate near bus stops, in other word – houses locate in a neighborhood– level or above street-network, will have higher prices.

Finally, “Distance to Hoan Kiem lake” and “Number of public facilities” are highly correlated, so that they can not be analyzed in the same model. “Distance to Hoan Kiem lake” has a negative statistically significant impact on housing values in areas Within RR2, Outside of RR3, which means the shorter distance to Hoan Kiem lake, the higher the housing price in this area. This variable is not introduced in the model of Urban core and From RR2 to RR3 because of its high correlation with other variables. The results in Within RR2 and Outside of RR3 are quite reasonable, especially in Outside of RR3 zone. The result implies that accessibility to the city center, where consists of a high level of economic and entertaining agglomeration, is an important factor affecting housing values in Hanoi’s urban periphery. “Number of public facilities” has a positive statistically significant association with property price in Urban core, Within RR2 and From RR2 to RR3, which means in these zones, areas with a higher number of nearby public facilities will have a higher price. When comparing the significant level, the results reflect that urban facilities have a stronger impact on housing prices in Within RR2 and From RR2 to RR3 zones than in Urban core. It is because areas in Urban core are very stable and already consist of a high level of public facilities. On the other hand, this variable falls to have statistical significance in the zone Outside of RR3. This somehow reflects the poor urban facilities in the urban periphery. “Distance to water” is significantly positive only in areas from RR2 to RR3, which means the longer the distance from water space, the higher land value. It is an unexpected result because water space often is considered as a positive determinant of land value. However, the reason might be in this study, we consider water spaces consist of not only lakes but also rivers or tunnels, which may give a negative effect on housing values in surrounded areas.

Based on these results above, it can be seen that there is an association between accessibility and property price in Hanoi. However, its impact is very complex and different in each study zones.

Regarding transit accessibility, the results show that accessibility to public transportation has a positive statistically significant impact on housing values in Urban core, Within RR2 and From RR2
to RR3, while it has no statistically significant impact on housing values outside of RR3. The results gave empirical evidence about the positive impact of public transport – at the moment it is bus service – on property prices. However, the relationship between property prices and transit service may be varied with the introduction of new UMRT and feeder-bus service.

Regarding automobile accessibility, our results also unveiled that the “Car accessibility” has a significantly positive association with the property prices, meanwhile the “street density” does not affect the property significantly. This might imply that Hanoians have already preferred residing at car-oriented BE areas although many of them still cannot afford to purchase their own private cars. As the average income of local people should increase along with the stable economic growth in Hanoi, it is afraid that car ownership will grow rapidly, and the car traffic should cause serious traffic problems in the near future. They may suggest that TOD policy should be further strongly promoted, maybe including travel demand management such as the introduction of road congestion pricing or car/truck-ban areas.

Regarding accessibility to urban service, the results also found that there is a positive connection between accessibility to urban service and property prices in all study areas. However, the results are still unclear because we use only 3 dis-aggregate variables to explain this characteristic. Combined variables that can cover the diversity of urban facilities in the neighborhood may be needed to get a clearer result. However, the different results among zones prove that better urban facilities may lead to higher neighborhood’s preference, then thus lead to higher property prices.

Finally, the results indicated that car accessibility is one of the most important determinants of property price premium in Hanoi. The fact shows that a house locates in front of a car-accessible street will have more value than others because this location is easy for private-own businesses, for rent, and easily accessing to customers and commodity. On the other hand, low-income unskilled people typically reside under poor conditions in urban core, at which they earn with motorbikes such as street vendors and small private-owned shops. Therefore, with the implementation of TOD, land prices in these areas are expected to increase and thus the displacement may occur. Therefore, the TOD policy implication should be carefully designed not only providing affordable housing but also ensuring job security for existing low-income people.

6. Conclusions
Based on the above results, it can be seen that in the condition of Hanoi city, when the proportion of private vehicles is high, the accessibility to car-accessible roads still strongly impacts to land and property prices. However, the research results also show a promising signal that bus accessibility and the quality of bus service have a positive impact on land and property prices. Consequently, it brings us a great expectation for a bright future with the positive effects on land and property prices due to the implementation of an urban railway system. Further studies are needed to analyze this relationship. Appropriate policies on land price management, measures to capture the extra land value need to be set up right now, along with policies related to travel demand management, ensuring to reduce automobile traveling and towards a sustainable transport for the city.

Although the impacts of accessibility to public facilities on land and property values are not clear in the models, it may be because of the limitations in this study which do not to mention the aggregate impacts or be influenced by the inter-correlated relationships among attributes in the analysis function. However, based on the results, the stronger impact of accessibility to public facilities on land and property prices in the area within the Ring road 3, compared to the urban periphery, also shows the role of accessibility to urban amenities on land prices. Therefore, building TOD areas around the stations, multi-functional transit hubs, along with a variety of services, will reflect complex land price fluctuations in this area.

Car accessibility has a very strong impact on property prices as shown in this study. It is not only because of the advantage for car-users, but also the business advantage. In fact, many small-scale businesses appear densely along every street in Hanoi. However, in the current context, with the presence as well as the growth of large-scale business models, operated by big business corporations,
the role of small businesses will be decline and gradually accounted for a negligible percentage. Furthermore, the TOD model around the station will create more conditions for the development of a large-scale commercial and business-center model where only potential investors can buy and rent high land prices. The imbalance of benefits can occur when traditional forms of individual business do not have the opportunity to access the land here. Therefore, there should be further studies on policies of sustainable socio-economic development in urban areas in the future.

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