SPATIAL DISTANCE AND MODE OF TRANSPORTATION CHOICES IN JABODETABEK METROPOLITAN AREA: A Sakernas 2017 Micro-Data Analysis on Commuting Pattern of Workers

Chotib¹

¹Head of Urban Studies Program, School of Strategic and Global Studies Universitas Indonesia, Indonesia
Email: chotib.m@ui.ac.id; chotib@hotmail.com

Abstract. The growth of Jabodetabek (Jakarta-Bogor-Depok-Tangerang-Bekasi) Metropolitan Areas raises several problems including the occurrence of traffic congestion in various parts of the metropolitan area. This congestion occurs partly because of the increasing number and use of private vehicles, especially by workers who commute mobility within the Jabodetabek metropolitan areas. The pattern of movement from the place of residence to the place of work in the metropolitan area is also a factor causing congestion. The purpose of this study is to find out the extent to which the distance factor measured by geographical distance and the proximity of the area between the place of residence and place of work has an impact on the preference for the use of transportation modes by workers who are commuting. In accordance with the availability of data in the Sakernas 2017 (National Labor Force Survey 2017) Micro Data, the transportation mode preference consists of two choices: public transportation mode or private transportation mode. The Sakernas 2017 micro data analysis was conducted with descriptive analysis (cross tabulation) and inferential analysis (Binary Logit Regression). The analysis shows that the probability of using public transportation tends to be used by workers whose travel distance is longer (above 10 km), in areas that do not directly border between residence and workplace, female workers, young workers, workers with education Junior high school and below, and workers who work in the agricultural sector. Urban managers covering the Greater Jakarta Metropolitan Area should continue to disseminate and promote the importance of using public transportation in travel from place of residence to place of work to reduce traffic congestion and urban air pollution.

KEYWORDS: Spatial Distance, Metropolitan Areas, Cross Tabulation, Binary Logit Model, Transportation Mode

1. Background
The growth of cities in Jabodetabek (Jakarta-Bogor-Depok-Tangerang-Bekasi) metropolitan area resulted in several problems, including traffic congestion. Whereas this congestion can have a following effect, which is higher travel and social costs and lower levels of worker productivity [8]. The results of the 2017 Sakernas data analysis conducted by [9] showed that around 22 percent of workers in the Greater Jakarta area carried out the pattern of shuttle mobility, which is called commuting. This percentage is the highest among the 9 other metropolitan areas in Indonesia.

Based on the results of an analysis of 2017 Sakernas micro-data by [3], it shows that more than 88 percent of workers who carry out non-permanent mobility (circular or commuting) in the Jabodetabek Metropolitan Area use private mode of transportation. This figure is actually somewhat lower than other metropolitan areas. In other words, the percentage of users of public transportation in the Jabodetabek Metropolitan Area is the highest compared to other metropolitan areas in Indonesia.

The pattern of workers’ movement from one origin to destination location influences the choice of transportation mode used. In this study, the location of origin is defined as ‘kabupaten’ or ‘kota’...
where the commuters live; while the destination location is defined as ‘kabupaten’ or ‘kota’ where the commuters work. The pattern is influenced by spatial proximity or travel distance. The Spatial Interaction Model suggests that the interaction between two locations is inversely proportional to the distance between the two locations and is directly proportional to the number of residents in each location. With this model it can be stated that the movement patterns of workers tend to occur in locations that are close together (next to each other).

The purpose of this study is to examine the impact of commute distance, in association with geographical distance and location closeness on the probability of public transportation modes utilization by commuter workers in the Jabodetabek metropolitan area based on Sakernas 2017 micro-data. In addition to this spatial identity variable, the study also examines the impact of other socio-demographic variables of workers on probability to choose public transportation mode.

The studies on effect of the travel distance on the choice of using mode of transportation have been conducted but with different destinations. [11] for example, conducted an examination on the impact of distance on freight transport. The results confirm the importance of distance for the mode of choice and showed there was not only one but in fact many break-even distances between the two options. They vary considerably depending on different travel plans, and the transport infrastructure conditions. Whereas [5] conducted a study of the effect of distance and transportation costs on the use of transportation modes in utilizing maternal health facilities in rural areas of Bangladesh. Findings from this evaluation study substantiates that distance and cost are major obstacles to service utilization.

2. Methodology
This study analyzes secondary data by utilizing the availability of variables in Sakernas 2017 micro data. Data exploration mainly uses transportation modes as a dependent variable in question no. 37e (the type of transportation that is usually used to commute to / from work). The available answer options are: 1. Public Transportation; 2. Joint Transportation; 3. Private Transportation; and 4. Walk. To simplify the model, the dependent variable only has two options: 1 = Public Transportation; 0 = Others

The Spatial Distance variable can be derived from several questions, namely: (1). Distance from home to work (question no. 37c); (2). Spatial distance is also operationalized by identifying the Regency/Municipality of residence whether or not directly adjacent to the Regency / Municipality of work. If the location of the residence is directly adjacent to the location of workplace, then it is coded 1. If the two locations do not directly border each other, then it is coded 0. Other variables were also used in the transportation mode choice model. Those variables are individual socio-demographic characteristics. The chosen characteristic variables are: sex, age groups, marital status, and sector of work.

The analysis was carried out in two ways, namely descriptive analysis and inferential analysis. Descriptive analysis is performed by cross tabulation between each independent variable to the dependent variable (choice of transportation mode). Inferential analysis uses a binary logistic regression, where the dependent variable is the choice of public transportation mode (code = 1) or other Transportation modes (code = 0). Way of this kind of analysis has been carried out by [12] and also by [7]. The binary logistic regression model proposed in this study is as follows:

$$\ln \left( \frac{p_1}{p_0} \right) = \beta_0 + \beta_1 \ast DISTANCE_1 + \beta_2 \ast DISTANCE_2 + \beta_3 \ast BORDER + \beta_4 \ast SEX + \beta_5 \ast AGEGROUP_1 + \beta_6 \ast AGEGROUP_2 + \beta_7 \ast EDUCATION + \beta_8 \ast SECTOR_1 + \beta_9 \ast SECTOR_2$$

where:

- $p_1 = \text{Probability of workers using public transportation mode}$
- $p_0 = \text{Probability of workers using other transportation modes}$
DISTANCE_1 = 1, if the distance between place of residence and place of work is 10-29 km; 0, if other distance (distance < 10 km or > 30 km)
DISTANCE_2 = 1, if the distance between place of residence and place of work is > 30 km; 0, if others distance (distance< 10 km or distance =10-29 km)
BORDER = 1, if 2 areas are sharing border; 0, if not sharing border
SEX = 1, if worker is male; 0 if worker is female
AGEGROUP_1 = 1, if worker’s age is 20-45 years; 0, if others (age<20 years or age>45 years)
AGEGROUP_2 = 1, if worker’s age>45 tahun; 0, if others (age<20 years or age between 20-45 years)
EDUC = 1, if level of education ≥ SLTA (senior high school and above); 0 if level of education ≤ SLTP (junior high school and below)
SECTOR_1 = 1, if occupation sector is industry; 0 if others (agriculture or services)
SECTOR_2 = 1, if occupation sector is services; 0 if others (agriculture or industry)

3. Results and Discussions
The results of Sakernas 2017 data analysis show that workers in Jabodetabek Metropolitan Area work in the core area (covering 83 percent), namely in some cities included in the Capital Special Region of Jakarta Province. South Jakarta and Central Jakarta are the largest regions where the commuters make those cities as destinations (place of work). Their percentages are about 25 percent and 24 percent, respectively, then followed by East Jakarta (11.6 percent), West Jakarta (11.1 percent), and North Jakarta (10.5 percent).

About 13 percent of workers in Jabodetabek Metropolitan Area work in suburban metropolitan areas, namely Bekasi Regency, Bogor Regency, Bogor Municipality, and Depok Municipality. Workers who work in these rural areas usually work in the manufacturing sector. Workers who work in Bogor Municipality and Depok Municipality usually pursue services sector and offices.

Table 1. Destination Locations of Commuters (Places of Work)

| Place of Work Location       | Number of Commuters | Percentages | Cumulative Percentages |
|------------------------------|---------------------|-------------|------------------------|
| West Jakarta                 | 300 677             | 11.1        | 11.1                   |
| Central Jakarta              | 667 835             | 24.6        | 35.6                   |
| South Jakarta                | 695 437             | 25.6        | 61.2                   |
| East Jakarta                 | 316 512             | 11.6        | 72.9                   |
| North Jakarta                | 284 609             | 10.5        | 83.4                   |
| Bekasi Regency               | 117 730             | 4.3         | 87.7                   |
| Bogor Regency                | 102 753             | 3.8         | 91.5                   |
| Bekasi Municipality          | 81 032              | 3.0         | 94.5                   |
| Bogor Municipality           | 86 036              | 3.2         | 97.6                   |
| Depok Municipality           | 64 425              | 2.4         | 100.0                  |
| Total                        | 2 717 046           | 100.0       |                        |

Source: Sakernas 2017 Micro-Data Analysis by Author

The commuting workers’ locations of residence are not as centralized as the location of the destination place of work. However, there is a tendency that workers’ residence locations generally originate from metropolitan suburban areas, with the largest coming from Depok Municipality (15.2 percent) and Bekasi Municipality (15.1 percent). After that, workers from Bogor Regency (10.4 percent), South Tangerang Municipality (8.1 percent), and Bekasi Regency (7.0 percent) were followed. This is in line with [1] which states that those who live in the Greater Jakarta area are residents who have migrated from DKI Jakarta since the 1990s. They have long settled in these suburbs to obtain affordable housing, while their work remains in the core of metropolitan area.
Sakernas 2017 data also shows that there is a large number of commuter workers residing in East Jakarta. East Jakarta is an area directly adjacent to metropolitan suburban areas such as Bekasi Municipality, Bekasi Regency, and Bogor Regency, which are known as places for the manufacturing industry [4].

Table 2. Origin Locations of Commuters (Places of Residence)

| Place of Residence Locations | Number of Commuters | Percentages | Cumulative Percentages |
|-----------------------------|---------------------|-------------|------------------------|
| West Jakarta                | 164 338             | 6.0         | 6.0                    |
| Central Jakarta             | 71 909              | 2.6         | 8.7                    |
| South Jakarta               | 146 742             | 5.4         | 14.1                   |
| East Jakarta                | 351 197             | 12.9        | 27.0                   |
| North Jakarta               | 125 513             | 4.6         | 31.6                   |
| Bekasi Regency              | 190 096             | 7.0         | 38.6                   |
| Bogor Regency               | 282 963             | 10.4        | 49.1                   |
| Tangerang Regency           | 72 083              | 2.7         | 51.7                   |
| Kepulauan Seribu            | 48                  | .0          | 51.7                   |
| Bekasi Municipality         | 409 631             | 15.1        | 66.8                   |
| Bogor Municipality          | 59 177              | 2.2         | 69.0                   |
| Depok Municipality          | 413 466             | 15.2        | 84.2                   |
| Tangerang Municipality      | 210 327             | 7.7         | 91.9                   |
| South Tangerang Municipality| 219 556             | 8.1         | 100.0                  |

Total                      | 2 717 046           | 100.0       |

Source: Sakernas 2017 Micro-Data Analysis by Author

Table 3. Commuting Flow Patterns by Location Proximity

| Location Proximity       | Number of Commuters | Percentages | Cumulative Percentages |
|--------------------------|---------------------|-------------|------------------------|
| Bordered each other      | 1 721 940           | 63.4        | 63.4                   |
| Not Bordered each other  | 995 106             | 36.6        | 100.0                  |
| Total                    | 2 717 046           | 100.0       |

Source: Sakernas 2017 Micro-Data Analysis by Author

The Gravity Theory model developed by Reilly in 1935 [10] which was later modified into a spatial interaction model showed that the interactions of the two regions were directly proportional to the number of populations in each of the two regions and inversely proportional to the alpha rank distance. From this model it is shown that the closer the distance, the greater the population flow from the two regions.

Sakernas 2017 data analysis shows that the majority of workers' commuting flows in Jabodetabek are flows where the two regions (Regencies/cities) directly border each other. This means that most commuters go to work and return to their homes at a distance directly adjacent to each other, reaching 63.4 percent, which can be seen in Table 3 below:

The use of public transportation in commuting trips is very important because it can reduce air pollution, traffic congestion, and fuel waste. According to Table 4 below, in Jabodetabek Metropolitan Area, the use of public transportation has only reached 24 percent of commuter workers. The use of transportation mostly uses private modes of transportation (75%). Research conducted by [2] revealed
that about 46 percent of commuter workers from Depok Municipality use motorcycle as mode of transportation, then followed by 30 percent of commuter line (train) users. According to [3], the use of public transportation in the Jabodetabek metropolitan area reaches 11.6 percent of non-permanent mobility (commuter or circular migration) workers. This figure is actually the highest rate compared to 9 other metropolitan areas in Indonesia.

The use of public transportation is closely related to distance, the further the distance of commuting trip, the greater the percentage of workers who use public transportation. The effect of distance can also be seen from whether the location of the workplace and the location of the residence are next to each other or not. If they are not next to each other (assumed to be longer travel distances), the percentage of use of public transportation is 33.2 percent greater than if the two regions are next to each other (only 18.9 percent).

The use of public transportation also varies according to socio-demographic characteristics. [6] conducted a research on how socio-economic status of workers in Wonosobo Regency has an impact on transportation mode choice. Women workers tend to use public transportation rather than men. Younger age groups appear to have a greater percentage in the use of public transportation. Mode of transportation choices was also determined by socio-economic status. Table 4 shows the higher the socioeconomic status, the lower the tendency of workers to use public transportation. The higher the education, the lower the use of public transportation. Workers working in the industrial and service sectors have lower use of public transportation than workers working in the agricultural sector.

| Table 4. Distribution of Mode of Transportation by Categories of Independent Variables |
|-------------------------------------|------------------|-------|
| **Indep. Variables** | **Mode of Transportation** | **#Obs (100%)** |
| **DISTANCE** | | |
| < 10 km | 83.90% | 16.10% | 655 765 |
| 10 – 29 km | 76.50% | 23.50% | 1 202 583 |
| >30 km | 68.90% | 31.10% | 858 698 |
| **BORDER** | | |
| Not Border each other | 66.80% | 33.20% | 995 106 |
| Border each Other | 81.10% | 18.90% | 1 721 940 |
| **SEX** | | |
| Female | 56.9% | 43.1% | 826 104 |
| Male | 84.2% | 15.8% | 1 890 942 |
| **AGE GROUPS** | | |
| <20 years | 65.7% | 34.3% | 121 683 |
| 20-45 years | 76.2% | 23.8% | 1 968 735 |
| >45 years | 76.9% | 23.1% | 626 628 |
| **EDUCATION** | | |
| <= Junior High School | 72.9% | 27.1% | 459 930 |
| >= Senior High School | 76.5% | 23.5% | 2 257 116 |
| **SECTORS** | | |
| Agriculture | 55.7% | 44.3% | 46 261 |
| Industry | 77.2% | 22.8% | 1 128 870 |
| Services | 75.6% | 24.4% | 1 541 915 |
| **TOTAL** | 75.9% | 24.1% | 2 717 046 |

Source: Sakernas 2017 Micro-Data Analysis by Author

The results of inferential analysis show that all variables in the model proposed by this study have statistically significant effect on the dependent variable (transportation mode choices) at $\alpha = 5\%$
(see column sig., where all independent variables have smaller value of probability than 0.05). This means that the different categories of each independent variable proposed in this model have a significant impact in terms of use preference of public transportation compared to private/other ones.

The magnitude and direction of the effect of each variable is indicated by the Regression Coefficient parameter (see Column B) or Odd Ratio (OR) parameter (see Column Exp (B)). Discussion of the magnitude and direction of their effects are optional whether using Parameter B or OR. According to the authors, reading OR is easier to be understood than reading B parameter.

As seen on Table 5, it is revealed that DISTANCE(1) variable has OR = 1.482, which means that the probability of public transportation choice is 1.5 times at a distance of 10-29 km compared to a distance of less than 10 km. Likewise, DISTANCE(2) variable has OR = 1.984, meaning that at a further distance (above 30 km), the probability of using public transportation is almost twice than the workers who are less than 10 km away.

The BORDER variable has OR = 0.451, meaning that the worker whose location of residence is directly adjacent to the location of work will have the probability of public transportation use 0.45 times to use if the location is not directly adjacent. It confirms that the probability of using public transportation will decrease in line with the reduced distance, both measured by geographical distance and by location proximity.

The effect of other variables can be briefly explained that public transportation tends to be used by female workers, young workers, workers with secondary education and below, and workers who work in the agricultural sector.

Table 5. Parameter Estimates of Binary Logistics Regression

| Independent Variables | B    | S.E. | Sig. | Exp(B) |
|-----------------------|------|------|------|--------|
| DISTANCE              |      |      | .00  |        |
| DISTANCE(1)           | .393 | .004 | .00  | 1.482  |
| DISTANCE(2)           | .685 | .005 | .00  | 1.984  |
| BORDER(1)             | -.796| .003 | .00  | .451   |
| SEX(1)                | -1.550| .003 | .00  | .212   |
| AGEGROUPS             |      |      | .00  |        |
| AGEGROUPS(1)          | -.518| .007 | .00  | .596   |
| AGEGROUPS(2)          | -.509| .007 | .00  | .601   |
| EDUC(1)               | -.369| .004 | .00  | .691   |
| SECTORS               |      |      | .00  |        |
| SECTORS(1)            | -.732| .011 | .00  | .481   |
| SECTORS(2)            | -.838| .011 | .00  | .432   |
| Constant              | 1.445| .013 | .00  | 4.244  |

Source: Sakernas 2017 Micro-Data Analysis by Author

4. Conclusions and Recommendations

Conclusion: The direction of commuter movements tend towards the core of metropolitan areas and their origins are from sub-urban areas of Jabodetabek. All variables proposed in this study show significant effect statistically. In summary, it can be concluded that public transportation tends to be used by workers whose commuting distance is further (above 10 km), in locations that do not directly border each other, female workers, young workers, workers with secondary education and below, and workers who work in the agricultural sector.
Recommendations: Although the use of public transportation in the Jabodetabek metropolitan area is the highest compared to other metropolitan areas, the use of public transportation is around 24 percent among the 2.7 million commuter workers which is actually relatively low. For this reason, urban managers covering the Jabodetabek urban area should continue to disseminate and promote the importance of using public transportation on their way from home to work. This socialization and promotion is important because it can be expected to reduce negative impact vs dense use of private vehicles such as air pollution, noise pollution, and traffic congestion in various places in the Jabodetabek Metropolitan Area.

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