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## Bus rapid transit system as a potent agent for transit-oriented development: A study of Transjakarta passengers' mode shift

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# Bus rapid transit system as a potent agent for transit-oriented development: A study of Transjakarta passengers' mode shift

L Prayogi\* and D Hanton

Universitas Muhammadiyah Jakarta, Jakarta, Indonesia

\*lutfi.prayogi@ftumj.ac.id

**Abstract.** Recently there has been discussions on the role of bus rapid (BRT) transit in transit-oriented development (TOD). This article explores a feature of bus rapid transit within the framework of TOD's principle of developing built environment and transit systems that trigger its citizens to shift from using private motorised vehicle to using transit system for daily mobility. This article explores Transjakarta BRT's ability to trigger mode shift from doing other way of travelling to using Transjakarta. This article was written through a descriptive-qualitative research using inductive reasoning. Mode shift data was collected through indirect interview using online questionnaire. Other way of travelling prior to using Transjakarta was asked to Transjakarta passengers. Detailed information regarding the passengers' background and the type of trips the passengers are doing was also gathered. The data was processed using simple statistical analysis and Bartlett's test for distribution variance. This article finds that Transjakarta is able to trigger mode shift among its passengers. Furthermore, Transjakarta is even able to trigger mode shift from using private motorised vehicle to using Transjakarta. The ability to trigger mode shift is relatively homogenous across all groups of Transjakarta passengers. This article proposes an alternate approach in evaluating a rapid transit system within the framework of TOD, that is evaluating its ability in triggering mode shift.

## 1. Introduction

Recently there has been discussions on the role of bus rapid transit (BRT) transit in transit-oriented development (TOD). There have been some research recording the suitability and even success of providing BRT system in conjunction with TOD in various urban contexts [1-4]. In general, those researches recorded that BRT system provision can go in line with, support, and even trigger the development of high-density mixed-use built environment around the system.

Meanwhile, there have also been some research evaluating BRT systems within the framework of TOD using various approaches. There has been a number of solid researches on the impact of BRT system towards urban development [5]. Those researches use a common and quite established approach of evaluating the influence of BRT system provision towards the increase of property price around the BRT system. Beside that approach, there are some other used approaches on evaluating BRT system within the framework of TOD, that are evaluating the influence of BRT system on transit ridership around the system and evaluating the citizens' mode shift triggered by the BRT system [6,7]. While the latter two approaches are theoretically valid considering the TOD principles, they haven't been much used by researchers trying to evaluate the impact of BRT system towards urban development.

This article tests evaluating a BRT system within the framework of TOD using the approach of evaluating the citizens' mode shift triggered by the BRT system. This article explores Transjakarta



BRT's ability to trigger its passengers' mode shift from doing other way of travelling to using Transjakarta for the same kind of trip. By doing so, this article intends to propose and provide for the development of an alternate approach in evaluating a rapid transit system within the framework of TOD.

## 2. Literature study

### 2.1. *Transit-Oriented Development (TOD) issues and principle*

There are a number of issues commonly agreed being part of transit-oriented development (TOD) [8] and commonly agreed TOD principles [6]. The issues commonly concerned by TOD are regional physical design, residents' mobility, built environment development staging, and transit and property development market and financing. There are a significant number of TOD principles related to the regional physical design, including providing sufficient walk, cycle, and transit facilities and providing high-density mixed-use development supporting the operation of transit systems. In regard to the residents' mobility, TOD encourages citizens to walk, cycle, and take transit more. TOD also encourages citizens to shift from using their private motorised vehicle to taking transit, walk, and cycle. In regard to the built environment development staging and transit and property development market and financing, TOD encourages the integrated transit and property development, or the development of transit system that can induce the development of property around the transit system.

### 2.2. *Evaluation of Bus Rapid Transit (BRT) system passengers' mode shift*

It is arguably proper to evaluate bus rapid transit (BRT) system within the framework of TOD [6]. Considering that TOD encourages citizens to shift from using their private motorised vehicle to using transit, the BRT systems that operate within the designated TOD area should act as an agent for such mode shift. The operation of the BRT systems should act as the 'pull' factor for citizens doing such mode shift [9]. The operation of the BRT systems should trigger citizens to shift from using their motorised vehicle to using the BRT systems.

There has been some research, evaluating the mode shift occurred among the passengers of a number of BRT systems when evaluating the performance or those BRT systems [10-12]. Even though those evaluations weren't carried out within the framework of TOD, findings of the evaluations showed the potential the BRT systems have in triggering mode shift. The BRT systems' mode shift-triggering potential shown is in line with the findings of a number of other researches on mode shift [9,13-15]. Those researches showed that the operation of a transit system, including a BRT system, may trigger a mode shift.

Heterogeneity of the mode shift phenomenon is predicted to happen among various groups of transit passengers [16]. The mode shift phenomenon is predicted to differ between transit passengers of different backgrounds, including different gender, age, income, and ownership of private vehicle and supporting license. The mode shift phenomenon is also predicted to differ between transit passengers doing different types of trip, including different trip purpose, trip time, trip distance, and trip duration. Bartlett's test is one valid way for evaluating the difference in variance among various groups of data [17].

## 3. Methods

This article intends to answer two research questions, that are "Is Transjakarta able to trigger mode shift from doing other way of travelling, including using private motorised vehicle, to using Transjakarta among its passengers?" and "Is the mode shift-triggering ability homogeneous across all identified groups of passengers?" The two research questions are crafted under the intention of analysing Transjakarta's ability to serve as the agent for a transit-oriented development (TOD) [1-4]. The mode shift data was collected through indirect interview to Transjakarta passengers using online questionnaire. The indirect interview implemented random sampling for picking respondents among Transjakarta passengers. Transjakarta passengers were invited through various media to fill the online questionnaire. In July 2019, 332 verified respondents filled the online questionnaire. The total number of the

respondents accounts for 0,3/1000 of Transjakarta daily total passenger of the time. The main question asked through the online questionnaire is the other way of travelling prior to using Transjakarta. The online questionnaire also gathers some detailed information as suggested by the previous study [16]. The data was processed using simple statistical analysis and Bartlett's test for distribution variance.

## 4. Findings and discussions

### 4.1. Passengers' statistics

Considering the previous study that summarised and pointed out the possibility of data heterogeneity among mode shift preference of various groups of bus rapid transit (RT) systems passengers, the respondents of this research were asked regarding their background and type of trip they mostly do by taking Transjakarta [16]. Some findings from the investigation of the passengers' background are in line with the data utilised in the mentioned previous study [16]. For instance, most of the respondents (41%) have monthly income of the lowest range (Rp0-Rp3.900.000). In general, less respondents stated that they have monthly income of the higher range. However, some statistics of the respondents probably need to be investigated further to confirm its ability to explain the whole Transjakarta passengers. For instance, 71% of the respondents stated that they are male and only 29% of the respondents stated that they are female. This almost 3:1 male to female ratio is not a ratio that will be obviously seen when visually observing Transjakarta daily passengers. Table 1 and table 2 show the complete statistics of the interviewed Transjakarta passengers divided by components of background and components of types of trip.

**Table 1.** Statistics of the interviewed Transjakarta passengers, divided by components of background.

	Male	Female	1-18	19-40	41-57	Rp0- Rp3.900.000	Rp3.900.001- Rp8.000.000	Rp8.000.001- Rp12.000.000	Rp12.000.001- Rp16.000.000	More than Rp16.000.000	Have	Doesn't have	Total
Gender	71%	29%											100%
Age cohort			9%	83%	7%								100%
Monthly income						41%	30%	16%	6%	7%			100%
Personal vehicle and supporting license ownership											66%	34%	100%

**Table 2.** Statistics of the interviewed Transjakarta passengers, divided by components of types of trip

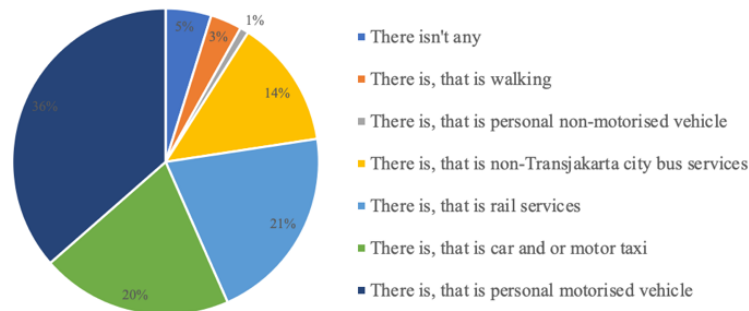
	Daily errands	Leisure	Commute	Weekends	Weekday non peak	Weekday peaks	1-5 km	6-10 km	11-15 km	16-20 km	21-25 km	26-30 km	31-35 km	>35 km	1-15 mins	16-30 mins	31-45 mins	46-60 mins	61-75 mins	76-90 mins	>90 mins	Total	
Purpose	2%	35%	63%																				100%
Time				23%	31%	46%																	100%
Distance							14%	27%	22%	20%	8%	3%	2%	4%									100%
Duration															9%	20%	23%	22%	11%	7%	8%		100%

### 4.2. Mode shift phenomenon and differed variances among groups

Out of 332 respondents, 316 (95%) stated that they utilize other way of travelling prior to mode shifting to taking Transjakarta for the same kind of trip. 121 (36%) respondents stated that they mode shifted from using their personal motorized vehicle (car and motorcycle). 67 (20%) respondents stated that they mode shifted from using paratransit (car and motorcycle taxi). The combined figure of the two groups is higher than the combined figure of passengers who mode shifted from other transit mode (i.e., rail and non-Transjakarta city bus services) and from active transport/non-motorised transport (NMT, i.e., personal non-motorised vehicle and walking). 114 (35%) respondents stated that they mode shifted from other transit mode, while 14 (4%) respondents stated that they mode-shifted from active transport. Figure

1 shows the proportion of mode shift occurring among the respondents. It is worth to highlight the significant figure of passenger's mode-shifted from using their personal motorized vehicle and paratransit. The phenomenon is a commonly agreed principle of transit-oriented development (TOD).

Is there any other mode of transport you use prior to shifting to taking Transjakarta?

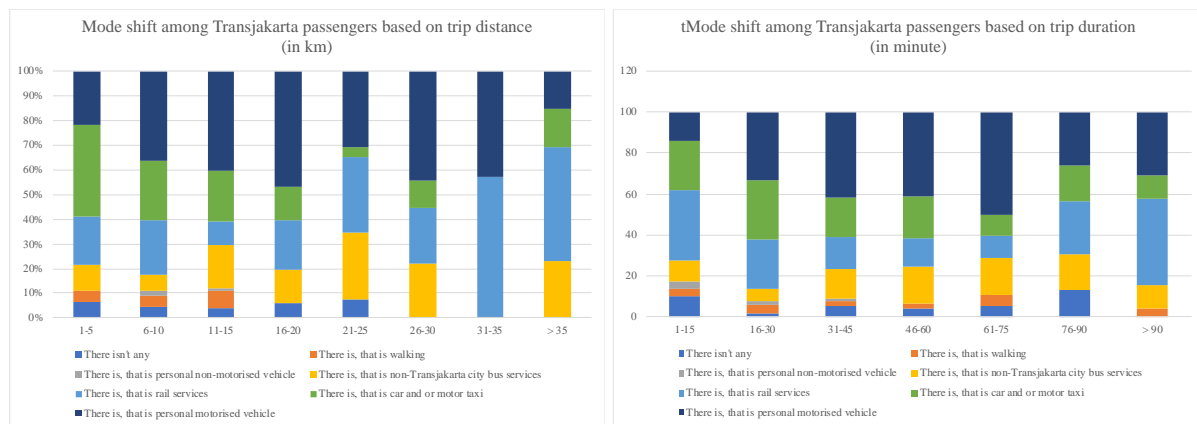


**Figure 1.** Proportion of mode shift occurring among the interviewed Transjakarta passengers.

The variance of mode shift phenomenon shown in figure 1 is found relatively homogenous across various groups of passengers, including groups based on gender, age, monthly income, vehicle ownership, trip purpose, and trip time. It is worth to note that quite contrary from assumption derived from the previous study, the mode shift variances don't really differ among passengers of different groups of monthly income [16]. It worth to note that the percentage of passengers who mode-shifted from using their personal motorised vehicle is not lower among passengers of higher monthly income. Table 3 shows the outputs, used probability constant, and conclusions of the Bartlett's test for variance difference. The variance of mode shift phenomenon is found heterogeneous among groups of passengers of different trip distance and trip duration. The variances among the mentioned groups yet to show any discernible pattern. Figure 2 shows the variance of mode shift phenomenon among groups of passengers of different trip distance and trip duration.

**Table 3.** Outputs, used probability constant, and conclusion of the Bartlett's test for variance difference used in analysing the heterogeneity of mode shift phenomenon among different groups of the interviewed Transjakarta passengers.

	Bartlett's test statistic	Probability constant	Critical value of chi square	Conclusion	Probability of Bartlett's test statistic	Conclusion
<b>Based on passengers' background</b>						
Gender	0,18	0,05	3,84	No significant difference	0,67	Variances are the same
Age	0,23	0,05	5,99	No significant difference	0,89	Variances are the same
Monthly income	0,87	0,05	9,49	No significant difference	0,93	Variances are the same
Vehicle ownership	0,84	0,05	3,84	No significant difference	0,36	Variances are the same
<b>Based on types of trip</b>						
Trip purpose	0,22	0,05	5,99	No significant difference	0,89	Variances are the same
Trip time	0,02	0,05	5,99	No significant difference	0,99	Variances are the same
Trip distance	104,10	0,05	14,07	There is a significant difference	0,00	Variances are not the same
Trip duration	60,15	0,05	12,59	There is a significant difference	0,00	Variances are not the same



**Figure 2.** The variance of mode shift phenomenon among groups of passengers of different trip distance and trip duration.

## 5. Conclusion

We may conclude from the previous section that based on the 332 verified respondents that are Transjakarta passengers, Transjakarta is able to trigger mode shift from doing other way of travelling to using Transjakarta. Transjakarta is even able to trigger mode shift from using private motorised vehicle to using Transjakarta. While there may be some notes regarding the distribution of the respondents, the Transjakarta's mode shift-triggering ability is relatively homogenous across many groups of Transjakarta passengers aside from various trip distance and trip duration groups. Due to its ability to trigger mode shift to using itself among residents of area along its corridors, we may argue that Transjakarta can be a potent agent for a transit-oriented development.

Furthermore, based on the findings from the mode shift data heterogeneity test, we may argue that future policies for increasing mode shift to using Transjakarta may homogeneously affect potential Transjakarta passengers of various gender, age, income, ownership of vehicle and supporting license, trip purpose, and trip time. Meanwhile, such future policies may need to be meticulously crafted to effectively affect potential Transjakarta passengers of different trip distance and trip duration. Considering Transjakarta's extensive network and varied services, a heterogeneity test may need to be carried out for mode shift data of Transjakarta passengers of different corridors and services.

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