ISSN: 04532198
Volume 64, Issue 05, October, 2022

The Characteristics of Business Places Within Transit-Oriented Development (TOD) In Jakarta In Terms of Proximities to Transit Stations and Urban Centers

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ABSTRACT— Jakarta has a long history of mass rail transit (MRT). At present, the MRT in Jakarta is being rejuvenated with the concept of Transit Oriented Development (TOD). Many writers mentioned how businesses could benefit from proximity to a transit station within a TOD. However, the idea of TOD can be considered new to Jakarta. To understand how TOD can be developed to benefit business places, the purpose of the study reported in this paper is to understand the characteristics of business places within a TOD area in Jakarta. One of the common characteristics of a business place related to a TOD is its proximity to a transit station and activity centers near a TOD. There are 18 variables of proximity being examined in this study. By using Factor Analysis, five factors were extracted from those variables. Factor-1 represents walking and bus ride proximity. Factor-2 and Factor-3 are proximity in terms of vehicular routes to/from transit stations from/to a business place. Factor-4 is proximity to urban activity centers, and Factor-5 is proximity to feeder lines and paratransit stops. This study also shows two types of TOD related to the characteristics of business places in Jakarta. One is the compact TOD located in the urban center of Jakarta, and the other is the loose TOD located in the periurban. Further results show road severance that differentiates vehicular route proximity into Factor-2 and Factor-3. There is also an indicator of competition between formal public transportation such as BRT and paratransit, which acts as a feeder line to MRT.

KEYWORDS: Business place, proximity, Transit-Oriented Development (TOD), transit stations.

1. INTRODUCTION

Since it was called Batavia in the Dutch Colonial era, Jakarta, the capital city of Indonesia, has had an extensive mass rail transit (MRT) network. The first part of the MRT in Jakarta was established in 1869 [1], [2]. However, since the Japanese occupation (1942-1945), the MRT in Jakarta and Indonesia has fallen into disrepair [2]. Since 2007 there has been an effort by the government of Indonesia to revitalize the MRT in Jakarta [3]. At present, there are several MRT lines in Jakarta. Some of those MRT lines are recent developments [4], and some are revitalized older railway systems from the colonial era [5].

The renewed fervours for developing the MRT line in Jakarta have introduced an urban development concept known as TOD (Transit Oriented Development). Many papers have shown the positive effects of transit stations on the surrounding area [6- 8]. TOD's introduction was considered to connect the MRT to urban development. This connection was missing in the history of railways in Jakarta. However, others mentioned the limited effects of transit stations on the surrounding area. There are various aspects that a business place should have so that it could benefit from a transit station [9]. One of the most important reasons a business place could benefit from a transit station is its proximity to the station.

The primary motivation of this study is to understand the characteristics in terms of various types of proximities of business places to transit stations and activities centers that were designated as part of a TOD. These characteristics could improve the condition of business places within a TOD catchment so it could benefit from its proximity to the transit station and other activities near a TOD. There is no single definition of TOD. [10] mentioned several types of TOD. First is the meaning of TOD in terms of the relational and regional aspects of TOD [10]. This definition usually focuses on the public transportation aspects. For example, in Indonesia, [11] consider that urban planning in a TOD area can increase ridership of mass-rapid transit.

The second definition of TOD is based on the intensity of development within a TOD catchment area. According to this definition, a TOD catchment area should have a high population and building density. However, density is contextual relative to where a TOD is located [10], [12]. For example, high-density development in the USA might not be regarded as high in the European context. In Indonesia, this second definition of TOD is the subject of research by [13] about the characteristics of TOD in Depok, West Java, in terms of functional density within a catchment area. The third type of definition describes TOD as a planning concept [10], [14]. TOD is considered a planning tool to alleviate a particular urban problem. As an example, [15] believe TOD can tackle the problem of degradation of Jakarta’s environmental quality by minimizing the carbon emission of private cars. The fourth definition considers TOD a spatial strategy for economic development [10], [16]. For example, [17] wrote about how TOD could improve the condition of commercial activities in the vicinity of a transit station.

Those definitions of TOD mentioned by [10] are based on a particular concept of proximities of a business place to a transit station within a TOD [18]. Therefore, this study aims to describe the characteristics of business places in Jakarta in terms of their proximity to transit stations within a TOD catchment area.

2. METHODS

The unit of analysis of most research on TOD can be summarized into three levels. First are people as a unit analysis. In such a study, people were considered respondents, and the research question is related to human perception of TOD [19]. The second type of analysis unit is on the TOD catchment area level. Usually, the TOD area is defined by a certain optimum walking distance as the radius of the catchment area. This optimum walking distance is generally taken from other previous studies. The third type of unit analysis in the analysis of TOD is an arbitrary point in space. Usually, the unit of analysis is in the form of grid points [20], [21]. The fourth type of unit analysis is defined as an administrative area such as the district or village [22].

For a particular type of unit of analysis, a problem may occur if the subject of the study is distance-based proximity. In the case where people were used as respondents since people are mobile, there will be difficulty determining how the distance to the transit station from the respondent could be defined and measured. At most, we will have to do several measurements of the distance from the respondents at a specific position and time to the transit station and have proximity measures in the form of aggregation of distances. On the other hand, if the catchment area of TOD or a particular administrative unit is used as the unit of analysis, the proximity of specific activities within the catchment area must be averaged or any central values of measured proximities. If the unit of analysis is an arbitrary point, we will have a single value of proximity. The arbitrariness of a data point makes it difficult to be connected to any actual entity, such as people or places.

In this paper, the unit of analysis is a business place like a restaurant or hotel, which is spatially stable. Therefore we could calculate a unique distance to any business place and have a particular and fixed measured proximity compared to an aggregated proximity. Furthermore, the distance of each business place to a transit station can represent a meaningful research entity unlike any other arbitrary point as a unit of analysis. The business place is sampled from a TOD catchment area centered within a circle of 1 km to a transit station to link the unit of analysis of a business entity to a TOD [23]. The scope of this study is 57 transit stations along five mass rapid transit lines in Jakarta. Each transit line, on average, has 5 to 6 transit terminals. A circular catchment centered on each transit terminal within a radius of 1 km area was formed and used as a sampling area. About 100 business places were sampled from each catchment area.

Many researchers have used Google Maps API as a research tool [24], [25]. In this research, the sampling process also used Google Maps. We used search keywords to sample business places while zooming on each catchment area on a Google Maps API. The search keywords are hotel, apartment (*apartemen*), boarding house (*kost*), restaurant (*restoran*), eatery (*warung*), and private company (*PT*). As a result, from the 57 transit stations/catchment areas (Figure 1), 5700 business places were sampled. Some of the samples are mislocated or duplicated. Only 2500 business places are analyzed.

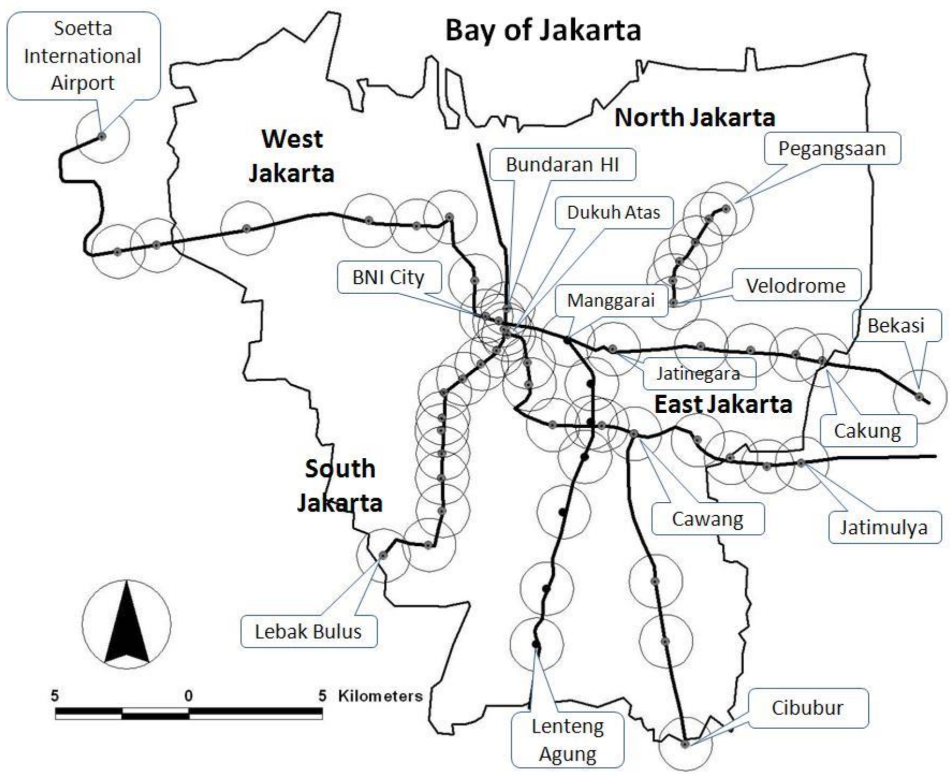


Figure 1. Transit lines, transit stations, and TOD's catchment areas in Jakarta.

The proximity variables of this study are the distance of the fastest routes from each business place to a transit station or activity centers of a relevant catchment area. There are several types of distance. First is distance as a sum of path length travelled, whether by walking or vehicular transportation. The second type of distance is a crow's flight distance between the sampled business places to transit stations. The third type of distance is the fastest route distance and crow's flight distance from the transit station to urban activity centers designated by Jakarta Spatial and Zoning Plan [26]. There are 18 proximity variables in this study. Table 1 shows this study's proximity variables and its operational definition.

Similar to the study done by [27], Factor Analysis (FA) is used to reduce the data into several Factor Scores (FS). However, unlike [27], this study's unit of analysis is not the catchment area of TOD but a business place within a TOD area. Only factors with Eigenvalue equal to or larger than 1.00 were extracted from the data. Only proximity variables with factor loading equal to or larger than 0.3 were included in the factor structure.

Factor Score (FS) were saved as new proximity variables. The business places then are analyzed using their Factor Scores (FS).

Table 1. Proximity variables and their operational definitions.

Variable	Operational definition
X1	X1 is the shortest walking path distance (km) from a business place to a transit station. X1 is measured using the "Direction" API of Google Maps
X2	X2 is X1 minus the crow's flight distance (km) from a business place to a transit station. The crow's flight distance was also calculated using Google Maps API.
X3	X3 is the fastest bus travel time from the nearest transit station. It is calculated using the "Direction" API of Google Maps.
X4	X4 is the fastest bus travel time (minutes) from the nearest transit station to a business place. X4 was calculated using the "Direction" API of Google Maps.
X5	X5 is the fastest route distance (km) travelled on a car from the nearest transit station to a business place. X5 is measured using the "Direction" API of Google Maps.
X6	X6 is the fastest distance (km) travelled on a motorbike from the nearest transit station to a business place. X6 is measured using the "Direction" API of Google Maps.
X7	X7 is the fastest time (minutes) needed to travel on a taxi from the nearest transit station to a business place. X7 is measured using the "Direction" API of Google Maps.
X8	X8 is the crow's flight distance (km) between the nearest transit stations to a business place. X8 is measured using the "Direction" API of Google Maps.
X9	X9 is the fastest distance (km) travelled by car to the nearest transit station from a business place. X9 is measured using the "Direction" API of Google Maps.
X10	X10 is the fastest distance (km) travelled on a motorbike to the nearest transit station from a business place. X10 is measured using the "Direction" API of Google Maps.
X11	X11 is the fastest time (minutes) needed to travel by taxi to the nearest transit station from a business place. X11 is measured using the "Direction" API of Google Maps.
X12	X12 is the shortest walking path length (km) from/to the nearest paratransit stops to/from a business place. X12 is measured using the "Direction" API of Google Maps.
X13	X13 is the density of Bus Rapid Transit stops within a circle of 1 km radius from a business place (stop/km^2. X13 is measured using the "Direction" API of Google Maps.
X14	X14 is the density of subway stations within a circle of 1 km radius from a business place (station/km^2). X13 is measured using the "Direction" API of Google Maps.
X15	X15 is the density of heavy rail stations within a circle of 1 km radius from a business place (station/km^2). X13 is measured using the "Direction" API of Google Maps.
X16	X16 is the crow's flight distance (km) from a business place to the nearest Jakarta's primary urban activity center. X16 is measured using the "Direction" API of Google Maps.
X17	X17 is the crow's flight distance (km) from a business place to Jakarta's nearest secondary activity center. X17 is measured using the "Direction" API of Google Maps.
X18	X18 is the average crow's flight distance (km) from a business place to urban attractions in Jakarta measured using Google Maps' "Direction" API.

3. RESEARCH RESULTS AND FINDINGS

Table 2 shows the rotated factor matrix containing the factor loading from FA. Five factors were extracted from the 18 proximity variables in Table 1. The cumulative variance is 68.051%, and the smallest Eigenvalue is 1.265. The factor loading of the variables determines the names of the factor and factor scores. Table 2 shows that variables X1 (the shortest walking path distance from a business place to a transit station), X2 (X1 minus the crow's flight distance (km) from a business place to a transit station), X3, and X4 (respectively, fastest bus travel time to and from the transit station) are grouped into Factor-1. Therefore, the name of Factor-1 is proximity in terms of the shortest walking distance and bus travel time relative to a transit station.

Table 2. Rotated factor matrix from Factor Analysis.

Variables	Factor-1	Factor-2	Factor-3	Factor-4	Factor-5
X1	**0.912**				

X2	**0.892**				
X4	**0.858**				
X3	**0.846**				
X5	0.355	**0.735**			
X6	0.361	**0.685**			
X17		**0.654**			
X7	0.368	**0.641**			
X15		**-0.510**			
X8		**0.465**		0.403	
X9			**0.908**		
X11			**0.849**		
X10			**0.791**		
X16				**0.742**	
X18				**0.591**	**0.421**
X14				**-0.454**	
X13					**-0.795**
X12					**0.765**

From the factor loading in Table 2, the variables X5 and X6 (respectively fastest car and motorbike routes from a transit station to business place), X17 (shortest crow's flight distance from a business place to secondary urban activity center), X7 (fastest taxi time from a transit station to a business place), X15 (a negative sign of density of heavy rail station within a circle of 1 km radius to a business place) and X8 (the crow's flight distance between the nearest transit stations to a business place) are grouped into Factor-2. For that reason, the name of Factor-2 is proximity in terms of the fastest vehicular travel distance from a transit station to a business place.

Table 2 also shows variables X9 (the fastest distance travelled by car to the nearest transit station from a business place), X11 (the shortest time by taxi to a transit station from a business place), and X10 (shortest travel distance on a motorbike to a transit station from a business place) are grouped into Factor-3. Therefore, the name of Factor-3 is proximity in terms of the fastest vehicular travel distance from a business place to a transit station.

Due to their significant loadings on Factor-4, the variables X16 (crow's flight distance from a business place to primary urban activity center), X18 (crow's flight distance from a business place to an urban attraction of Jakarta), X14 (a negative sign of density of subway entrance within a circle of 1 km radius from a business place), and X8 (the crow's flight distance between the nearest transit stations to a business place) are grouped into Factor-4. Therefore, Factor 4 is named proximity of business places to urban activity centers.

Factor-5 is a group of variables consisting of X13 (a negative sign of density of Bus Rapid Transit stops within a circle of 1 km radius from a business place), X12 (shortest walking routes to the microbus feeder lines and other paratransit-stops within a circle of 1 km radius from a business place), and X18 (the average crow's flight distance (km) from a business place to urban attractions). Therefore, the name of Factor-5 is the proximity of the business place to transit feeder lines and paratransit.

The Factor Scores (FS) of each Factor were analyzed by grouping the business places into the 100 business places with the smallest factor scores (Min FS) and the 100 business places with the largest factor scores (Max FS). The business places of Min FS are the cases with the highest proximity (for certain variables such as X1, it is the shortest distance). Max FS represents the business places with the smallest proximity.

Table 3 shows the average characteristics of the 100 business places with the smallest FS1. For the 100 business places with the smallest FS1 or Min F1, the average of X1 is 0.29 km. According to the national standard set by the government, the walking time from a place to public transportation stop/terminal is between 5 to 10 minutes, or 300 to 500 meters walking distance [28]. The average X1 is well below the national standard set by the government for TOD in Indonesia [28]. For the same business places grouped in Min F1, the averages of X3 and X4 are 3.34 and 3.41 minutes, which can be considered a relatively short time on a bus to reach a business place from the nearest transit station [28], [29]. For the same group of business places, the difference between the shortest walking routes to the crow's flight distance between a business place and transit station (X2) is 0.03 km. This small average value of X2 indicates that the walking route is relatively the same as the length of axial lines that visually connect a business place to a transit station. This visual connection was considered by several writers, such as [30], [31], as an essential characteristic that gives the possibility of raising the walkability of a TOD.

Table 3. Characteristics of 100 business places with smallest (Min FS1) and largest Factor Score 1 (Max FS1).

Main variables of Factor-1	Average for Min FS1	Average for Max FS1
X1 (shortest walking path from a business place to the nearest transit station)	0.29 km	2.99 km
X2 (X1 minus crow's flight distance from a business place to the nearest transit station)	0.03 km	2.36 km
X4 (shortest bus travel time to the nearest transit station from a business place)	3.34 min.	31.52 min.
X3 (shortest bus travel time from the nearest transit station to a business place)	3.41 min.	30.93 min.

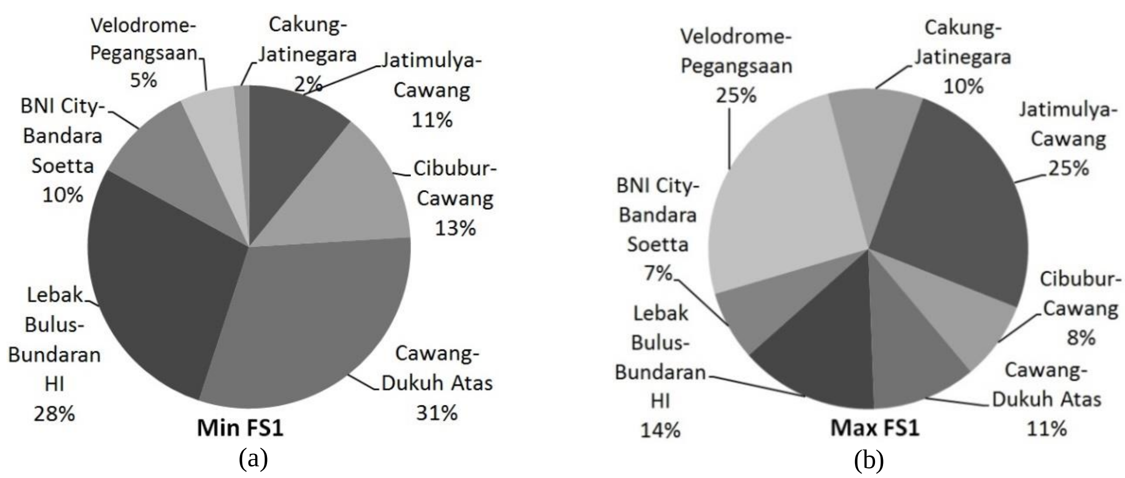


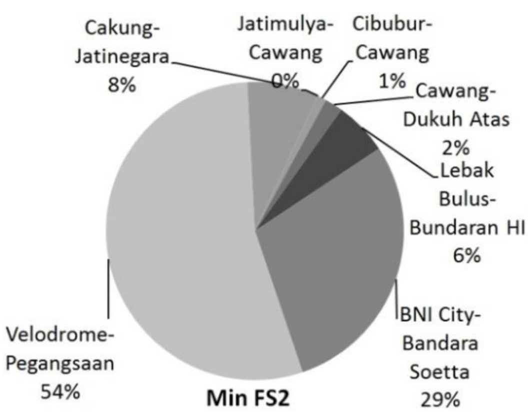
Figure 2. Percentage of business places of Min FS1 (a) and Max FS1 (b) near transit lines.

Figure 2 shows that most business places grouped as Min FS1 are at the Lebak Bulus-Bundaran HI line (28%) and Cawang-Dukuh Atas Line (31%). The business places grouped in Min FS1 are mostly the office of private companies (43%). Table 3 also shows the average Factor-1 variables for 100 cases of business places with the largest FS1 (Max F1). The average of X1 is 2.99 km, which is above the national TOD standard. The average value of X2 is 2.36 km, which indicates no visual proximity between the business place and the transit station. The averages of X3 and X4 are 31.52 and 30.93 minutes which is too long to attract commuters to use the bus to/from the mass rail transit system [32]. If we call the TOD where the business places grouped in the Min F1 as a compact TOD, then as for TOD related to the business place of Max F1 as loose TOD. Figure 2 shows that the loose TOD in Factor-1 is located in the Jatimulaya-Cawang line (25%) and the Velodrome-Pegangsaan line (25%).

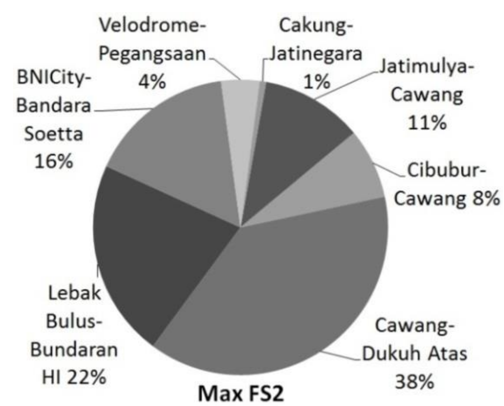
The resume of Factor Score-2 (Table 4 and Figure 3) shows two groups of business places in terms of variables X5, X6, X17, X7, X15, and X8. Table 4 shows the averages of X5, X6, X17, X7, X15, and X8 for 100 business places with smallest FS2 (Min FS2) respectively are 0.64 km, 0.63 km, 0.29, 2.30 minutes, 0.9 station/km2, and 0.21 km. All of the averages of Min FS2 variables are within the national standard for TOD. Therefore the TOD where the 100 business places with the smallest FS2 is considered a compact TOD of Factor-2. Most business places of compact TOD of Factor-2 (Figure 3) are located along the Velodrome-Pegangsaan line (54%) and BNI City-Soetta International Airport line (29%).Table 4 also shows the averages of variables of Factor-2 for the 100 business places with the highest FS2 (Max FS2). Most averages of variables of Factor-2 for the business place of Max FS2 are relatively larger than the national standard for TOD [28]. Therefore, TOD with business places grouped as Max FS2 is considered a loose TOD. The business place of loose TOD of Max F2 are located along Cawang-Dukuh Atas line (38%) and Lebak Bulus-Bundaran HI line (22%).

Table 4. The characteristics of the 100 business places with the smallest (Min FS2) and largest FS2 (Max FS2).

The primary variables of Factor-2	Average for Min FS2	Average for Max FS2
X5 (fastest travel distance by car from the nearest transit station to a business place)	0.64 km	4.44 km
X6 (fastest travel distance via motorbike from the nearest transit station to a business place)	0.63 km	4.21 km
X17 (crow's flight distance from a business place to the nearest secondary urban center)	0.29 km	1.95 km
X7 (fastest taxi ride time from the nearest transit station to a business place)	2.30 min.	13.00 min.
X15 (density of heavy rail station entrance within a circle of 1 km radius from a business place)	0.9 sta./km^2	0.03 sta./km^2
X8 (crow's flight distance from the nearest transit station to a business place)	0.21 km	0.81 km



(a)



(b)

Figure 3. Percentage of business places of Min FS2 (a) and Max FS2 (b) near transit lines.

Table 5. The characteristics of the 100 business places with the smallest (Min FS3) and largest FS3 (Max FS3).

The primary variables of Factor-3	Average for Min FS3	Average for Max FS3

X9 (shortest travel distance via car to the nearest transit station from a business place)	0.42 km	5.37 km
X11 (shortest taxi ride time to the nearest transit station from a business place)	1.57 min	14.98 min.
X10 (shortest travel distance via motorbike to the nearest transit station from a business place)	0.46 km	4.58 km

Table 5 and Figure 4 show the average variables of Factor-3 for 100 business places with the smallest FS3 (Min FS3) and largest FS3 (Max FS3). Similar to Factor-2, business places are grouped in Min FS3 and Max FS3. Factor-2 and Factor-3 both represent proximities in terms of the fastest vehicular routes. However, the variables of Factor-2 represent the vehicular proximity from a transit station to business places, while the variables for Factor-3 are proximity from business places to a transit station.

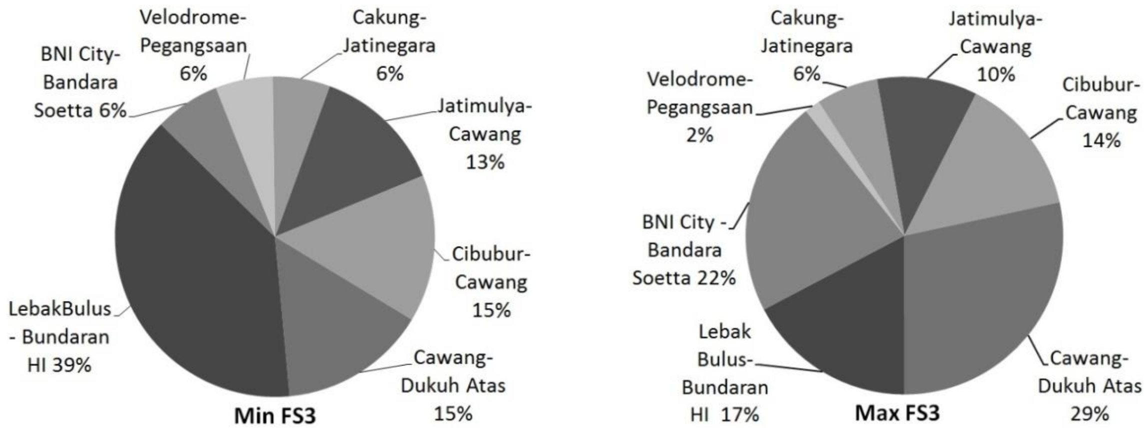


Figure 4. Percentage of business places of Min FS3 (a) and Max FS3 (b) near transit lines.

Table 6 and Figure 5 show the averages of variables of Factor-4 for the 100 business places with the smallest FS4 (Min FS4) and largest FS4 (Max FS4). The compact TODs of Factor-4 (Min FS4) are located along the Lebak Bulus-Bundaran HI line (48%) and the Cawang-Dukuh Atas line (34%). These TODs are considered nearer to urban primary activity centers and subway terminals than the loose TODs (Max FS4) located along the Cibubur-Cawang line (54%) and Jatimulya-Cawang line (22%).

Table 6. The characteristics of the 100 business places with the smallest (Min FS4) and largest FS4 (Max FS4).

The primary variable of Factor-4	Average for Min FS4	Average for Max FS4
X16 (crow's flight distance of a business place to the nearest primary urban activity center)	0.98 km	8.45 km
X18 (average crow's flight distance of a business place to urban activity centers)	7.04 km	18.45 km
X14 (density of subway stations within a circle of 1 km from a business place)	0.79 sta./km^2	0.02 sta./km^2
X8 (crow's flight distance from a business place to the nearest transit station)	0.32 km	2.36 km

ISSN: 04532198
Volume 64, Issue 05, October, 2022

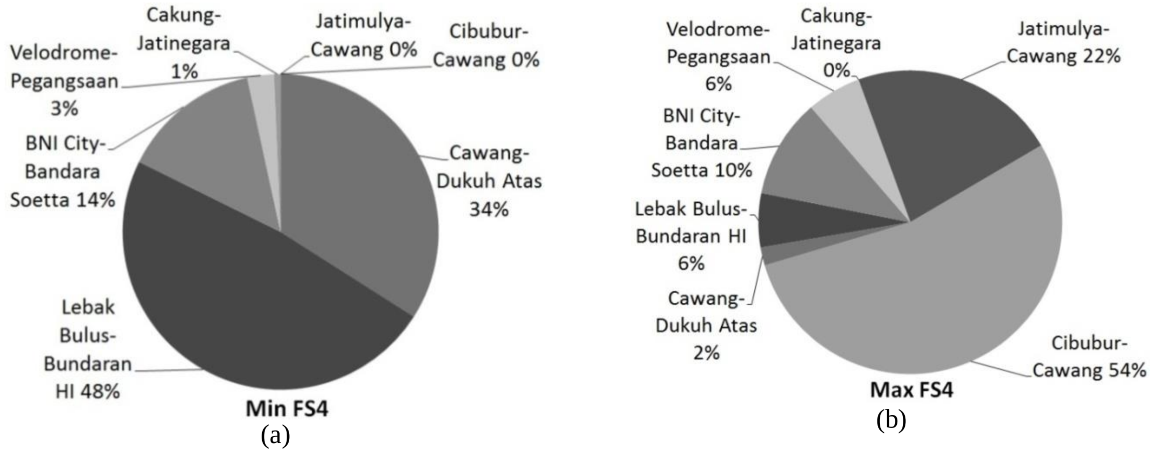


Figure 5. Percentage of business places of Min FS4 (a) and Max FS4 (b) near transit lines.

Table 7 shows the average of Factor-5 variables for the 100 business places with the smallest FS5 (Min FS5) and the largest FS5 (Max FS5). Again two types of related TODs appeared (Figure 6). The compact TODs of Factor-5 (related to Min FS5) are located along the Lebak Bulus-Bundarn HI line (39%) and Cawang –Dukuh Atas line (22%). In contrast, the loose TODs (related to Max FS5) are situated along the BNI City-Soetta International Airport line (65%). Another result shows that Factor-5 represents the business places where variables related to big buses or BRT (X13) negatively correlate with variables related to paratransit stops (X12).

Table 7. The characteristics of the 100 business places with the smallest (Min FS5) and largest FS5 (Max FS5).

The primary variable of Factor-5	Average for Min FS5	Average for Max FS5
X13 (density of Bus Rapid Transit stops within a circle of 1 km radius of a business place, with negative factor loading)	0.77	0.08
X12 (shortest walking path length from/to the nearest paratransit stop to/from a business place)	0.08 km	1.03 km
X18 (average crow's flight distance from a business place to urban activity centers)	10.11 km	18.85 km

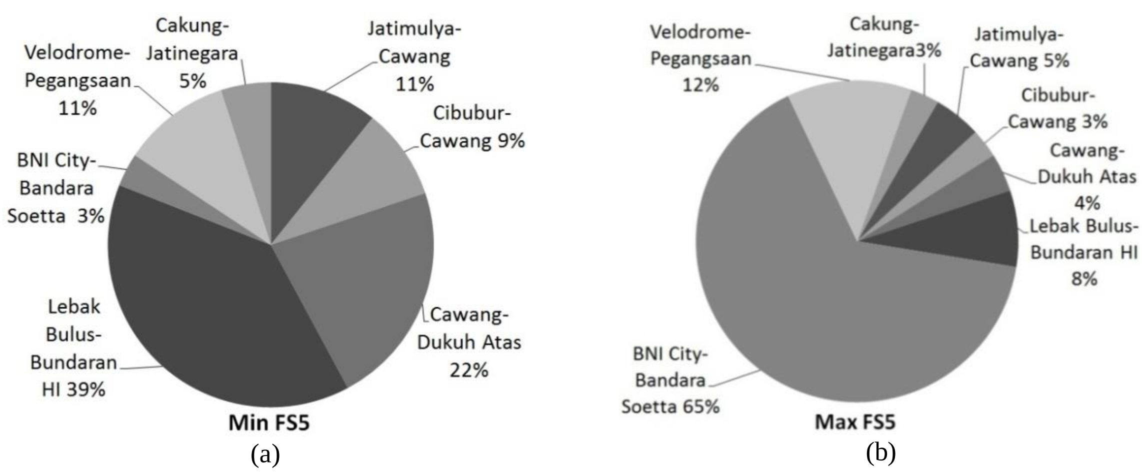


Figure 6. Percentage of business places of Min FS5 (a) and Max FS5 (b) near transit lines.

4. DISCUSSION

The analysis results in this study show that all proximity factors of business places, except for Factor-2 and Factor-3, indicate there are two types of related TODs in Jakarta. The first type is the compact TOD, where proximities are higher than the national standard for TOD [28]. The second type is the loose TOD, where the proximities are smaller than what is mentioned in the national standards [28]. If we look at the transit lines where the TODs exist, the compact TODs are located near Jakarta's urban centers, while the loose TODs are situated in the periurban parts of the capital city.

As an example, for Factor-1 (proximity in terms of shortest walking distance and bus travel time to a transit station), the 100 business places with the smallest FS1 are located on the main thoroughfares of Jakarta, such as Blok A, Blok M, Senayan, Setiabudi, Dukuh Atas, and Bundaran HI (Figure 7). This main thoroughfare called Jalan Sudirman is known as the Protocol Road of Jakarta, which connects the urban center of Jakarta built after the Indonesian independence in the vicinity of Bundaran HI and the newer development established in 1958 known as Blok M at Kebayoran Baru. These two main urban centers represent areas with the highest business place density in Jakarta [33], [34].

In contrast, the loose TODs related to Factor-1 are located along the Velodrome-Pegangsaan and Jatimulya-Cawang lines. These two lines are located in the newer developments of Jakarta. The Velodrome-Pegangsaan line is situated around Rawamangun, a housing area that started to be developed in the 1970s [33]. The Jatimulya-Cawang line is located in the periurban area of Jakarta in the vicinity of Bekasi, West Java which was initially developed in the 1990s [34].

Theoretically, we can relate the loose TOD of Factor-1 to the lesser population density of the periurban compared to the higher density of the urban section of a city. However, this was not the case since the population density of the Bekasi region is larger than Jakarta (the population density of Bekasi is 15000 people/km2, and of Jakarta is 13000 people/km2). Therefore, we could only relate the existence of a loose TOD of Factor-1 in the periurban of Jakarta with its nature as a sprawl distribution [35]. Sprawl development depends on infrastructure but does not develop infrastructure. With high population density, sprawl development has become a big problem for urban authorities to provide the needed infrastructure for its ever-growing population.

Factor-2 also presented compact and loose TOD. However, the compact and loose TODs of Factor-2 represent the vehicular proximity from a transit station to a business place. Unlike the TODs of Factor-1, the compact TOD of Factor 2 is located in the periurban of Jakarta. The loose TODs are located in the urban section of Jakarta. It is strange since vehicular proximity should positively correlate with road density [36]. From Factor-2 in this study, we found that the density of road infrastructure in a TOD makes vehicular travel longer, which may be due to the congested state of most streets in Jakarta and its surrounding areas.

The TODs related to FS3 also show similar characteristics to TODs of Factor 2. Both factors represent vehicular proximity. Interestingly Factor Analysis differentiates vehicular proximity into two factors (Factor-2 and Factor-3). Factor-2 represents vehicular proximity from a transit station to a business place, while Factor-3 represents similar proximity but from a business place to a transit station. The difference between the vehicular proximity of Factor-2 and Factor-3 indicates the existence of the phenomenon called routes asymmetry, known as the asymmetric vehicular routing problem [37], [38]. Usually, route asymmetry is due to one-way roads [39] and certain physical boundaries, such as highways that separate an area into two halves. For instance, TODs of Factor-2 and Factor-3 are located along the Cawang-Dukuh Atas line that coincides with the Jakarta Inner Toll Roads. Combined with the tendency for most roads in Jakarta to be designed as one-way streets, the toll highway had caused what [40] called the routes severance phenomena.

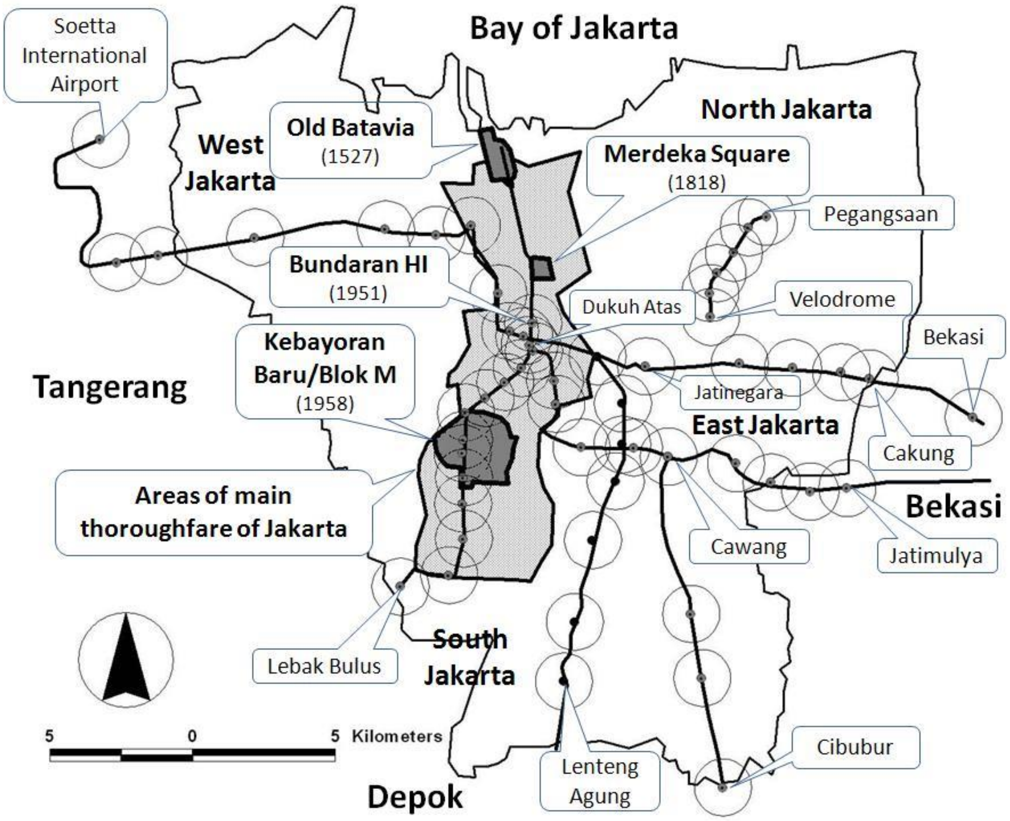


Figure 7. Main thoroughfares of Jakarta where the compact TODs of Factor-1 are located.

Factor-4 represents the proximity of the business place to subway stations and urban activity centers. It is evident since the Lebak Bulus-Bundaran HI line at present is the only subway system in Jakarta. Therefore, the business places located along Lebak Bulus-Bundaran HI lines have the highest proximity to a subway station in Jakarta. By looking at the variables grouped in Factor-5, the Factor can represent the proximity of paratransit feeder modes (X12) that connect a business place to a transit station. However, variable X13 (density of BRT stops within a circle with a radius of 1 km from a business place) has high negative loading in Factor-5. In other words, X13 has a negative correlation to variable X12. There seems to be a competition between BRT and paratransit. This fact corroborates research results done by [41], [42]; in the Jakarta case, there is a competition for facilities between the BRT and the paratransit.

The compact TODs related to Factor-4 are located in the vicinity of the urban centers of Jakarta. The loose TODs are situated at the periurban of the capital city. The compact TODs related to Factor-4 have higher proximity to primary urban activity centers since it is near the historical part of Jakarta, where most primary urban activity centers were designated in the Detailed Spatial and Zoning Plan Jakarta [26].

5. LIMITATION OF THE STUDY

This study uses Google Maps as a data source. However, this study focuses only on spatial proximity and has not harnessed the complete information content of Google Maps for which non-spatial proximities could be extracted. For instance, this study has not associated proximity to any place values such as the one indicated by the Google Reviews and Google Ranks. We suggest that future studies relate proximity to the Google ranks or reviews of a place, whether spatially or socially.

The focus on proximity in this study has let us miss the possibility of studying the spatial distribution of non-spatial place values such as the Google Ranks and Reviews of places. For future studies, it might be interesting if it can be directed to study the spatial distribution of behavioral aspects of businesses within a TOD. Such a study might shed light on many problems, such as the competition among various modes of public transportation mentioned above. Google Maps could be considered to have the potential to connect the geographical space to cyberspace. It would be exciting if future studies could shed light on the connection between both types of spaces related to a TOD.

Finally, this study has not touched on the urban planning and design aspects of a TOD. We are sure that understanding the characteristics of a business place within a TOD catchment area could be used to solve some urban planning and design problems. Future studies should intentionally focus on how the proximity of business places within a TOD can assist urban planning and design.

6. CONCLUSION

The subjects of this study are business places near 57 transit stations. The area around each of the transit stations was designated as TOD. Each business place was analyzed according to proximity to a transit station, and other transit stops within a TOD. Other characteristics of the business places being studied are their proximity to Jakarta's urban centers. The results of Factor Analysis to proximity variables five factors were extracted. Factor-1 is proximity in terms of walking distance and bus ride time. Factor-2 and Factor-3 are proximities in vehicular routes to/from transit stations from/to a business place. Factor-4 is proximity to urban activity centers, and Factor-5 is proximity to feeder lines and paratransit stops. Each Factor's factor scores can be considered the characteristics of business places within a TOD area in Jakarta.

There are two types of TOD in Jakarta related to the proximity of the business places, the compact and loose TOD. The compact TODs are located along the transit lines in the urban section, while the loose TODs are on Jakarta's periurban lines. In contrast, the characteristics of business places defined by Factor-2 and Factor-3 put the loose TOD in the center of Jakarta. This fact shows the effect of road congestion that frequently happens in the city center rather than in the periurban. From the analysis of the various proximity or characteristics of business places, it can also be concluded that there is an indicator of road severance around the transit station within a TOD catchment area. There is also an indicator of competition between paratransit feeder lines and other non-rail public transportation such as the BRT.

The results of this study can be used to improve the condition within a TOD. For example, the road severance phenomena can be used to prevent a concentration of traffic near a transit station by separating the access and egress to and from the station. The competition between paratransit and bigger and formal bus transit such as BRT can be used as a base to separate the two transportation modes. The separation can prevent overcrowding on feeder stops. Finally, it can be said that the existence of compact and loose TOD does not have to mean the compact is more valuable than the loose type. The loose TOD does not have to be developed into a compact one. It might be better to let both types of TOD exist so the environmental problem that might arise if the loose TOD is transformed into a compact TOD can be avoided.

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