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Modal Shift in Public Transport Under Fiscal-Based Policies Scenarios for Jakarta

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Abstract. For many years, Metropolitan Jakarta has struggled with acute transport problems, particularly long commuting times during workdays. The government responded to this issue by providing various public transport facilities, including commuter trains (known as KRL), bus rapid transit (BRT), mass rapid transit (MRT), and light rail transit (LRT). Despite such efforts, the majority of commuters still rely on private vehicles such as cars and motorcycles. This makes transport policies based on travel demand management more effective and impactful than the traditional "predict and provide" strategy that focuses solely on expanding urban roadways. According to the Jabodetabek Transportation Master Plan (RITJ), the proposed fiscal-based policies include (i) the use of biofuel with standards higher than EURO IV, (ii) congestion charging in specific road segments, and (iii) increases in parking prices. Therefore, this study aimed to investigate the effectiveness of the policies in motivating private vehicles users to shift to public transport. A stated preference survey was conducted, and a binomial logit model and standard utility function were developed for analysis. Diagrams showing commuters' willingness to shift to public transport were then generated from the analysis. The result showed that commuters residing outside Jakarta had a higher probability of shifting and a greater willingness to pay than those living within the city. Firstly, commuters outside this city were willing to pay IDR 2,500 more for increased fuel prices. Secondly, when congestion charging was integrated, commuters outside Jakarta were willing to pay around IDR 30,000 compared to IDR 20,000 by those within the city. Thirdly, commuters outside the city were willing to pay additional parking fees exceeding IDR 2,000 per hour. Additionally, most private vehicles users would be willing to shift to public transport services when the three fiscal-based policies were used. The results showed that the policies could be effective when the characteristics of the users were considered before the adoption.

Keywords: Congestion charging; Jakarta; Stated preference survey; Transport demand management; Willingness to Shift

1. Introduction

Jakarta, as a significant global economic hub, is facing acute traffic problems including

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congestion, heavy pollution, and stagnation of the transportation infrastructure (Latief *et al.,* 2016). Compared to other cities such as London and Singapore, transportation management in the Indonesian capital covers various local and national sectors, posing challenges, specifically in using fiscal-based policies. Over recent decades, the city government has responded by enhancing public transport infrastructures, including commuter trains (KRL), bus rapid transit (BRT), mass rapid transit (MRT), and light rail transit (LRT). Despite these substantial infrastructure improvements, JUTPI (2019, 2012) reported a drastic decline in the proportion of public transport users. In 2002, public transport was dominant, with over 50% of commuters using it, but by 2010, the figure dropped below half. By 2018, private vehicles overwhelmingly dominated Jakarta's transportation, accounting for more than 80% of the mode of transport. The Central Statistical Bureau data showed that 72% of commuters use private vehicles such as cars and motorcycles (BPS, 2019), with motorcycles constituting 59% of this proportion (Kompas, 2022).

Several factors influence travel mode selection, including user characteristics, travel behaviors, and mode choices (Ortúzar and Willumsen, 2011). Cities worldwide, particularly Jakarta, have adopted travel demand management strategies, such as fiscal-based policies, to tackle transportation challenges (Gärling and Schuitema, 2007). These interventions typically constitute measures comprising the use of biofuel, congestion charging, and increased parking prices. Although the effectiveness of such measures may vary between city due to socio-economic and cultural differences, a reduction in road-based services and a shift in travel mode choice are generally anticipated (Kusumantoro *et al.,* 2009).

Some economists argue that fiscal-based policies are more effective and impactful than physical-based ones (Chatterjee and Ghosh, 2011). These policies can drive behavioral changes and enable adjustment in the cost of transport mode choices. Financial instruments, such as fuel taxes, emissions taxes, engine size taxes, vehicle age taxes, road congestion charges, parking charges, and public transport fare subsidies have been extensively documented in the literature. Conversely, non-fiscal and physical regulatory frameworks focus on road supply provision, emissions regulation, traffic calming, and vehicle restrictions, particularly odd-even policies, parking area restrictions, and land use planning. Surprisingly, odd-even policies have not significantly reduced air pollution in Jakarta (Zulkarnain and Ghiffary, 2021).

In Jakarta, the use of biofuel for transportation has been introduced, even though other sectors such as agriculture and livestock, continue to compete for raw material supply (Chanthawong and Dhakal, 2016). The national government projects a 23% increase in biofuel use by the end of 2024 (Ministry PPN RI, 2019). Tjahjono *et al.* (2021) showed that most of the respondents were willing to shift to biofuel, even when the price was higher than current fuels. The analysis assumes the elimination of subsidized fuels and the enforcement of EURO IV standard emissions policies, necessitating supportive policies for this transition. Additionally, various cities, including Singapore (Agarwal and Koo, 2016), London (Santos, 2005), and Nagoya (Sugiarto *et al.,* 2017; 2015), have used congestion taxes or charging policies. Research on congestion charging in Jakarta indicates that its usage has reduced the probability of car users (Belgiawan, Ilahi, and Axhausen, 2019; Prayudyanto and Tamin, 2019). Effective use of congestion charging is influenced more by social and psychological factors than merely by cost and mobility considerations (Sugiarto *et al.,* 2015). Previous reviews have also shown the impact of parking policies and facilities on public transport use (Nunns, Donovan, and Genter, 2020; De Gruyter, Truong, and Taylor, 2020; Nahry, Tjahjono, and Brotoadi, 2015). Parking policies have been widely used in various cities to discourage the use of private vehicles (Gutman, Vorontsova, and Seredin,

2021; Shoup, 2019). In Jabodetabek, investigations have shown that the policies schemes significantly affect private vehicles usage and reduce traffic congestion (Ilahi, Belgiawan, and Axhausen, 2020).

This study aimed to investigate the tendency of commuters to shift from private vehicles to public transport under three policies scenarios, including the use of biofuel, congestion charging, and increased parking prices based on the Jabodetabek Transportation Master Plan (RITJ) (Republic of Indonesia, 2018). The scenarios were selected based on their relative popularity and potential acceptability among the public. Therefore, the investigation focuses on commuters' behavioral changes and how the policies may reduce emission pollution, as substantiated by (Anjum *et al.,* 2019; Bharadwaj *et al.,* 2017).

2. Methods

This section outlined the data collection and processing methods adopted for the study. Additionally, it provided a brief overview of the stated preference survey conducted to collect data and the development of a discrete choice model for predicting travel behavior, specifically mode choice. The model, derived from utility function theory, has been extensively adopted in various investigations, such as Tjahjono *et al.* (2021), to predict the shift in traveler preference due to changes in utility values (Tjahjono *et al.,* 2021; Lubis, Pantas, and Farda, 2019).

2.1. Data Collection

Data were collected through the distribution of online questionnaires to commuters who worked or engaged in some activities in Jakarta. To qualify as a sample, respondents were required to use private vehicles such as cars and motorcycles for daily commuting. The questionnaires covered socio-demographic inquiries, including age, gender, occupation, income level, and education. It also elicited information on respondents' travel patterns, such as frequency of use, transportation expenses, fuel costs, toll road expenses, parking prices, and travel time. Furthermore, respondents' stated preferences were assessed by querying their willingness to pay or shift to public transport when each of the three proposed policies were used.

Table 1 The distribution of respondents compared to proportion of commuters

Regency/City	Motorcycles	Cars	Number of Respondents	Proportion of Respondents	Proportion of Commuters (based on BPS (2019))
South Jakarta City	53	8	61	12.95%	7.30%
East Jakarta City	48	11	59	12.53%	12.00%
Central Jakarta City	16	2	18	3.82%	4.50%
West Jakarta City	37	6	43	9.13%	10.50%
North Jakarta City	21	5	26	5.52%	6.00%
Bogor City and Regency	28	6	34	7.22%	7.80%
Depok City	50	10	60	12.74%	14.30%
Tangerang City and Regency	46	8	54	11.47%	11.60%
South Tangerang City	26	9	35	7.43%	7.50%
Bekasi City and Regency	67	14	81	17.19%	18.80%
	392 (83%)	79 (17%)	471		

A stratified random sampling method was adopted, with samples allocated proportionally based on the number of commuters in each regency/city. The domicile

addresses of the respondents were considered as strata, following the method outlined by Arnab (2017). The distribution of samples collected for the study was presented in Table 1. With a sample size of 471, it was important to observe that when subdivided into more detailed respondent groups, the results should be interpreted as indicative and necessitate further in-depth investigations. Similar reviews using the stated preference method have been conducted with comparable sample sizes (Tjahjono *et al.,* 2021; Lubis, Pantas, and Farda, 2019). To better understand the context of respondents' willingness to shift to public transport, this study also collected data on their demographic and travel characteristics. Table 1 presented that motorcycles were the dominant mode of commuting (83%), while car users accounted for 17% of the total.

2.2. Stated Preference Survey

This study used the Stated Preference (SP) questions to present respondents with three hypothetical scenarios. The scenarios were based on three fiscal-based policies, including the use of biofuel, congestion charging, and increased parking prices. The respondents were subsequently asked whether they were willing to pay specified costs to continue using private vehicles or would rather shift to public transport. Additionally, an explanation of the benefits of shifting to public transport, such as reduced travel time and decreased externalities, was provided to the respondents. The following was one of the SP questions:

> *"When the transport cost increases due to biofuel use affecting an increase in fuel expenses, would you consider shifting from private vehicles and using public transport, given that public transport reduces travel time and air pollution? Would you shift to public transport when the fuel costs increased by IDR 3,000 per liter, given the benefit of a 10% travel time reduction and a 5% air pollution reduction?"*

When respondents answered "No," the question was followed by presenting scenarios with lower costs and increased benefits until they agreed to shift, or the minimum costs threshold was reached. Given the hypothetical nature of these questions, the questionnaire design significantly influenced the respondents' answers. The questionnaire was designed based on two key assumptions, including (i) respondents' understanding regarding the scenarios, and (ii) respondents answering logically, guided by the principles of economic rationality and utility maximization.

2.3. Discrete Choice Model

The discrete choice model, adopted to predict mode choices (Boto-García *et al.,* 2022; Steimle *et al.,* 2022), operated on the concept of random utility maximization. The model assumed that decision-makers comprehended all available alternatives and their associated terms and conditions, thereby making trade-offs among these options when presented with a set of discrete, such as mode choice (private vehicles or public transport services). The alternatives could range from binary choices to more than two choices, as evidenced by (Train, 2009). Rooted in the utility function theory, this model posited that individuals would always choose the option of maximizing their satisfaction. This study adopted the utility function theory to explore the willingness of commuters who might opt for public transport modes when fiscal-based policies were proposed. Its discrete situation focused on whether commuters would continue using private vehicles or shift to public transport as the cost of private vehicles usage gradually increased due to higher fuel costs, congestion fees, or parking fees. The situation prompted commuters to consider the benefits of public transport services. Moreover, the discrete choice model could serve as a powerful instrument to analyze user perceptions regarding various alternatives.

The alternatives were simplified to whether a willingness to shift to public transport or a reluctance to change by continuing to use private vehicles as the primary commuting mode. To compare the two alternatives, a utility function was required to understand the significant factors included (Train, 2009; Ortuzar and Cifuentes, 2000). Given that there were only two alternatives, particularly shifting or staying, the appropriate model was a binomial logit model (Tjahjono *et al.,* 2021). The probability of choosing between the alternatives could be modeled using the following logistic regression formula (see equation 1).

$$P_{i-j} = \frac{1}{[\,1+ e^{-(Ui-Uj)}]} = \frac{e^{Ui}}{e^{Ui}+e^{Uj}} \quad (1)$$

The model assumed that the random error was independent and identically distributed.

3. Results and Discussion

3.1. Results

The socio-demographic characteristics of the respondents were explained in the following ways. Based on gender, the majority of the respondents (72%) were male, while the remaining were female. The majority (79%) fell within a productive age range, with 46% aged 20–25 and 33% aged 25–45 years old. In terms of occupation, most of the respondents were company workers (43%), followed by students (21%), entrepreneurs/self-employed (19%), government employees (10%), and housewives or job seekers (7%). Regarding income levels, the majority were mid- to low-income earners, with 29% earning less than IDR 3 million, while 30% earned between IDR 3 and 5 million, and another 30% earned between IDR 5 and 10 million.

The respondents' travel characteristics included the frequency of commuting during the week, transport expenses, commuting time, and concerns about transport externalities, specifically pollution. The majority commuted seven days (25%), with others commuting six days (21%) and five days (18%) weekly. On average, the remaining of the respondents commuted one to four days a week. Regarding daily transport expenses, most of the respondents (51.6%) spent IDR 10,000 to IDR 25,000. Fuel expenses were low, with 62.8% of them spending less than IDR 150k per week. Additionally, toll road fees were relatively low, with the majority (58.5%) spending less than IDR 10,000 per day. Daily parking expenses for most respondents (40.3%) also ranged from IDR 5,000 to 10,000.

The utility result showed that 14 variables were highly significant for the three scenarios. Socio-demographic variables such as living location (X2), occupation (X3), education (X4), gender (X5), and frequency of commuting (X6), were all significant in the scenarios. These variables, along with stated preference variables, including expected cost increase (X12), expected travel time reduced (X13), and expected pollution reduced (X14), formed the utility function for each scenario, as shown in Table 2.

Table 2 Utility function of the scenarios

Scenario	Utility function
1. Fuel cost increase	$-4.318+0.67X_2+0.66X_3+0.198X_4+0.477X_5+0.219X_6+0.099X_8-0.4X_9-0.000175X_{12}+0.03X_{13}+10.08X_{14}$
2. Congestion charge	$-3.837+0.624X_1+0.63X_2+0.492X_3+0.186X_4+0.559X_5+0.2115X_6+0.0788X_7-0.0000414X_{12}+0.027X_{13}+8.622X_{14}$
3. Parking cost increase	$-4.063-0.533X_1+0.701X_2+0.5039X_3+0.2006X_4+0.559X_5+0.186X_6-0.171X_{10}+0.11X_{11}-0.00037X_{12}+0.0337X_{13}+10.17X_{14}$

In relation to the probability chart, Figure 1 provided the probability of each scenario resulting in a shift to public transport modes, based on where the respondents live, whether in Jakarta or satellite cities such as Bekasi, Bogor, Tangerang, and Depok.

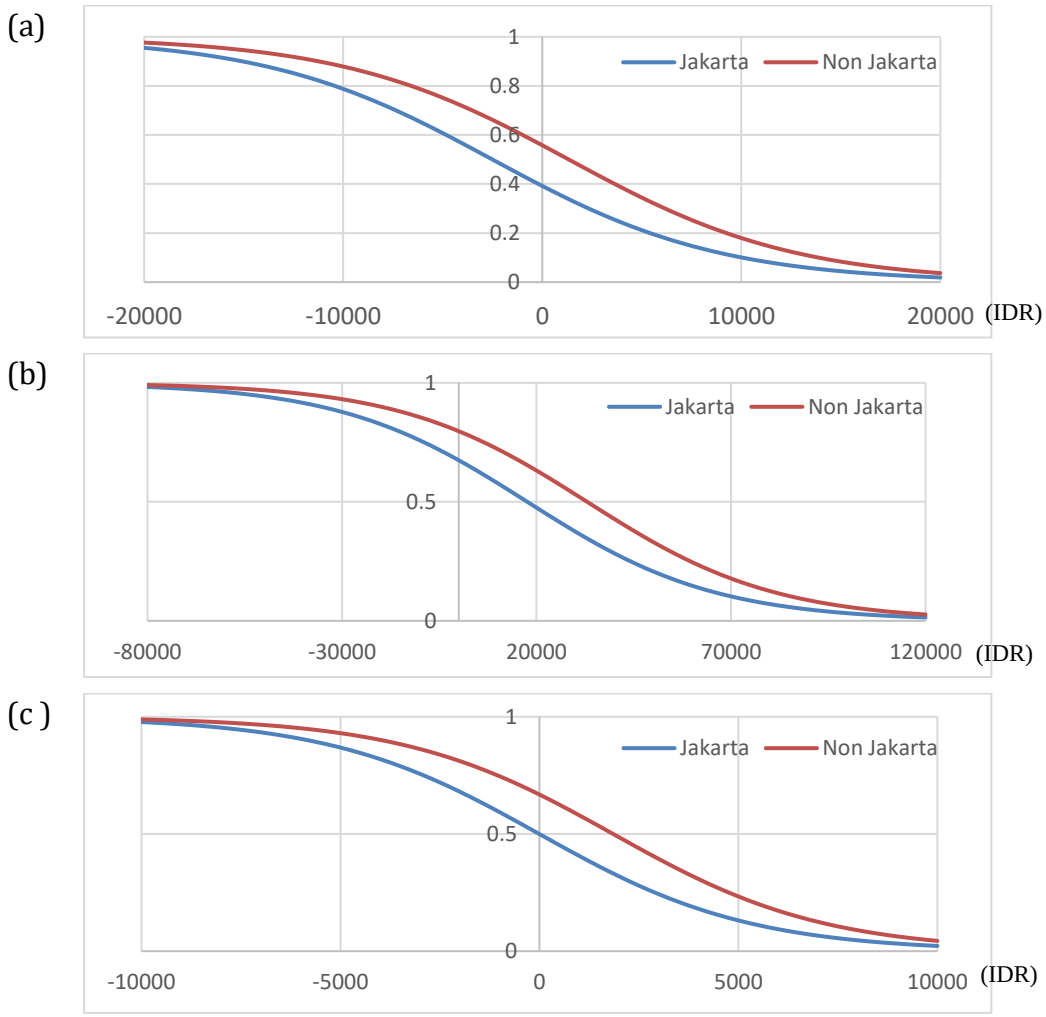

Figure 1 (a) Willingness to pay fuel cost increase scenario, (b) Willingness to pay congestion charging fee scenario, (c) Willingness to pay parking cost increase scenario

3.2. Discussions

The socio-demographic characteristics of the respondents closely resembled those outlined in the census report published by the Central Statistical Bureau (BPS, 2019). According to the report, 40% of commuters earned a monthly income exceeding IDR 5 million, while 48% fell within the range of IDR 3 to 5 million monthly. Moreover, the report indicated a predominantly male (70%) population in their productive years (71%), with half of the commuters having completed high school.

In terms of travel characteristics, the Central Statistical Bureau (BPS, 2019) reported that in Jabodetabek, 30.3% of commuters spent between IDR 15,000 and IDR 25,000 daily on trips, while 24.7% spent more than IDR 25,000. The result was in line with this study, with the majority of commuters (83%) using affordable motorcycles for their daily commute. Additionally, most commuters earned less than IDR 5 million per month, incentivizing the use of economical transportation modes, which was below IDR 150k per week. Motorcycle users typically allocated around IDR 50,000 weekly for fuel expenses and did not use toll roads.

Although the utility function scenarios shared similar variables, they had differences in significant variables. In Scenario 1 (Fuel cost increase), transport expenses (X8) and fuel expenses (X9) were highly influential. The scenario suggested that higher transport expenses enhanced the willingness to shift to public transport.

In Scenario 2, the propensity was influenced by travel mode (X1) and current travel time (X7). Respondents with lower fuel expenses had a greater willingness to shift from private vehicles to public transport. Furthermore, longer travel time significantly motivated respondents to shift to public transport with the use of congestion charging. Scenario 3 (parking cost increase) was also influenced by travel mode (X1), current parking expenses (X10), and externalities compensation (X11). This explained why motorcycle users were particularly sensitive to parking fees, given their substantial contribution to total transport expenses. The increase in parking fees for motorcycles, proportionally higher compared to car users, contributed to Scenario 3. Additionally, the results showed that externalities compensation variables were only significant for the scenario.

To discuss probability, as shown in Figure 1, residents of satellite cities had a higher probability of shifting and willingness to pay compared to those residing in Jakarta. The result of Scenario 1 with the use of new fuel (higher price) showed that commuters had a willingness to pay approximately IDR 2,500 more than current fuel prices (Table 3). Conversely, individuals in Jakarta were generally disinclined to pay more and anticipated lower prices. The heavy congestion in the city might render private vehicles usage less attractive, thereby extending daily commuting times.

Based on the analysis of Scenario 2, congestion charging use resulted in a similar pattern. Commuters were willing to pay approximately IDR 30,000 to access the corresponding road, whereas those in Jakarta were only willing to pay IDR 20,000 (Table 3). This phenomenon could be attributed to their familiarity with urban road networks and the availability of various alternative modes. Individuals familiar with the routes could avoid alternative routes subjected to congestion charging. Conversely, individuals outside Jakarta might have less knowledge of the routes, resulting in shorter travel distances (Rizki *et al.,* 2016). Additionally, transaction costs were influenced by the perception regarding the importance of welfare development (Miharja *et al.,* 2021).

In Scenario 3, including parking price adjustments, commuters expressed a willingness to pay IDR 2,000 or more (Table 3). Individuals in Jakarta tended to resist paying parking fees exceeding their current rates. For instance, car users typically pay IDR 5,000 on average for the first hour of parking and IDR 4,000 for subsequent hours. In other cities, residents only paid IDR 3,000 for the first hour and IDR 2,000 for the next hour. A fee increase would significantly affect the willingness to pay, particularly given the disparity in charges between the two areas. For instance, individuals in Jakarta were only willing to pay IDR 500 more, resulting in an hourly parking cost of around IDR 5,500. Meanwhile, those outside the city were willing to pay IDR 1,500 more, bringing the final parking cost to IDR 4,500 per hour, as shown in Figure 1.

Table 3 Willingness to pay in the three fiscal policies scenarios

	Scenario 1	Scenario 2	Scenario 3
Commuters outside Jakarta	IDR 2,500 (compared to the existing price)	IDR 30,000 (compared to the existing fee)	IDR 2,000 (compared to the existing fee)
Commuters in Jakarta	0 (unwilling)	IDR 20,000 (compared to the existing fee)	0 (unwilling)

4. Conclusions

In conclusion, the use of public transport services in Jakarta has remained stagnant for decades. Despite recent efforts by both national and provincial governments to enhance transport infrastructure, private vehicles users appeared hesitant to shift to public transport modes. Fiscal-based instruments could be deployed to incentivize such transition and offset the high costs associated with private vehicles usage. The instruments had the potential to increase transport expenses for users while concurrently discouraging reliance on private vehicles.

This study indicated that the majority of private vehicle users were willing to shift to public transport services across all three fiscal-based policies scenarios. The results showed the efficacy of the scenarios, but different effects were observed based on commuters' place of residence. For instance, in Scenario 1, commuters outside Jakarta had a willingness to pay IDR 2,500 more for increased fuel prices. Similarly, in Scenario 2, commuters outside the city were willing to pay around IDR 30,000, while those within were willing to pay only IDR 20,000. Regarding Scenario 3, commuters outside Jakarta were willing to pay additional fees exceeding IDR 2,000 per hour for parking.

The analysis results showed that fiscal instruments remained viable options for integration, given the willingness of most private vehicle users to shift to public transport services across all three scenarios. The utility function model offered insights into the significant factors, such as domicile, influencing commuters' decisions to adopt private vehicles or public transport modes.

Future reviews should prioritize conducting more in-depth interviews to investigate the underlying choices and behaviors of private vehicle users when selecting public transport for their daily commutes. As this study relied on a stated preference survey, biases and question framing might affect respondents' answers. Moreover, respondents' preferences were contingent upon their understanding of the benefits and drawbacks associated with each scenario. Future reviews should strive to capture a more comprehensive understanding of respondents' perspectives.

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