The Impact of Congestion Pricing on Public Transport Utilization in Jakarta, Indonesia

Asep Yayat Nurhidayat[1,*], Adita Utami[2], Dwi Phalita Upahita[1]

[1]Research Centre for Transportation Technology, National Research and Innovation Agency, Jakarta 10340, Indonesia
[2]Department of Civil Engineering, Faculty of Infrastructure Planning, Universitas Pertamina, South Jakarta 12220, Indonesia

*Author to whom correspondence should be addressed:
E-mail: asep050@brin.go.id

(Received May 26, 2025; Revised October 06, 2025; Accepted December 15, 2025)

Abstract: Traffic congestion causes an increase in fuel consumption, vehicle operational cost, travel time, and increased traffic accidents, while at the same time reducing the air quality. Congestion pricing (CP) is one of the strategies that various cities have implemented to reduce private car usage, leading to improvements in traffic conditions and air quality. This study aims to determine the impact of congestion pricing on private vehicle use in Jakarta by modelling the probability of mode shift to public transport. Stated preference and binomial logit model are used to analyze the impact of congestion cost implementation on mode shift. The results show a possible shift from private cars to bus rapid transit (BRT) by 56% with the implementation of congestion pricing. The findings provide insight that congestion pricing has an impact on potential mode shift to public transport. The shift is influenced by the amount of the congestion charge imposed. The more expensive the congestion charge, the more likely car users are to switch to public transport.

Keywords: binomial logit model; congestion pricing; impact; mode shift; stated preference

1. Introduction

Traffic congestion is a problem faced by many major cities worldwide. It is caused by population growth, increased private vehicle ownership, changes in travel patterns, and insufficient transportation infrastructure. Economic growth has caused an increase in travel demand[1,2]. Rapid urbanisation is one of the factors that causes traffic congestion[3,4]. A study by[5] showed that economic growth led to a rapid increase in people's mobility, increasing vehicle usage. The increase in vehicle numbers is also a problem that is faced by many cities in the world[6,7]. Besides, traffic congestion in urban areas is also caused by the condition where transportation infrastructure cannot accommodate trip demand, especially during peak hours[8]. Economic growth and technology advancement also drive urban agglomeration growth[9]. It causes more people movement between city centre and satellite cities. Traffic congestion is caused by insufficient road capacity that leads to slower travel. It caused travel time lost, vehicle emissions related loss, and an increase in road accident[10]. In Jabodetabek, trips by motorcycle increase by 27.5% while trips by public transportation decreased by 28.4%[11]. Compared to other cities in the world such as Tokyo, Jakarta has severe traffic congestion, indicated by average vehicle speed of 15 km/hour[12].

According to Raux[13]The transportation sector is one of the primary sources of air pollution, contributing to 25 – 30% of global CO2 emissions. Majority of transport-related emissions came from road transport[14]. Air pollution from vehicle emissions can cause severe health effects[15]. It is the leading cause of death for 3.3 million people globally[16] and 50.000 people in UK[17]. Traffic congestion also increases the risk of traffic accident[18,19]. Traffic congestion caused increases in fuel consumption and vehicle operation costs. Inefficiency in the current urban transport system in Bangkok leads to congestion, air and noise pollution, traffic accidents, as well as contributing to global warming with externality cost about 7% - 10% of the GRP, half of which comes from traffic congestion[20].

Congestion pricing or congestion cost scheme is one measure that has been applied in several cities to reduce traffic congestion. Travel time saving is the most influential and attractive factor of congestion pricing scheme[21,22], thus travel time usually became the main variable in road congestion cost scheme and is given a special attention. Implementation of congestion pricing potentially increase the vehicle speed, due to the reduction of vehicle traffic[23]. Higher speed will lead to shorter travel time which can be translated to travel time savings.

London started charging fees to drive on roads in central district during peak hours in 2003[24]. Congestion pricing is used as a tool to reduce traffic and increase average speed. Several cities such as London, Stockholm, Singapore, and Milan have implemented congestion pricing in the last 20 years, although cities like New York, Hong Kong, Manchester and Edinburgh have refused to implement such scheme. Cities that have adopted this policy put emphasis on different aspects, for example London aims to increase the average speed while Milan focused on pollution reduction. The revenue from the congestion pricing was allocated for different purposes. In London the revenue is allocated for public transport improvements, while Stockholm allocates the revenue to build road networks. Congestion pricing has been proven to be successful in reducing traffic volumes. This scheme has the potential to reduce pollution from vehicles emissions in areas with high population and pedestrian density.

Jakarta has yet to implement congestion pricing as a strategy to reduce the traffic congestion. Currently, the provincial government implements the odd-even policy on several main road segments to control private cars traffic and reduce traffic congestion. However, looking at current traffic congestion in Jakarta, the scheme may not be effective to reduce traffic. The provincial government has a plan to implement congestion pricing in the form of electronic road pricing (ERP) scheme since several years ago. However, the potential impact on the traffic and mode shift if the congestion pricing is implemented in Jakarta has yet to be explored. Jakarta has its own unique characteristics compared to other cities. High population of motorcycles give Jakarta different traffic conditions. The income level also the availability of alternative mode may affect the effectiveness of congestion pricing scheme in Jakarta.

Implementation of congestion pricing and defining the charge for private vehicles usage in the city area is the main tools to ask car users to pay for the air pollution, noise, and traffic jam that occur due to private vehicles activities[25]. The policy on congestion pricing tends to encourage people to change to public transportation, since driving will cost more. To accommodate the shift from private vehicles to public transportation, the public transportation service should be improved.

Most research on congestion pricing has focused on technical economic approaches, such as the valuation of time or fuel consumption, and the reduction in private car use. Congestion has cross-cutting impacts on health, increased pollution, psychological stress, social impacts, and environmental impacts. However, the impact of congestion pricing on improving public transit performance is still limited. This study explores the introduction of a congestion pricing scheme in Indonesia, especially Jakarta, using traffic data and preference survey data of private vehicle users. This study also analyses the impact of congestion pricing on traffic conditions and the potential mode shift to public transport. It is important knowledge as the basis for the government to take active measures in reducing traffic congestion.

2. Implementation of Congestion Pricing

Congestion Pricing (CP) is a strategic approach in managing urban traffic by charging a fare to vehicles during peak hour or when they pass through a congested area. This method aims to reduce traffic congestion, improve air quality, and increase the public transport ridership. The implementation of congestion pricing has been proven to have significant impact on the traffic conditions and congestion level in the urban area. Different congestion pricing schemes can effectively reduce the dependency on private vehicles and improve traffic conditions in general that lead to more sustainable urban transportation system. Various studies that explored the effectivity and implication of congestion pricing, has shown potential benefits and challenges as well as the impact of congestion pricing on traffic and congestion[26].

Traffic congestion is the main problem that currently hinders sustainable urban development, especially in the transportation sector. The implementation of congestion pricing is believed to be an effective strategy to reduce urban traffic congestion. Traffic congestion in Jakarta is very severe, with average speed only about 15 km/hour. In the other hand, the public transport mode share is only 28,4%, thus it calls for improvement in the urban mass transportation system, especially in the dense area. congestion pricing is one of the strategies that can be implemented to reduce traffic congestion in Jakarta.

Congestion pricing has never been implemented in Jakarta. The provincial government has had a plan to implement congestion pricing for several years ago, as an alternative for current odd-even policy. The implementation of congestion pricing in Jakarta was planned to adopt electronic road pricing (ERP) scheme in Singapore. Vehicles, especially private vehicles, will need to pay a certain amount of charge when they pass through certain road segments. It was planned to be installed on the main roads of the city that have severe traffic congestion. The implementation of congestion pricing in Jakarta may need to consider the different traffic characteristics and demographics. Jakarta has a high population of motorcycles which are quite different from the other cities. Socio demographic conditions such as income may also affect the implementation of congestion pricing in Jakarta. Congestion pricing is usually charged to private and commercial vehicles that enter congested areas during certain periods. However, congestion pricing is not charged to public transport, motorcycle, and taxi. When

Cite: A. Nurhidayat, A. Utami, D. Upahita, "The Impact of Congestion Pricing on Public Transport Utilization in Jakarta, Indonesia". Evergreen, 12 (04) 2058-2069 (2025). https://doi.org/10.5109/7402637.

they made a trip during a certain period, they will need to pay a certain amount of money. In London, congestion pricing was first implemented in 2023. The initial fare was £5 to enter the congestion zone between 07.00 am and 6.30 pm on working days. Then, the fare increases to £8 in 2025, £10 in 2011, and £11,50 in 2014. Theoretically, the marginal costs of congestion are equivalent to ideal road charges, and over time, marginal fuel prices also alter the shape of cities, possibly leading to greater sustainability and energy efficiency[27)].

In 2014, the average speed in Beijing urban road networks was about 28 km/hour in morning peak hours and 25 km/hour in evening peak hours[7)], which indicates severe traffic congestion. It was much lower than the highway free-flow speed. Besides, it is essential to improve the public transport services to reduce the usage of private vehicles and reduce congestion[28)]. The congestion pricing scheme's revenue can be allocated to improve mass public transport service quality, road safety, and air quality. After the introduction of congestion pricing, there is a reduction in traffic volume, while trips by bus and trip by taxi increased by about 22% and 21% respectively[29)].

Congestion pricing aims to reduce congestion, improve travel efficiency, and internalise external costs (such as pollution and time wastage). Many studies have shown that congestion pricing impacts vehicle volume and travel time, reduces emissions and air pollution, and increases revenue from congestion pricing, which can be used to improve public transit services. However, the impact of congestion pricing on encouraging public transit usage is still very limited based on the variables of travel time and congestion pricing applied.

2.1. Bibliometric Analysis

Understanding the trend in publications from time to time can be helpful to assess the growth of specific research topics[30)]Figure 1 gives a general picture of the number of publications and average citations per year on congestion pricing from 2010 to 2024.

There are 58 contributing countries, with 51 of them having formed networks, and Indonesia has connections with Japan and France. Figure 2a shows the network of productive and collaborative countries. The data indicated that the USA is the most productive and collaborative country, with 253 publications and a total link strength of 134. The most cited country is Switzerland, which has an average citation of 42,56. The results of the bibliometric analysis show that research on congestion pricing in Indonesia is still lacking, so there will be a gap for decision makers regarding the plan to implement congestion pricing in Indonesia. Indonesia, especially Jakarta, has a unique traffic characteristic with a high population of motorcycles. This different characteristic may require different strategies in the implementation of congestion pricing.

In this dataset, Indonesia was ranked 21st and contributed to 4 publications. As can be seen in Table 1, Indonesia collaborated with Japan and France on this topic.

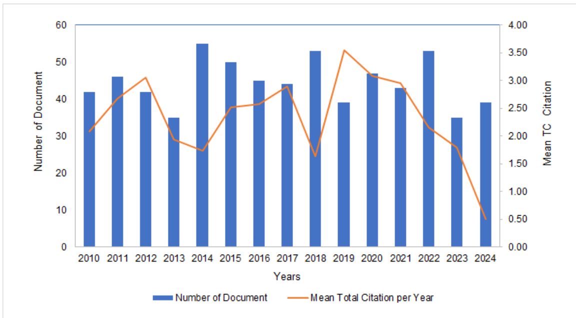
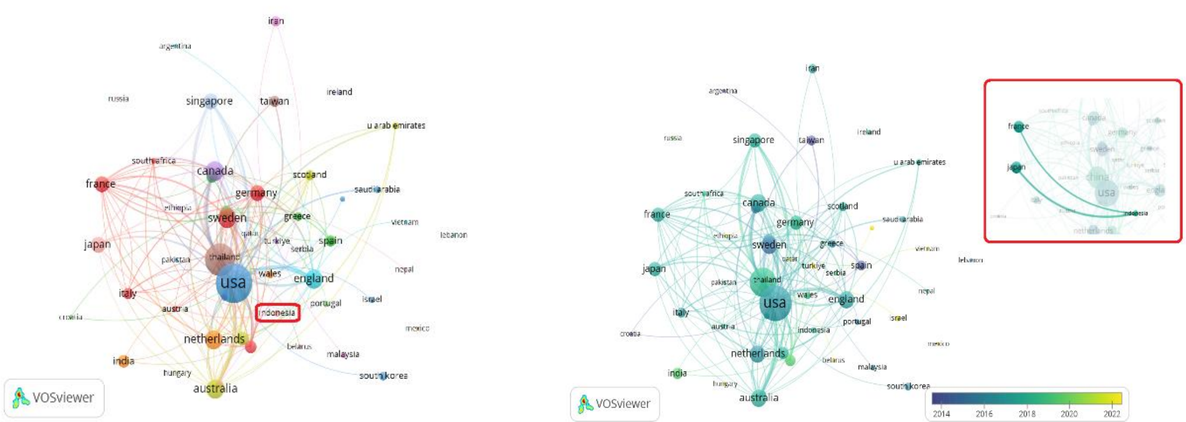


Fig. 1: Distribution of number of documents and citation *(sources: WOS)*



(a) (b)

Fig. 2: Bibliography analysis visualization (a) network visualization productive and collaborative countries (co-authorship-countries); (b) overlay visualization productive and collaborative countries (co-authorship-countries)

Table 1: Top 10 productive and collaborative countries on congestion pricing topic

Country	NP	TC	Links	Total link strength	Avg. pub. year	Avg. citations
USA	253	5082	30	134	2016.48	20.09
China	157	3276	20	107	2018.18	20.87
Sweden	45	1237	13	29	2015.16	27.49
Canada	44	1122	13	38	2017.20	25.50
Australia	41	749	16	41	2017.68	18.27
England	40	804	19	43	2016.93	20.10
Netherlands	40	879	14	24	2016.30	21.98
France	27	602	15	32	2017.41	22.30
Germany	27	599	13	22	2017.74	22.19
Japan	26	271	8	15	2017.38	10.42
Singapore	26	685	8	29	2017.73	26.35
Belgium	19	249	8	14	2017.05	13.11
Switzerland	18	766	11	17	2017.61	42.56
…						
Indonesia	4	21	2	4	2018	9.75

According to the results from the author keywords analysis, 1863 keywords were found from the dataset that has been refined using open refine. Co-occurrence analysis result found 70 keywords. The results from the co-occurrence analysis indicate three main themes, as can be seen in Figure 3. Vos Viewer map the relationship between cluster where similar keywords were clustered together. The map also indicates that the study on congestion pricing mostly covered on topic such as traffic management, user equilibrium, traffic simulation, and economics analysis of congestion pricing. Study on influence of congestion pricing on mode choice is still limited. Therefore, this study wants to explore how congestion pricing could impact mode shifting to public transport, in this case bus rapid transit (BRT).

To understand the current and future research, two types of analysis were conducted: co-occurrence analysis with overlay visualization and content analysis, as can be seen in Figure 4. Overlay visualization gives a general picture of the trending research topic that has significant impact on congestion pricing research. Content analysis was used to explore potential future research topics. The result indicates that the direction of research on congestion pricing was mainly on traffic management and simulation. Research on how congestion pricing influenced mode choice and mode shift is still underexplored.

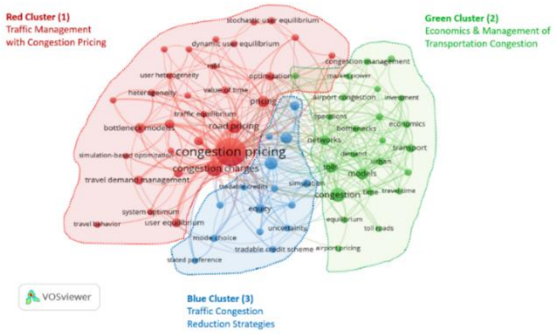
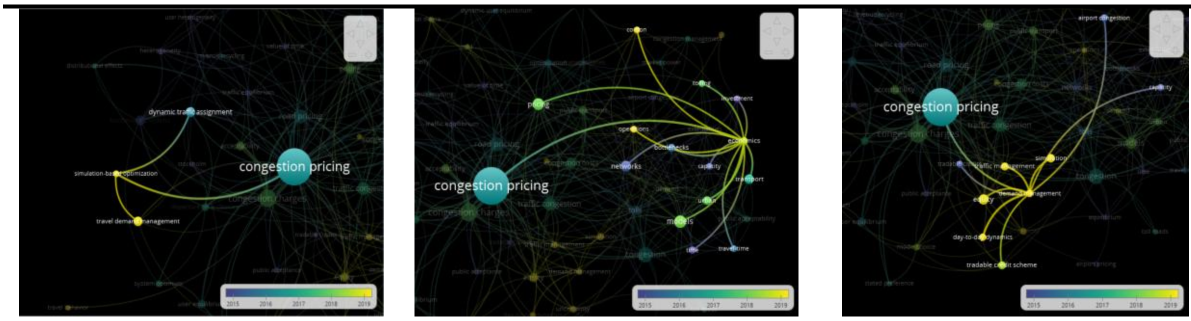


Fig. 3: Network visualization from co-occurrence analysis that results in 3 clusters



(a) (b) (c)

Fig. 4: Overlay visualization of potential future research (a) Simulation-based optimisation, (b) Demand management; traffic management, (c) Economics and operation

3. Data and Methodology

3.1. Study Location

This research focuses on nine road segments in Jakarta, as shown in Figure 5. These are Jakarta's main road segments, which are also served by several public transport routes such as MRT and Transjakarta BRT. Daily traffic data of those road segments, from 1 January 2023 to 31 December 2023, were obtained from the Jakarta Transport Authority. Field surveys were conducted to collect daily traffic data for one day. The field data was used to check the accuracy of the data from the Jakarta Transport Authority. Additional data were also collected, such as road segment length, road geometry, average travel time, and average speed. The perceived travel time for the road segment was collected through an intercept survey of the road users who pass through the road segment.

3.2. Vehicle Operation Cost

Vehicle operation cost is the cost of operating the vehicle from its origin to its destination. It is divided into two components: fixed cost and variable cost. Fixed cost remains unchanged, although the travel distance changes. Meanwhile, variable cost depends on the travel distance. The cost will vary according to the type of vehicle, fuel type, maintenance, and other costs.[31]The Pacific Consultant International (PCI) 1988 method calculates the vehicle

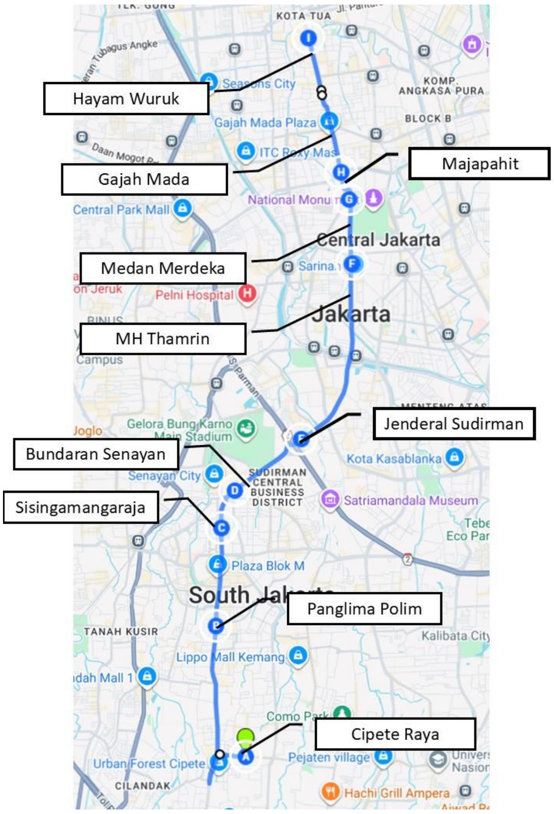


Fig. 5: Study locations (Basemap: GoogleMaps)

operation cost. It was developed by Pacific Consultant International and is widely used to calculate the operating cost of a vehicle based on several components: fuel consumption, lubricant consumption, tire, spare part, labour, shrinkage factor, capital, and insurance. Table 2 shows the cost component and the calculation formula for the PCI 1988 method.

3.3. Pollution Cost

The cost of pollution was calculated based on Marginal Health Cost (MHC), reported by the World Bank (1993) in Indonesia, available in the Reference in USD cents per liter. Motorised vehicles are one of the primary sources of air pollution in urban areas. In recent years, emissions from motorized vehicles, such as carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx), and particulate matter (PM), have been reported to be at very high levels in urban corridors[32,33]Without any intervention, vehicle emissions will create a profound environmental impact in the future. In this research, the pollution cost will be calculated using the Marginal Health Cost Method, which was released by the World Bank. The calculation will depend on the vehicle type, fuel, and dollar exchange rate.

3.4. Value of Time and Travel Time Cost

Value of Time (VOT) is defined as the willingness to pay more to reduce travel time[34]. A good understanding of VOT can lead to better service quality. Understanding VOT is critical in the context of transport policy. Every individual may perceive different travel time than the actual travel time[35] that can lead to different estimated travel times. VOT has many influences in transport analysis, e.g., in transport modelling for route choice analysis.

VOT is calculated by comparing the differences in travel cost and travel time savings from origin to destination between different transport modes. The income method is commonly used in developed countries as a practical

Table 2: Formulation for vehicle operation cost component (PCI 1988 method)

Components	PCI 1988
Fuel Consumption Cost	Y = 0,05693S2 - 6,42593S + 269,18567
Lubricant Cost	Y = 0,00037S2 - 0,0407S + 2,20403
Tire Cost	Y = 0,0008848 S - 0,0045333
Spare Part Cost	Y = 0,0000064 S + 0,0005567
Maintenance Labour Cost	Y = 0,00362 S + 0,36267
Shrinkage Cost	Y = 1/(2,50 S + 125)
Capital Interest Cost	Y = 150/(500 S)
Insurance Cost	Y = 38 / (500 S)

approach to defining resource and behavioural values. In previous studies, the perceived travel time is about 1.5 times higher than the actual travel time[36,37]. It indicates that estimated travel time is usually longer than the actual travel time. The difference between perceived and actual travel time shows that stated preference (SP) survey could lead to bias in VOT[38,39]. Study by[38,39] Showed that the VOT based on a revealed preference (RP) survey is more accurate than the one based on an SP survey. However, the SP survey is still essential in comparing different scenarios in transport planning. VOT as a ratio between time and cost is shown in (1).

$$VOT^{*}_{iq} = \frac{\partial V_{iq}}{\partial t^{*}_{iq}} \Big/ \frac{\partial V_{iq}}{\partial C_{iq}} \quad (1)$$

Travel time cost (TTC) is the value of money per unit that an individual is willing to pay to reduce their travel time or get to their destination in a certain period of time. TTC is calculated by multiplying VOT for each type of vehicle with the travel time by each mode from origin (i) to destination (j) (TT_{ij}^{m}). TTC is formulated as follows.

$$TTC_{ij}^{m} = VOT\ (TT_{ij}^{m}) \quad (2)$$

Where
TTC_{ij}^{m} : travel time cost using mode m from i to j
VOT: value of time
(TT_{ij}^{m}) : total travel time using mode m from i to j

3.5. Congestion Pricing Implementation Model

A stated preference survey was conducted to understand the impact of congestion pricing implementation on the mode shift between private vehicles and bus rapid transit. The result from the SP survey is used to obtain a logit binary model. The formulation of individual utility function is developed from the logit biner model. This study uses three independent variables: travel time, congestion pricing, and frequency. Mode shift probabilities will be the dependent variable. A set of scenarios with variation of these three independent variables is included in the SP questionnaire. Table 3 shows the SP scenarios. Logit binary regression is used to define factors that influence the trip maker choice with the implementation of congestion pricing. It aims to obtain the probability of mode shifting from private vehicle to public transport, in this case bus rapid transit (BRT), when the congestion pricing is implemented.

According to the random utility concept, the probability of choosing alternative i is equal to the probability if the utility of alternative i is equal to or greater than the utility of other alternatives. Therefore, the probability for alternative I to be chosen by individual n that faces several alternatives Cn can be formulated as shown in (3).

$$P_n(i|C_n) = Prob\left(U_{in} \geq U_{jn},\ \forall j \in C_n\right) \quad (3)$$

In the logit binomial model, Cn consists of two alternatives (in this case, we refer to them as alternatives i and j); thus, the probability of individual n choosing alternative i can be formulated as shown in (4).

$$P_n(i|C_n) = Prob\left(U_{in} \geq U_{jn}\right) \quad (4)$$

While the probability of choosing alternative j is shown in equation (5)

$$P_{jn} = 1 - P_{in} \quad (5)$$

Logit binomial model is built based on the assumption that $\varepsilon_n = \varepsilon_{jn} - \varepsilon_{in}$ will be independent and identically distributed according to the logistic spread function or the Gumbel function, as follows.

$$F(\varepsilon_n) = \frac{1}{1+e^{-\alpha\varepsilon_n}}, \alpha > 0, -\infty < \varepsilon_n, \infty. \quad (6)$$

Where α is the positive scale parameter, although a normal distribution is good enough, a logistic distribution is easier for analysis. With the assumption that ε_n Following a logistic distribution, the probability for alternative i is formulated as follows.

$$P_n(i) = Prob\left(U_{in} \geq U_{jn}\right) = \frac{1}{1+e^{-\alpha\varepsilon_n}} = \frac{e^{\alpha U_{in}}}{e^{\alpha U_{in}} + e^{\alpha U_{jn}}} \quad (7)$$

If the utility functions Uin and Ujn are assumed to be linear, the logit binomial model will be as shown in (8).

Table 3: SP scenarios of congestion pricing implementation

Scenario	Travel Time (Minutes)	Congestion Cost (thousand IDR)	Response
1	15 minutes slower	20	Using Passenger Car/Using BRT
2	20 minutes slower	15	Using Passenger Car/Using BRT
3	25 minutes slower	10	Using Passenger Car/Using BRT
4	10 minutes slower	20	Using Passenger Car/Using BRT
5	15 minutes slower	15	Using Passenger Car/Using BRT
6	20 minutes slower	10	Using Passenger Car/Using BRT
7	5 minutes slower	20	Using Passenger Car/Using BRT
8	10 minutes slower	15	Using Passenger Car/Using BRT
9	15 minutes slower	10	Using Passenger Car/Using BRT

$$P_n = \frac{e^{\alpha\beta x_{in}}}{e^{\alpha\beta x_{in}} + e^{\alpha\beta x_{jn}}} = \frac{1}{1+e^{-\alpha\beta(x_{in}-x_{jn})}} \quad (8)$$

3.6. Data Analysis

The data collected from field data collection, SP survey, and other sources are then analysed in several stages. The cost components and the congestion implementation model will be obtained from those stages.

1) Traffic Volume Analysis

Traffic volume data are collected from field observations and the Jakarta Transportation Authority. They are classified into four categories: passenger cars, heavy vehicles, buses, and motorcycles. The data is collected on an hourly basis. Field observations and secondary sources are compared to analyse the daily traffic volume trend.

2) Vehicle Operation Cost

Vehicle operation cost is calculated based on the formulation from the PCI 1988 method. Data on travel time and/or average speed are required to calculate the vehicle operation cost. From data collection, there are two travel time data: perceived travel time and actual travel time. Travel time is converted to speed, thus producing actual speed and perceived speed. Both speed data are used as input to calculate the vehicle operation cost using PCI methods.

3) Pollution Cost

In this study, the pollution cost is calculated using the marginal health cost method, which was released by the World Bank. The pollution depends on the type of vehicle, fuel, and the dollar's exchange rate with the local currency, in this case, IDR.

4) VOT and TTC Analysis

The income method is commonly used in developed countries as a practical approach to define resource value and behavioural value. Once the VOT is obtained, the TTC is calculated using the formula in (2).

5) Congestion Cost Calculation

Congestion cost is obtained by summing up the vehicle operation cost, pollution cost, and TTC in actual and perceived conditions. The differences in cost in actual condition and perceived condition are assumed to be the loss that private vehicles experience when driving through the congested segment.

6) Implementation of Congestion Pricing and Mode Shift Analysis

An SP survey is conducted to understand road users' responses to congestion pricing. In the survey, the respondents are asked to respond to a series of congestion pricing implementation scenarios (as shown in Table 3). The responses are analysed using a logit binomial model to get the probability of mode shifting from private vehicle to public transport if congestion pricing is implemented.

4. Result and Discussion

4.1. Traffic Volume

Speed and traffic volume data were collected from a one-year record produced by the Jakarta Transportation Authority. Then, a field survey was conducted to validate the daily traffic and average speed data. The records from the Jakarta Transportation Authority and field survey were compared to see whether both data sets have similar daily trends. Traffic data was classified into four categories: passenger cars, motorcycles, buses, and trucks. Vehicle speed data were collected using a speed gun. Table 4 shows the yearly traffic volume at the study locations.

Traffic data indicates a high traffic volume at the study locations, which leads to low vehicle speeds. According to the field survey results, the average vehicle speed during peak hours is 18.1 km/hour. Slow vehicle speeds will lead to higher vehicle operation costs and time loss.

4.2. Vehicle Operation Cost

Vehicle operation cost is calculated using the PCI 1988

Table 4: Yearly traffic volume data

Street	Total (units)				
	Motorcycle	Car	Bus&truck	VOL^{KND}	VOL_{smp}
Cipete Raya	33,458,459	15,129,734	380,787	48,968,980	23,989,372
Panglima Polim	17,203,716	4,365,958	228,133	21,797,807	8,963,460
Sisingamangaraja	22,622,156	7,783,144	881,059	31,286,359	14,584,060
Bundaran Senayan	29,113,033	23,126,306	2,033,073	54,272,412	33,047,559
Jenderal Sudirman/Karet	26,753,438	24,888,272	2,113,212	53,754,922	34,323,807
MH. Thamrin	28,959,551	13,294,143	1,207,279	43,460,973	22,103,493
Medan Merdeka	26,804,515	13,053,766	1,289,426	41,147,707	21,431,149
Majapahit	43,960,164	13,040,889	843,013	57,844,066	25,126,847
Gajah Mada	14,857,719	3,932,242	406,672	19,196,633	8,175,345
Hayam Wuruk	21,440,749	5,881,290	358,685	27,680,724	11,707,768

Sources: Jakarta Transportation Authority, 2024

Table 5: Total travel cost (generalized cost)

	Condition	Components			
		VOC (IDR)	PC (IDR)	TTC (IDR)	Generalized Cost (IDR)
1	Actual Condition	119,698	11,990	81,153	212,841
2	Normal Condition	82,551	11,990	36,888	131,429

method. The actual average vehicle speed is 18.1 km/hour, with a travel time of 66 minutes for 20 km. Meanwhile, the travel time in normal (not congested) conditions is 30 minutes, with an average vehicle speed of about 40 km/hour. The actual condition indicates an average vehicle speed below 25 km/hour. Vehicle speed is the basis of VIT and travel cost calculations[40].

Based on the calculation (Table 2), the operation cost in actual condition is IDR 5.984/km, while in the normal condition, the operation cost is IDR 4.127/km. Therefore, for 20 km road segment, the total vehicle operation cost in the actual is IDR 119.698 while in the normal condition is IDR 82.551. IDR 37.147 differences between the vehicle operation cost in actual and normal conditions. The results show higher vehicle operation cost in the exact (congested) condition than in the normal (not congested) condition. This indicates that traffic congestion has led to higher vehicle operation costs.

4.3. Pollution Cost

Pollution cost is calculated using the Marginal Health Cost Method. The pollution cost per vehicle is obtained by multiplying the marginal health cost per vehicle by the USD to IDR exchange rate (IDR 15.769/USD) and the road length (20 km) divided by the travel distance per 1 litre of fuel. Based on this calculation, the pollution cost is IDR 11.900.

4.4. VOT and TTC

VOT calculation is based on the IHCM study using the Welfare Method. VOT for each type of vehicle is calculated by multiplying the GDP growth by the occupancy and percentage of vehicle usage, then divided by population and monthly working hours. From the calculation, it was obtained that the VOT for passenger cars is IDR 73.775/hour. TTC calculation is influenced by the travel time on the road segment in actual (congested) and normal (not congested) conditions. Therefore, the TTC is also calculated for both conditions. Table 5 shows the cost in actual and normal conditions.

After calculating vehicle operation cost, pollution cost, and TTC, generalized cost for is obtained by summing up all those costs. Generalized cost is calculated for both actual and normal conditions. The generalised cost in the exact condition is IDR 212.841, while the generalised cost in the normal condition is IDR 131.429. The congestion cost is the extra cost that was spent by a vehicle because of congestion. The total congestion cost is calculated based on the differences between the generalised cost in actual and normal conditions. For this study, the congestion cost is IDR 81.412 per vehicle.

4.5. Impact of Congestion Pricing Implementation

An SP survey is conducted with 122 respondents who are private car users. Regression analysis is performed to determine the independent and dependent variables. Table 6 shows the parameters obtained from the regression analysis.

Table 6 shows that the determination coefficient R^2 is 0,86. It indicates that the influence of this model's utility attributes is about 86%. The attributes used in this model are travel time and congestion cost. The analysis also shows that the t-test value is higher than the t-table value, indicating that the independent variables significantly influence the model. It should be carefully noted that the model is developed specifically for private car users. A separate model must be designed to determine the mode shift from other vehicle users.

This mode selection model aims to determine the proportion of people, specifically private car users, who will shift to BRT after implementing congestion pricing. The impact of congestion pricing on public transport usage was determined by calculating the proportion of private car users who will switch to BRT public transport after implementing congestion pricing in different scenarios. A utility function is obtained based on the regression analysis, as shown below.

$U (P_{pc} – P_{brt}) = 1,25264 + 0,008852 (TT) - 0,05585 (CC)$.

Using the utility function and probability, the shifting probability from private vehicles to BRT can be calculated if a congestion cost is implemented. Table 7 presents the probability of shifting from private cars to BRT under various combinations of travel time and congestion cost scenarios. When the travel time for private vehicles increases by 15 minutes and a congestion charge of IDR

Table 6: Regression analysis result

Regression Statistics	
Multiple R	0,927581
R Square	0,860406
Adjusted R Square	0,860151
Standard Error	0,10753
Observations	1098

Table 7: Shifting probability

Scenario	Travel Time (Minutes)	Congestion Cost (thousand IDR)	Using BRT	Using a Passenger Car
1	15 minutes slower	20	57%	43%
2	20 minutes slower	15	64%	36%
3	25 minutes slower	10	71%	29%
4	10 minutes slower	20	56%	44%
5	15 minutes slower	15	63%	37%
6	20 minutes slower	10	70%	30%
7	5 minutes slower	20	54%	46%
8	10 minutes slower	15	62%	38%
9	15 minutes slower	10	70%	30%

20,000 is applied, the probability of choosing BRT is 57%. By comparison, when the travel time remains 15 minutes longer but the congestion charge is reduced to IDR 15,000, the probability of using BRT increases to 63%. A further increase to 70% is observed when the congestion charge is set at IDR 10,000 under the same travel time condition. These results indicate that a higher congestion charge tends to encourage a greater mode shift toward BRT, whereas changes in travel time have a relatively smaller influence on mode choice. Overall, the findings highlight a trade-off between time and cost that respondents consider when deciding on their preferred mode of transportationThe pattern also indicates that the congestion cost is essential in increasing the shift probability. The respondents are more cost sensitive than time sensitive. When the congestion cost is small, the respondents tend to choose private cars.

The findings suggest that the implementation of a congestion pricing scheme could lead to an estimated 56% reduction in traffic volume, under conditions where the average travel time increases by 10 minutes and a congestion fee of IDR 20,000 is imposed, assuming that the occupancy is one person per car. It will potentially reduce the use of private vehicles and reduce traffic congestion. It will further improve the air quality. It is in line with a study by Basso et al that found that congestion pricing combined with a dedicated bus lane will push people to shift to public transport and increase welfare[41)]. However, further analysis should be done to calculate the impact of congestion pricing on the traffic performance.

The results of this probability model provide insight into the impact of congestion pricing on the likelihood of switching, which is influenced by the congestion charge imposed. The more expensive the congestion charge, the more likely car users will switch to public transport. Therefore, to encourage a shift to public transport, the government should impose a significant congestion charge, so that the trade-off of cost and travel time will push private car users to shift to public transport. Meanwhile, the government also needs to improve public transport services to ensure their travel time reliability.

However, the results also indicate that road users still tend to use private vehicles, even with the implementation of congestion pricing. It is stated by shifting probability that is lower than 50%. More than half of the road users still prefer to use their car. This may be because they still feel that private vehicles are more comfortable than BRT and are willing to pay more for this comfort and convenience. Poor accessibility, limited integration, schedule reliability, and poor infrastructure conditions may hinder people from using public transportation. Therefore, it is important to also improve the service of public transportation, in this case BRT, so that people will be more willing to shift. It will also maximise the impact of congestion pricing on mode shifting and reduce the use of private vehicles.

One of the strategies to improve the public transport system is by improving the accessibility of public transport itself. One example is by providing park and ride facilities near a station or BRT hub located in a suburban area, so that commuter can park their private vehicles and continue their journey using public transport[42)].

Other things that need to be considered are that many other variables can affect mode choice besides travel time and cost. Qualitative and demographic factors, such as gender, occupation, income, and trip purpose, may also affect mode choice[43,44)].

4.6. Congestion Pricing Scheme

Lack of public acceptance is a major barrier to introducing congestion pricing. We compared congestion charging experiences in cities around the world such as Stockholm and Gothenburg in Sweden, showing the importance of procedural factors, such as consistency of objectives in the policy package, communication and marketing efforts, and the use of public referendums, and contextual factors, including urban form, congestion levels, and public transit functionality[45)]**.** While the implementation of congestion pricing in the UK led to a reduction in the number of trips and the resulting emissions, there was an increase in emissions from diesel gas because these vehicles were not charged a congestion charge[24)]**,** it led to a reduction in travel for social purposes[46)]**.**

The result from this study indicates that while congestion pricing can encourage people to leave their cars and shift to public transport, in Jakarta case, more people are still preferring to use their car even if they need to pay more. There are other factors that need to be considered when exploring the mode shifting. Previous study showed that improvement of public transport services is one of success keys for the implementation of congestion pricing[47].

Important lessons can be drawn from the city, but mainly on how to design, rather than secure public acceptance of congestion pricing schemes. To build acceptance of congestion pricing, attention must be paid to the local political and geographical context when designing and implementing the scheme. The implementation of congestion pricing in Indonesia is new and therefore requires public outreach as well as political support to get the plan up and running. Implementation of congestion pricing must be followed with improvement of public transportation to optimise the impact. Congestion pricing revenues can be used for public purposes such as road repairs, public transportation improvements and public transport subsidies.

5. Conclusion

This study explores the potential implementation of congestion pricing on the main roads of Jakarta and the impact of its implementation on mode shifting to public transport. The results of the analysis show that there is a big difference between travel time in congested and normal conditions. This leads to an increase in the total generalised cost. The total congestion cost for the road segment is IDR 81.412 per vehicle.

A mode choice model was developed to model the mode shifting behavior with the implementation of congestion pricing. From the specified scenario, it was found that the highest probability of shifting is 56%, when the congestion cost is IDR 20.000 and travel time is 10 minutes slower. The congestion charge variable is also considered to be more influential than travel time as can be seen from the model coefficients. The more expensive the congestion charge, the greater the potential for people to switch to public transport. This study can be used as the basis to estimate the impact of implementation of congestion pricing in Jakarta, especially on the reduction of private cars usage and increase the use of public transport. It can be a basis for the policy makers to establish the CP scheme and charge for Jakarta.

This study has several limitations related to the survey implementation. Challenges in respondent coverage and field conditions may have affected the representativeness of the sample. Moreover, variations in respondent participation levels and differing levels of comprehension regarding the questionnaire items present additional limitations, particularly in ensuring uniform interpretation of each question. Future research should aim to expand the survey coverage to include a more diverse and representative sample, employ alternative data collection methods such as stated preference or simulation-based experiments, and integrate more robust validation techniques. In addition, further studies could incorporate real-time behavioral data or larger-scale modeling to enhance the generalizability and reliability of the findings. This research only focuses on the impact of congestion pricing on mode shifts. However, there are many other aspects that will be affected by congestion pricing. Future research may investigate the impact of congestion pricing implementation on vehicle emissions and pollution in general, equity, social justice, displacement of congestion to alternative roads, social rejection, technology and infrastructure needs. Future study may also look into other externality aspects that can affect congestion cost such as noise and accident rate. Other factors such as the public transport infrastructure and services, as well as the trip characteristics and behaviour, should be considered when building the model in the future.

Acknowledgment

The author would like to thank Jakarta Transportation Authority that have provided traffic data for this study. The author also would like to thank the survey team for their support in data collection, both for traffic data and stated preferences survey.

References

1) S. Roy, D. Cooper, A. Mucci, B. Sana, M. Chen, J. Castiglione, and G.D. Erhardt, “Why is traffic congestion getting worse? a decomposition of the contributors to growing congestion in san francisco-determining the role of tncs,” Case Stud Transp Policy, 8 (4) 1371–1382 (2020). doi:10.1016/j.cstp.2020.09.008.
2) A.Y. Nurhidayat, A. Roschyntawati, S.P. Primadiyanti, D.P. Upahita, and T. Fiantika, “Impact of traffic volume on vehicle operation cost after covid-19 pandemic in dki jakarta,” Evergreen, 11 (3) 2458–2467 (2024). doi:10.5109/7236888.
3) D. Chen, J. Ignatius, D. Sun, M. Goh, and S. Zhan, “Impact of congestion pricing schemes on emissions and temporal shift of freight transport,” Transp Res E Logist Transp Rev, 118 (June) 77–105 (2018). doi:10.1016/j.tre.2018.07.006.
4) Y.N.R. Hendra, R. Pujiwat, M.M.T. Sampetoding, D.P. Utomo, Sucipto, H. Putra, D. Arianto, W.P. Humang, and M.I.A. Saputro, “Traffic congestion management in south tangerang city as an effort to conserve energy in the transportation sector,” Evergreen, 11 (4) 3595–3605 (2024).
5) D. Albalate, and X. Fageda, “On the relationship between congestion and road safety in cities,” Transp

Policy (Oxf), 105 (May 2020) 145–152 (2021). doi:10.1016/j.tranpol.2021.03.011.

6) C.K. Tang, "The cost of traffic: evidence from the london congestion charge," J Urban Econ, 121 (May 2020) 103302 (2021). doi:10.1016/j.jue.2020.103302.

7) K. Wu, Y. Chen, J. Ma, S. Bai, and X. Tang, "Traffic and emissions impact of congestion charging in the central beijing urban area: a simulation analysis," Transp Res D Transp Environ, 51 203–215 (2017). doi:10.1016/j.trd.2016.06.005.

8) V. Bernardo, X. Fageda, and R. Flores-Fillol, "Pollution and congestion in urban areas: the effects of low emission zones," Economics of Transportation, 26–27 (August) 100221 (2021). doi:10.1016/j.ecotra.2021.100221.

9) C. Maulidi, A.F. Aritenang, A. Dwicaksono, and H. Winarso, "Urban transformation under technological disruption: a literature review," Evergreen, 11 (2) 1028–1039 (2024). doi:10.5109/7183392.

10) D. Metz, "Tackling urban traffic congestion: the experience of london, stockholm and singapore," Case Stud Transp Policy, 6 (4) 494–498 (2018). doi:10.1016/j.cstp.2018.06.002.

11) A.Y. Nurhidayat, H. Widyastuti, S. Sucipto, and D.P. Utomo, "Model of transportation mode selection between private vehicle and serpong-tanahabang commuter line," 147 (Grost) 238–249 (2018). doi:10.2991/grost-17.2018.21.

12) Haryono, D. Darunanto, and E. Wahyuni, "Persepsi masyarakat tentang kemacetan lalu lintas di jakarta perception of society towards traffic jam in jakarta," Jurnal Manajemen Transportasi & Logistik, 05 (03) 277–285 (2018).

13) C. Raux, "The potential for co2 emissions trading in transport: the case of personal vehicles and freight," Energy Effic, 3 (2) 133–148 (2010). doi:10.1007/s12053-009-9065-7.

14) A. Rakowska, K.C. Wong, T. Townsend, K.L. Chan, D. Westerdahl, S. Ng, G. Močnik, L. Drinovec, and Z. Ning, "Impact of traffic volume and composition on the air quality and pedestrian exposure in urban street canyon," Atmos Environ, 98 260–270 (2014). doi:10.1016/j.atmosenv.2014.08.073.

15) J. Currie, and R. Walker, "Traffic congestion and infant health: evidence from e-zpass," Am Econ J Appl Econ, 3 (1) 65–90 (2011). doi:10.1257/app.3.1.65.

16) J. Lelieveld, J.S. Evans, M. Fnais, D. Giannadaki, and A. Pozzer, "The contribution of outdoor air pollution sources to premature mortality on a global scale," Nature, 525 (7569) 367–371 (2015). doi:10.1038/nature15371.

17) S.S. Lim, T. Vos, A.D. Flaxman, G. Danaei, K. Shibuya, H. Adair-Rohani, M. Amann, M. Ezzati, et al., "A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the global burden of disease study 2010," The Lancet, 380 (9859) 2224–2260 (2012). doi:10.1016/S0140-6736(12)61766-8.

18) C.P. Green, J.S. Heywood, and M. Navarro, "Traffic accidents and the london congestion charge," J Public Econ, 133 11–22 (2016). doi:10.1016/j.jpubeco.2015.10.005.

19) H. Li, D.J. Graham, and A. Majumdar, "The effects of congestion charging on road traffic casualties: a causal analysis using difference-in-difference estimation," Accid Anal Prev, 49 366–377 (2012). doi:10.1016/j.aap.2012.02.013.

20) E. Ayaragarnchanakul, and F. Creutzig, "Bangkok's locked-in traffic jam: price congestion or regulate parking?," Case Stud Transp Policy, 10 (1) 365–378 (2022). doi:10.1016/j.cstp.2021.12.016.

21) C. Raux, S. Souche, and D. Pons, "The efficiency of congestion charging: some lessons from cost-benefit analyses," Research in Transportation Economics, 36 (1) 85–92 (2012). doi:10.1016/j.retrec.2012.03.006.

22) S.G. Stradling, "Transport user needs and marketing public transport," Proceedings of the Institution of Civil Engineers: Municipal Engineer, 151 (1) 23–28 (2002). doi:10.1680/muen.2002.151.1.23.

23) G. Sugiyanto, "The Effect of Congestion Pricing Scheme on the Generalized Cost and Speed of a Motorcycle," 2018. http://wjst.wu.ac.th.

24) C.P. Green, J.S. Heywood, and M. Navarro Paniagua, "Did the london congestion charge reduce pollution?," Reg Sci Urban Econ, 84 (June) 103573 (2020). doi:10.1016/j.regsciurbeco.2020.103573.

25) G. Sugiyanto, "The effect of congestion pricing scheme on the generalized cost and speed of a motorcycle," Walailak Journal of Science and Technology, 15 (1) 95–106 (2018). doi:10.48048/wjst.2018.2347.

26) A.Y. Nurhidayat, H. Widyastuti, Sutikno, D.P. Upahita, and A. Roschyntawati, "Impact of traffic volume on the pollution cost, value of time, and travel time cost in jakarta city centre area," Civil Engineering and Architecture, 11 (5) 3209–3220 (2023). doi:10.13189/cea.2023.110830.

27) F. Creutzig, "How fuel prices determine public transport infrastructure, modal shares and urban form," Urban Clim, 10 (P1) 63–76 (2014). doi:10.1016/j.uclim.2014.09.003.

28) J.O. Jansson, "Public transport policy for central-city travel in the light of recent experiences of congestion charging," Research in Transportation Economics, 22 (1) 179–187 (2008). doi:10.1016/j.retrec.2008.05.027.

29) J. Leape, "The london congestion charge,"

Futuribles: Analyse et Prospective, 20 (337) 157–176 (2008). doi:10.1051/futur:200833749.

30) A. Wijaya, N.A. Setiawan, and M.I. Shapiai, "Mapping research themes and future directions in learning style detection research: a bibliometric and content analysis," Electronic Journal of E-Learning, 21 (4) 274–285 (2023). doi:10.34190/ejel.21.4.3097.

31) V. Ovaskainen, M. Neuvonen, and E. Pouta, "Modelling recreation demand with respondent-reported driving cost and stated cost of travel time: a finnish case," J For Econ, 18 (4) 303–317 (2012). doi:10.1016/j.jfe.2012.06.001.

32) S. Vosough, H. Poorzahedy, and R. Lindsey, "Predictive cordon pricing to reduce air pollution," Transp Res D Transp Environ, 88 (October) 102564 (2020). doi:10.1016/j.trd.2020.102564.

33) S. Jia, G. Yan, and A. Shen, "Traffic and emissions impact of the combination scenarios of air pollution charging fee and subsidy," J Clean Prod, 197 678–689 (2018). doi:10.1016/j.jclepro.2018.06.117.

34) M.J. Alonso-González, N. van Oort, O. Cats, S. Hoogendoorn-Lanser, and S. Hoogendoorn, "Value of time and reliability for urban pooled on-demand services," Transp Res Part C Emerg Technol, 115 (March) 102621 (2020). doi:10.1016/j.trc.2020.102621.

35) V. Dixit, S. Jian, A. Hassan, and E. Robson, "Eliciting perceptions of travel time risk and exploring its impact on value of time," Transp Policy (Oxf), 82 (May) 36–45 (2019). doi:10.1016/j.tranpol.2019.08.001.

36) P. Rietveld, B. Zwart, B. van Wee, and T. van den Hoorn, "On the relationship between travel time and travel distance of commuters," Ann Reg Sci, 33 (3) 269–287 (1999). doi:10.1007/s001680050105.

37) D.H. Henley, I.P. Levin, J.J. Louviere, and R.J. Meyer, "Changes in perceived travel cost and time for the work trip during a period of increasing gasoline costs," Transportation (Amst), 10 (1) 23–34 (1981). doi:10.1007/BF00165615.

38) D. Brownstone, and K.A. Small, "Valuing time and reliability: assessing the evidence from road pricing demonstrations," Transp Res Part A Policy Pract, 39 (4 SPEC. ISSS.) 279–293 (2005). doi:10.1016/j.tra.2004.11.001.

39) K.A. Small, C. Winston, and J. Yan, "Uncovering the distribution of motorists' preferences for travel time and reliability," Econometrica, 73 (4) 1367–1382 (2005). doi:10.1111/j.1468-0262.2005.00619.x.

40) J.A. DiBartolomeo, "Commuting speed as a proxy for the value of time," Econ Lett, 193 109342 (2020). doi:10.1016/j.econlet.2020.109342.

41) L.J. Basso, C.A. Guevara, A. Gschwender, and M. Fuster, "CONGESTION PRICING, TRANSIT SUBSIDIES AND DEDICATED BUS LANES: EFFICIENT AND PRACTICAL SOLUTIONS TO CONGESTION," 2010.

42) I.W. Agustin, I.R. Dwi Ari, S. Irawati, and E. Siankwilimba, "Strategy for implementing park-and-ride as a supporting facility for commuter movement," Evergreen, 11 (2) 1068–1080 (2024). doi:10.5109/7183406.

43) D.P. Upahita, Sucipto, Y.N.R. Hendra, D.P. Utomo, M.A. Salsabilla, and R. Pujiwat, "Influence of qualitative factors on mode choice between high speed train and airplane using logit model with dummy variables: case study jakarta - surabaya corridor," Evergreen, 10 (3) 2047–2055 (2023). doi:10.5109/7151772.

44) D. Kusmayadi, A. Kusuma, and I.S. Gunarta, "An analysis on e-scooter preference for the first and last mile trip in tourist area," Evergreen, 11 (1) 481–492 (2024). doi:10.5109/7172311.

45) E. Hysing, and K. Isaksson, "Building acceptance for congestion charges - the swedish experiences compared," J Transp Geogr, 49 52–60 (2015). doi:10.1016/j.jtrangeo.2015.10.008.

46) L.A. Munford, "The impact of congestion charging on social capital," Transp Res Part A Policy Pract, 97 192–208 (2017). doi:10.1016/j.tra.2017.01.018.

47) G. Santos, "Urban congestion charging: a comparison between london and singapore," Transp Rev, 25 (5) 511–534 (2005). doi:10.1080/01441640500064439.

Cite: A. Nurhidayat, A. Utami, D. Upahita, "The Impact of Congestion Pricing on Public Transport Utilization in Jakarta, Indonesia". Evergreen, 12 (04) 2058-2069 (2025). https://doi.org/10.5109/7402637.