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# Evaluation of the Relationship between the Transit Ridership and Accessibility Variables: A Case Study of the Bangkok Metro Stations

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**Abstract.** Many studies and planning projects related to Thailand metro system is now highly concentrating on the improvements of Transit-Oriented Development (TOD) and the feeder system to ensure smooth transferring for users traveling from their origins to destinations. Leaving off policies related measures, improvements that could immediately focus in order to enhance the smooth transfer services are infrastructure and land-use developments. This study evaluates relationships of accessibility variables, focused on service design and land-usages, and demand of metro ridership. The objective is to improve the understanding of what types of expanding infrastructures or land deployments that could help to support the metro system and encouraging more transit ridership. The existing Bangkok metro stations are the case study area for this research. Gathered data are transport services, roadway infrastructures, and land use. These data are available in the Geographic Information System format and ready to extract as testing variables at each station. Relationship between the number of transit ridership and variables form transport services, network connectivities, and land use are explore based on the correlation analysis. Results from the study found that the number of bus lines, bus stops, and railway stations are associated with the transit ridership, while there is no relationship between ridership demands and ferry services. Further for land-use perspective, the commercial, industrial, and mixed-used area have a significant influence on the ridership demand while there is no signal from the Residential area.

## 1. Introduction

The accessibility is one of the significant indicators in transport planning. It helps planners define the connectivity status between land use and transportation in their study areas. Planners can use accessibility indicators to define the effectiveness of changes in the system infrastructures or policies. Hence, improving transport accessibilities will directly advance both service quality and the number of users [1][2].

The existing metro system in Thailand is now operating with the only total of 100 kilometers of services, approximately. However, within the year of 2035, the service will be more than 464 kilometers, covering both Bangkok and its vicinity areas. The developments of this future system are well-progressing in terms of the central service infrastructures or the metro itself, except its surrounding system. Hence, many studies and planning projects related to Thailand metro system



highly concentrate on the improvements of Transit-Oriented Development (TOD) and the feeder system to ensure smooth transferring for users traveling from their origins to destinations. Leaving off policies related measures, improvements that could immediately focus in order to enhance the smooth transfer services are infrastructure and land-use developments. This study evaluates relationships of accessibility variables, focused on service design and land-use, and demand of metro ridership. The objective is to improve the understanding of which infrastructure or land deployment that could help to support the metro system and encouraging more transit ridership.

## 2. The measure of accessibility in transportation

There are four types of accessibility measures classified in the literature, including infrastructure-based, location-based, person-based, and utility-based measures [3][4]. The infrastructure-based accessibility measure focuses on time, level of congestion, and average travel speed in the transport network. The location-based accessibility measures the spatial distribution of opportunities or activity demands in the area, i.e., the number of jobs within 30 mins travel time. The person-based measures focus on the activities in which an individual can participate within a given time. Finally, the utility-based accessibility measures the individual-level benefits from land use or transport improvements.

Additionally, four fundamental components of accessibility are transport, land-use, temporal, and individual components. The transport components are transport infrastructure, passenger demands, and service determinations of the infrastructure, including times, costs, and efforts to use such services. The land-use component reflects the land use system consists of the amount, quality, and spatial distribution activities found at each destination (jobs, shop, and home). The temporal component relates to the availability of activities at different times. The individual component is the peoples' needs, abilities, and opportunities in using such the services. Table 1 presents the relationship between accessibility measures and accessibility components for classifying the type of accessibilities [5][6][7].

**Table 1.** Accessibility measures and components.

Measures/ Components	Transport component	Land use component	Temporal component	Individual component
Infrastructure based measures	Average travel time; Travel speed; Level of congestion		Peak hour period	Trip based stratification (e.g., Homework, business trips)
Location-based measures	Travel time or costs between locations of activities	Spatial distribution of opportunities in space (e.g., Job per zone)	Travel time and costs may vary in time (e.g., Between peak hours and off-peak hours)	Stratification the population (e.g., by income, education level)
Person-based measures	Travel time	Distribution of opportunities in space	Time constraints for activities and time available for activities participation	Accessibility is analysed at an individual level
Utility-based measures	Travel time or costs between locations of activities	Distribution of opportunities in space	Travel time and costs may vary in time (e.g., between peak hours and off-peak hours)	The utility is derived for population groups level or at the individual level

Source: [7]

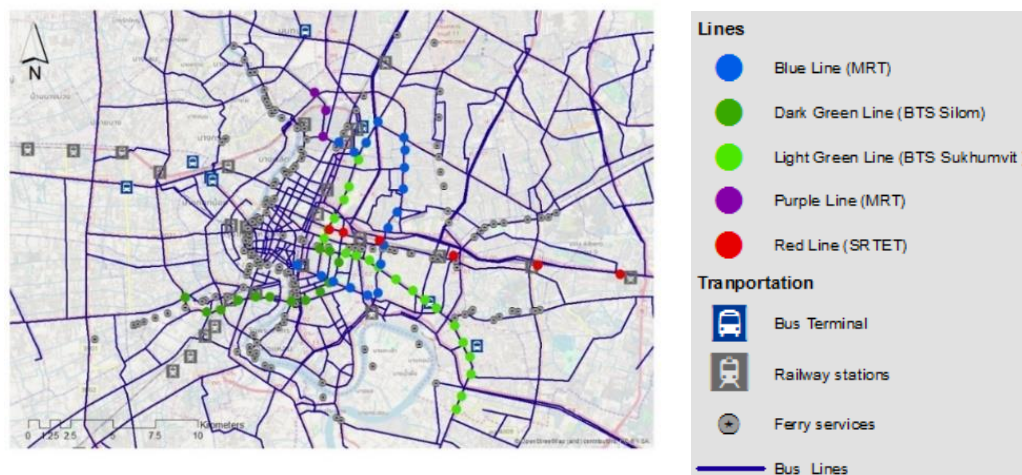
As prior discussions, this study focuses on the improvements of accessibilities by paying attention to infrastructure improvements and land use developments. Hence, as present in table 1, the evaluations in this study will focus on the incorporation of the location-based measure and the land-use component. There is a relation between land use and accessibility. If accessibilities change, land use will also relatively change. For example, improving transit coverage services will also enhance business development and residential land use in those development areas. For location-based, due to its availability and simple, the most used measure found in researches is distance (i.e., distance from home to public transport services). There are four types of location-based accessibility measures found in the literature. These measures are (1) direct distance measurement, (2) travel time, distances, or cost

contour, (3) potential accessibility measures (i.e., concentrations of jobs and population), and (4) balancing factor measures [6][7].

### 3. Case study area

The case study area is the existing metro stations in Bangkok, Thailand. Five operating lines with 79 stations are currently opening for services. This study considered only the urban area stations, which has a total of 64 stations. Figure 1 presents the distribution of the selected study stations.

Gathered data are transport services, roadway infrastructures, and land use. These data are available in the Geographic Information System format and ready to extract as analyzed variables at each station. The number of ridership data (Y) is the most existing data from the service operators. For the independent variables (Xi), besides its availabilities, types of variables are from recommendations and usages in the literature related to transit-oriented development. All data are in the Geographic Information System (GIS) format and ready for extract as the testing variables. Additionally, collected data concentrating for those spatially existed around 800 meters around the studied stations. Section 5 discussed these variables again in more details.



**Figure 1.** Bangkok metro stations area

### 4. Methodology

Pearson's correlation analysis is used to analyze the relationship between variables and select the critical variable in order to explore the significant accessibility measures for enhancing future transit service and development [8]. The rule of thumb for analyzing variable correlation in this study are as follows:

1. The statistical significant is when  $0.01 < P < 0.05$
2. If  $P < 0.01$ , it means that p values associate between two variables is strongly significant
3. If  $P > 0.05$ , p-value associated between the two variables is not significant
4. R-value is normally greater than 0.6 will be considered as a strong relationship between variables

### 5. Data collections

The collected data for this study has two categories (transportation connectivity and land-use). The transportation connectivity incorporates of eight transportation variables includes: the distance to municipal public service facilities, the distance to landmark and retail services, the distance to public transport stations, the number of ferry services, the number of bus lines, the number of bus stops, the number of railway stations, and the street network. The first three variables represent the Euclidean distance of the rail system to the major facilities or landmarks. Additionally, two main variables for land-use are the development scale of residential and other uses of commercial industrial and mixed-use development. The variables represent development scale in terms of floor area (square meters) development. Table 2 presents the list of collected data in this study.

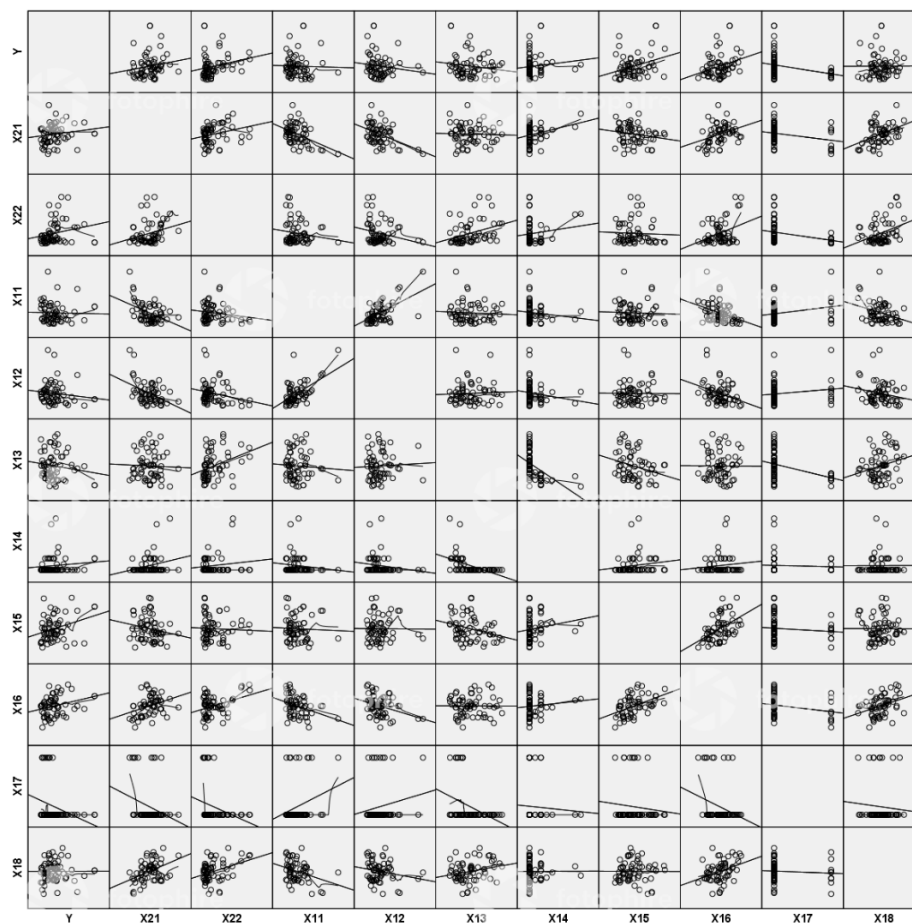
**Table 2.** List of collected Data.

Groups	Data	Variables	Units
Transportation Connectivity	Distance to Municipal Public Service facilities	$X_{11}$	Meters
	Access to landmark and retail services	$X_{12}$	Meters
	Public transport accessibility	$X_{13}$	Meters
	Number of ferry services	$X_{14}$	Ferries
	Number of bus lines	$X_{15}$	Lines
	Number of bus stops	$X_{16}$	Stops
	Number of railway stations	$X_{17}$	Stations
	Street network	$X_{18}$	Meters
Land use	Residential area	$X_{21}$	Sq-m
	Commercial, Industrial and mixed-used area	$X_{22}$	Sq-m

## 6. Results and discussions

From Pearson's correlation analysis, figure 2 presents the correlation matrix for the variables considered this study. From figure 2, many variables have a high correlation to others. The significant correlation between variables are:

- Access to landmark and retail services ( $X_{12}$ ) has a high correlation with Distance to municipal public service facilities ( $X_{11}$ )
- Public transport accessibility ( $X_{13}$ ) has a high correlation with Commercial, Industrial and mixed-used area ( $X_{22}$ )
- Public transport accessibility ( $X_{13}$ ) has a high correlation with Street network ( $X_{18}$ )

**Figure 2.** Correlation Matrix.

This preliminary correlation results, it presents that accessibility currently exists to support the commercial, industrial, and mixed land use. Besides, Table 3 shows the results of the correlation between transit ridership (Y) and accessibility variables ( $X_{ij}$ ). The results found that when considered R-value, only a few variables have R-value greater than 0.2, and no variables have R-value higher than 0.4. However, some variables show significant results of the p-value, which meant that these variables are a part of influencing to the ridership volumes. These variables are Number of bus lines ( $X_{15}$ ), number of bus stops ( $X_{16}$ ), number of railway stations ( $X_{17}$ ), and Commercial, industrial and mixed-used area ( $X_{22}$ ).

From a simple correlation analysis between selected accessibility measures and transit ridership in this study, the results are as follows. The number of bus lines ( $X_{15}$ ) and the number of bus stops ( $X_{16}$ ) within the 800-buffer area are positively associated with the transit ridership, while the relationship between ridership demands and the number of railway stations ( $X_{17}$ ) is negative. On the other hand, the results cannot find the relationship between ridership demands and ferry services ( $X_{14}$ ).

Further for land-use perspective, the commercial, industrial, and mixed-used area ( $X_{22}$ ) have a significant influence on the ridership demand while there is no signal from the Residential area ( $X_{21}$ ). In this case, it is an unexpected result since most land development in Bangkok has a high residential concentration around the transit stations. The reason must be that more people in Bangkok still choose to drive for their work trips, while the metro is a choice for other trip types.

**Table 3.** Pearson's correlation analysis of associability variables and ridership.

Variables	Y	$X_{21}$	$X_{22}$	$X_{11}$	$X_{12}$	$X_{13}$	$X_{14}$	$X_{15}$	$X_{16}$	$X_{17}$	$X_{18}$
Correlation coefficient	1	.160	.217*	-.026	-.132	-.148	.105	.310**	.285*	-.271*	.003
P-value		.104	.043	.419	.149	.122	.204	.006	.011	.015	.490

## 7. Conclusions

For future research, further study is also progressing to comprehend more variables such as population density and some other design variables such as roadway configuration. Since results of correlation matrix found that there is a severe multicollinearity problem in the stock of variables, linear regression may not be fit for the future model in this study. Other modeling technique such as random parameter estimations and the neural network may be suited to the problems.

## 8. References

- [1] Cheng J, Bertolini L and le Clercq F 2007 Measuring sustainable accessibility *Transportation research record* vol 1 pp 16 - 25.
- [2] Manout O, Bonnel P and Bouzouina L 2018 Transit accessibility: A new definition of transit connectors *Transportation Research Part A: Policy and Practice* 113 pp 88-100.
- [3] Handy S L 2002 Travel behavior-land use interactions: An overview and assesste of the research. IN: in pereptual motion: Travel behavior research opportunities and application challenges.
- [4] Geurs K T and Van Wee B 2004. Accessibility evaluation of land-use and transport strategies: review and research directions *Journal of Transport geography* vol 12 no.2 pp 127-140.
- [5] Curl A, Nelson J D and Anable J 2011 Does accessibility planning address what matters? A review of current practice and practitioner perspectives *Research in Transportation Business & Management* vol 2 pp 3-11.
- [6] Geurs K T and Ritsema van Eck J R 2001 Accessibility measures: review and applications. Evaluation of accessibility impacts of land-use transportation scenarios, and related social and economic impact *RIVM rapport* 408505006.
- [7] Breheny M J 1978 The measurement of spatial opportunity in strategic planning *Regional Studies* vol 12 no.4 pp 463-479.
- [8] Chuan C L and Penyelidikan J 2006 Sample size estimation using Krejcie and Morgan and Cohen statistical power analysis: A comparison *Jurnal Penyelidikan IPBL* vol 7 no.1 pp.78-86.