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Impact of Congestion Pricing Scheme on the Generalized Cost and Speed of Motorcycle to the City of Yogyakarta, Indonesia

Running title
Mechanical and Civil Engineering

Abstract

The increases of car ownership, population growth, and urbanization have increased traffic congestion in many cities in the world. One of the alternatives to reduce congestion is application of congestion pricing. The aim of this research is to estimate congestion cost of motorcycles and impact of congestion pricing scheme on the generalized cost and speed of motorcycle to the city of Yogyakarta. The amount of congestion pricing is the difference between generalized cost in free-flow speed and actual generalized cost in traffic jam condition. Generalized costs of motorcycle from origin to destination consist of vehicle operating cost and travel time cost. This study shows that while the free-flow speed of motorcycle to the city of Yogyakarta is 45.45 km/h bring on the generalized cost is IDR774 per trip, the actual speed in traffic jam condition is 12.57 km/h produce the generalized cost is IDR1655 per trip, giving the congestion pricing of motorcycle is IDR881 per trip. The impact of application of congestion pricing for motorcycles users will increase the vehicle speeds between 0.42 - 6.32 percent and decreases the generalized cost. Vehicle speed will increase as 1.76 km/h in Malioboro Street. The amount of generalized cost of motorcycles will decrease 3.63 percent.

Keywords: Congestion pricing, generalized cost, vehicle operating cost, motorcycle, speed

Introduction

The increases of car ownership, population growth, and urbanization have increased traffic congestion in many cities in the world. Congestion is one of the significant transport problems in Indonesia. It does not only occur in urban area, but also in rural area, especially during peak hour. Transport problems become more complex and give more effects to society in area with high activities, such as in Yogyakarta, Indonesia. This situation happens because the imbalance between the number of vehicles and the length of the road. The congestion becomes worse with the increasing activities in the roadside for non-toll road and bad behavior in driving [1].

Congestions will generate many problems due to inefficiency. With congested roads, consumption fuel of vehicle will be increase, vehicle speed will be simultaneously up and down, and the average speed will be lower and hence the cost will increase. Therefore, road users will suffer from increasing vehicle operating cost and losing more time. The environment will be in worse conditions due to pollutions. In other words, transport costs will increase due to congestions. The costs incurred by the society as the result and the effect of transportation include vehicle operating cost, travel time cost and externality cost [2]. Externality cost like the congestion cost [3,4], environmental cost, pollution cost, and traffic accident cost [5]. Externality cost is often forgotten because these costs do not directly affect to road users and are

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distributed to many people so that they are difficult to measure. Transport cost, especially for passengers, can be reduced by the use of public transportation, but, in contrast, in Yogyakarta the use of public transport decreases and the use of private cars and motorcycle are quickly growing. This condition causes the cost that must be borne by passengers even greater. Transportation Demand Management (TDM), application of pricing policy in charging zone, congestion pricing, road pricing, and traffic restraint are the alternatives to reduce the transportation cost [1,6].

The congestion costs in France, United Kingdom, United States, and Japan are respectively 2.1%, 3.2%, 1.3%, and 2.0% of the respective Gross National Product (GNP) of the countries [7,8]. Santos [9] quoted The European Commission report that the congestion costs in Western industrialized countries are two percent of the Gross Domestic Product (GDP). Traffic Master in [9], which calculates the congestion costs in England for three months in 1996 as £2.1 billion, including wasted time, extra fuel, missed deliveries, and higher maintenance costs. While Dodgson and Lane (1997) in [9] estimated congestion costs for England as £6.9 billion for 1996. The congestion cost for 85 cities in the United States of America was US$63.3 billion in 2002, for value of time US$13.45/hour [10]. Total congestion cost for the year 2000 in The Netherlands are estimated to be 0.799 billion Euros using the traditional speed-flow curve (assignment) based method, while the log sum based method (consumer surplus) provides an estimated value of 1.509 billion Euros [11].

The economic loss caused by the traffic congestion in the Jabodetabek region could be as much as $68 million per year due to traffic congestion and this estimate excludes the impacts of traffic congestion and pollution on human health [12]. Marginal congestion costs for different types of roads in England, the last update being around 45 pence per passenger car unit (pcu)-km for urban roads at peak time [13]. Estimation of congestion cost in CBD Malioboro, Indonesia for private passenger car users as IDR2701 per trip [1] and for motorcycle users as IDR522.77 per trip [14].

The application of road pricing in other countries have a positive impact on reducing the use of private vehicle users and increased the use of public transport. In Belgium, the use of public transport increased 10 percent. If the application of road pricing with improve the public transportation service quality, the use of public transport will be increase 23 percent [15]. Implementation of congestion charging for private vehicle users in urban centers in London increase the use of urban bus 18 percent, taxi users 17 percent, and decreased the use of private car 33 percent [16]. The application of congestion charging as IDR 4000 per trip for motorcycles user as a through traffic in Malioboro, Yogyakarta, Indonesia will be shift as 6.848% motorcycle user to bus TransJogja [17]. Among 15-20 percent, reductions in generalized cost are surprisingly small for charge levels, which have achieved 15 percent reduction in overall trip making. It appears that the ability of traffic to reroute reduces the benefits gained from road pricing to levels significantly below those predicted by strategic models, which permit only limited rerouting responses [18].

The other impact of application of congestion pricing in the other country as follows: the empirical evidence on the effect of Electronic Road Pricing (ERP) rate changes on traffic volumes in Singapore and proposed a practical framework for modeling the impact of road pricing on the time distribution of traffic volumes. The traffic pattern at Ayer Rajah Expressway gantry before and after the implementation of toll and the model predictions . The mean coefficient of variation of 15-min volumes, which was 3.9 percent during the week before ERP started, has actually decreased to 3.3 percent after the ERP introduction and then decreased further to 2.8 percent in the week after the rate revision [19].

The effect of congestion cost in Stockholm, Sweden, a new Western bypass is estimated to reduce traffic across inner city bridges by 11 percent [20]. Based on Stockholm Transport (2006) in [20] the number of passengers by public transit was 6 percent larger in spring 2006 than 12 months earlier. Motorists endure average welfare losses ranging from €0.7 to €1.0 per trip when a toll that induces a 20 percent traffic reduction is implemented. Motorists taken as a whole tend to lose when a toll is introduced. This result is not surprising when one considers their values of travel time. They reach €11.4 per hour at the most, which would require a travel time reduction of around 11 min to outweigh a €2 toll [21].

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The aims of this paper is to estimate the congestion cost of motorcycle user and the impact of congestion pricing scheme on the generalized cost and speed of motorcycle to the city of Yogyakarta, Indonesia.

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Materials and methods

Analysis approach

Generalized cost of travel can be calculated based on combination of cost paid by user, travel time cost and vehicle-operating cost [22]. Equation 1 shows the generalized cost by mode m from origin zone i to destination zone j.

$$GC_{ij}^{m} = VOT\ (time_{ij}^{m}) + VOC\ (dist._{ij}^{m}) \qquad (1)$$

In which GC_{ij}^{m} is the generalized cost in pence per Passenger Car Units (PCU) by mode m to go from origin zone i (Oi) to destination zone j (Dj), VOT is the value of time in pence per-PCU-min, $time_{ij}^{m}$ is the time taken to complete the trip in minutes, VOC_{ij}^{m} the total vehicle operating cost in pence per PCU-km, and $dist._{ij}^{m}$ is the distance travelled to go from origin zone i to destination zone j, in km, while i is origin zone and j destination zone.

Data collection

In this paper, speed of motor cycles is counted in two conditions, the first is in free-flow speed condition and the second is in actual condition that potentially causes traffic jam. Traffic is congested if there are so many vehicles that each one travels slower than it would do if the other vehicles weren't there and traffic is congested if there are so many vehicles that they are brought to a standstill or can only crawl along [23]. Related with speed and traffic flow congestion is defined as the impedance vehicles impose on each other, due to the speed-flow relationship, in conditions where the use of a transport system approaches its capacity [24]. The travel time in free-flow speed condition of motorcycles in CBD Malioboro, Yogyakarta is obtained based on formula Indonesian Highway Capacity Manual (IHCM) 1997 [25]. The travel time in actual cost condition is obtained from Moving Car Observer (MCO) survey in Central Business District (CBD) Malioboro, Yogyakarta. The CBD Malioboro consist of two lane one-way direction undivided road (2/1 UD) 1.414 kilometers long from Malioboro Street to Ahmad Yani Street. The collection of data in the study area CBD Malioboro, Yogyakarta, Indonesia as can be seen in **Figure 1**.

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Figure 1 Study area in CBD Malioboro, Yogyakarta, Indonesia [1,14,17].

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Results and discussion

The generalized cost of motorcycle from origin to destination consists of two components of cost: the first is vehicle operating cost (VOC) and the second is travel time cost (TTC).

Vehicle operating cost

In this paper, vehicle-operating cost (VOC) of motorcycles is counted in two conditions, based on travel cost in free-flow speed condition and travel cost in actual condition that potentially cause traffic jam. There are five components of vehicle operating costs of motorcycles: (a) consumption of fuel, (b) lubricating oil consumption, (c) tire consumption, (d) maintenance cost (spare part and repair), and (e) fixed cost. Relationship between speed and dependent fuel consumption rates of motorcycles use The Study on Integrated Transportation Master Plan (SITRAMP) for the Jakarta-Bogor-Depok-Tangerang-Bekasi or Jabodetabek in 2004 [26]. Fuel economy improvement can be implemented by raising traveling speed and replacing overage vehicles with fuel saving ones like hybrid cars. Especially traveling speed has a significant effect on fuel consumption and the lowest fuel consumption rates occur in a speed range of 40 to 55 km/h [26,27].

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Vehicle operating cost and speed relationship

Speed is the main factor to estimate the vehicle operating cost of motorcycles. **Figure 2** shows a graph to estimate vehicle-operating cost of motorcycles. The figure showing the relationship between vehicle operating cost and speed of motorcycles for CBD Malioboro, Yogyakarta, Indonesia as presented in [6,14].

From **Figure 2**, it can be seen that there is an optimum speed with the minimum vehicle operating cost. The optimum speed for motorcycles in CBD Malioboro, Yogyakarta along the 1.414 kilometer is

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47.50 km/hour with vehicle operating cost of IDR350.79 per kilometer. The vehicle-operating cost model for motorcycles is formulated as:

$$y = 0.0921V2 - 8.8647V + 555.51 \quad (2)$$

in which V is speed of motorcycle (km per hour) and y is vehicle-operating cost of motorcycles (IDR per kilometer).

Based on the survey and then is analyzed with Indonesian Highway Capacity Manual (IHCM) 1997 the speed of motorcycles in free-flow speed condition is 45.45 km/hour so the vehicle operating cost is IDR351/km (**Figure 2**). Based on the Moving Car Observer (MCO) survey, the speed of motorcycles in actual cost condition that potentially cause traffic jam is 12.57 km/hour, so the vehicle-operating cost is IDR461/km (**Figure 2**). The vehicle-operating cost of motorcycles at CBD Malioboro, Yogyakarta in free-flow speed and actual cost condition was calculated by multiplying with 1.414 km, the length of CBD Malioboro, the vehicle operating cost in free-flow speed condition is IDR496.4 per trip and in actual cost condition is IDR651.9 per trip.

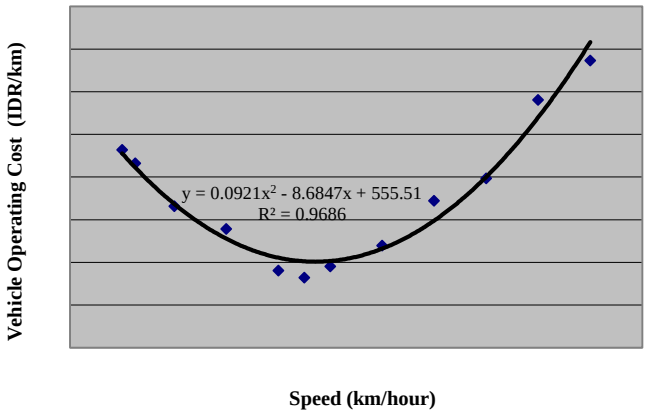

Figure 2 Relationship between speed and vehicle-operating cost [6,14].

Travel time cost (TTC)

Value of time of motorcycles users in Yogyakarta city in December 2009 based on Gross Regional Domestic Product (GRDP) is IDR3367.55/hour [6]. Based on the analysis of questionnaires from 150 respondents, value of time with willingness to pay (WTP) of motorcycles users to the CBD Malioboro, Yogyakarta is IDR8912.62/hour. Based on the survey and analysis of speed of motorcycles in CBD Malioboro, Yogyakarta, travel time in free-flow speed condition is 1 minute 52 second. Based on moving car observer (MCO) survey, the average of travel time in actual cost condition is 6 minutes 45 second. Travel time cost of motorcycles in CBD Malioboro, Yogyakarta was calculated by multiplying travel time with the value of time based on willingness to pay (WTP) of respondent is IDR8912.62/hour. The travel time cost in free-flow speed condition is IDR277.3 per trip and in actual cost condition is IDR1002.7 per trip

Generalized cost

Generalized cost of motorcycles consists of vehicle operating cost and travel time cost. The generalized cost of motorcycles in actual cost condition is IDR1655/trip and generalized cost in free-flow

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speed condition is IDR774/trip. Generalized cost of motorcycles in actual condition is more expensive than in free-flow speed condition.

Congestion cost

The approach to estimate congestion cost in this study is similar with the approach of [9] and [28]. They define congestion costs as the difference between the level of costs in actual speeds and the level of costs in free flow speeds [9,28]. The amount of congestion cost of motorcycles is the difference between generalized cost in actual cost condition with speed 12.57 km/hour and travel time 6 minutes 45 second, then generalized cost in free-flow speed condition with speed 45.45 km/hour and travel time 1 minute 52 second. The generalized cost of motorcycles in actual condition is IDR1655 per trip, and generalized cost in free-flow speed condition IDR774 per trip, thus the congestion cost of motorcycles in CBD Malioboro, Yogyakarta is IDR881 per trip.

Impact of congestion pricing

Implementation of congestion pricing for motorcycles users at Malioboro Street and Ahmad Yani Street in Yogyakarta resulted change in vehicle speed between 0.42 - 6.32 percent (**Table 1**). Speeds in some roads have increase like at Pangeran Mangkubumi Street, Malioboro Street, and Ahmad Yani Street while in Jenderal Sudirman Street and Mayor Suryotomo Street decrease. The highest increase of vehicle speed occur in Malioboro Street as 1.76 km/h while the largest decrease occurs in Mayor Suryotomo Street at north-south direction as 1.07 km/h (2.64 percent) and in Bhayangkara Street as 0.93 km/h (2.94 percent).

Based on the results of the simulation of application congestion pricing for motorcycles users in Malioboro was obtained the improvement of road network performance. Application of congestion pricing increase the vehicle speeds and decreases the generalized cost. These results are similar with study of [29] that examine the application of congestion charging in central London that can increase the average speed of vehicle ± 4 km/hour. The highest increase of vehicle speed due to the implementation of congestion pricing occurs in Malioboro Street 1.76 km/hour (6.32 percent). These results are similar with the research of [30] which examined the implementation of Electronic Road Pricing (ERP) in Paris. ERP increase the vehicle speed from 44.80 to 45.40 km/hour.

Vehicle speed on Malioboro Street in existing condition without pricing is 27.85 km/h. In this condition, the amount of vehicle-operating cost of motorcycles is IDR538 per trip, travel time cost is IDR453 per trip, and therefore the generalized cost is IDR991 per trip. Based on the results of the simulation, vehicle speed on Malioboro Street with pricing is 29.61 km/h. In this condition, the amount of vehicle-operating cost of motorcycles is IDR529 per trip, travel time cost is IDR426 per trip, and therefore the generalized cost is IDR955 per trip. The amount of generalized cost will decrease IDR36 per trip (3.63 percent).

Table 1 Impact of congestion pricing of motorcycles users on vehicle speed.

No.	Node Origin-Destination	Name of link and direction movement	Vehicle speed (km/h)		Δ Vehicle speed (km/h)	Δ Vehicle speed (%)
			Without pricing	With pricing		
1.	2-3	Kyai Mojo Street (W-E)	45.10	44.21	-0.89	-1.97%
2.	3-2	Kyai Mojo Street (E-W)	45.34	45.97	0.63	1.39%
3.	3-4	Pangeran Diponegoro A Street (W-E)	44.85	45.29	0.44	0.98%
4.	4-3	Pangeran Diponegoro A Street (E-W)	44.89	44.43	-0.46	-1.02%
5.	4-6	Pangeran Diponegoro B Street (W-E)	44.85	45.04	0.19	0.42%
6.	6-4	Pangeran Diponegoro B Street (E-W)	44.89	44.43	-0.46	-1.02%
7.	6-8	Jenderal Soedirman Street (W-E)	45.24	44.51	-0.73	-1.61%
8.	8-6	Jenderal Soedirman Street (E-W)	45.09	44.13	-0.96	-2.13%
9.	9-8	Urip Sumoharjo Street	43.29	42,11	-1.18	-2.73%

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10.	6-23	Pangeran Mangkubumi Street	36.16	37.53	1.37	3.79%
11.	24-25	Malioboro Street	27.85	29.61	1.76	6.32%
12.	25-26	Ahmad Yani Street	31.59	32.34	0.75	2.37%
13.	26-22	Ahmad Dahlan Street (E-W)	45.16	44.30	-0.86	-1.90%
14.	22-26	Ahmad Dahlan Street (W-E)	45.53	44.95	-0.58	-1.27%
15.	22-21	Bhayangkara Street	31.63	30.70	-0.93	-2.94%
16.	26-37	Pangeran Senopati Street (W-E)	42.27	41.62	-0.65	-1.54%
17.	37-26	Pangeran Senopati Street (E-W)	42.38	41.88	-0.50	-1.18%
18.	36-35	Mataram Street (S-N)	30.19	30.48	0.29	0.96%
19.	35-36	Mataram Street (N-S)	30.23	29.47	-0.76	-2.51%
20.	36-37	Mayor Suryotomo Street (N-S)	40.48	39.41	-1.07	-2.64%
21.	37-36	Mayor Suryotomo Street (S-N)	40.39	40.68	0.29	0.72%

Note: W is west, E is east, S is south, and N is north.

Within the Charging Zone (CZ), the Wilcoxon test has shown that the difference in speed between pre and post London's Congestion Charging Scheme (CCS) periods has increased on average 2.1 km/h and that these changes are significant at the p = 0.05 level [29]. In Mashhad CBD urban road network, the cordon based pricing scheme brings 7.99 percent social welfare improvement. The maximal social welfare is achieved when the value of time is equal to 1200 tomans per hour [31]. Impact of the congestion-pricing scheme with Sioux Falls network, the number of links with Level of Service (LoS) D, LoS E, and LoS F are reduced and LoS of a great number of links becomes LoS C. The value of objective function improves 65.97% after toll pricing process [32]. The boundary of charging zone marked by tollgate that separates with the other road networks [33,34]. Implementation of congestion costs in CBD Malioboro, Yogyakarta needs two tollgates at the intersections of Malioboro Street with Pasar Kembang Street.

Conclusions

The estimation of congestion cost for motorcycles users in CBD Malioboro, Yogyakarta Indonesia and the impact of congestion pricing scheme on the generalized cost and speed of motorcycles to the city of Yogyakarta presented in this paper. From the analysis and results, it can be concluded as follows:

1. The generalized cost at CBD Malioboro, Yogyakarta, Indonesia for motorcycles in free-flow speed condition IDR774 per trip and in actual cost condition is IDR1655 per trip, giving the congestion pricing of motorcycle to the city of Yogyakarta is IDR881 per trip.
2. The impact of congestion pricing scheme on the generalized cost for motorcycles to the city of Yogyakarta will decrease IDR36 per trip (3.63 percent).
3. The impact of application of congestion pricing on vehicle speed will increase between 0.42 - 6.32 percent , the highest increase of vehicle speed occur in Malioboro Street as 1.76 km/h (6.32 percent) while the largest decrease occurs in Mayor Suryotomo Streets at north-south movement as 1.07 km/h (2.64 percent) and Bhayangkara Street as 0.93 km/h (2.94 percent).

Acknowledgements

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References

[1] G Sugiyanto, S Malkhamah, A Munawar, and H Sutomo. Estimation of congestion cost of motorcycles users in Malioboro, Yogyakarta. *Civil Engineering Dimension*, 2010; **12**(2), 92-97.
[2] JD Ortuzar and LG Willumsen. 2001, *Modeling Transport*. England: John Wiley and Sons Ltd.

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[3] PC Stubs, WJ Tyson, and MQ Dalvi. 1980, *Transport Economics*, London: George Allen and Unwin (Publisher) Ltd.
[4] ET Verhoef. Second-best congestion pricing in general networks, Heuristic algorithms for finding second-best optimal toll levels and toll points. *Transportation Research Part B*, 2002; **36**(8), 707-729.
[5] JF Tsai, CP Chu, and SR Hu. Road pricing for congestion and accident externalities for mixed traffic of motorcycles and automobiles. *Transportation Research Part A: Policy and Practice*, 2015; **71**(1), 153-166.
[6] G Sugiyanto. The Effect of Application of Congestion Cost for Private Passenger Cars Users as a Through Traffic in Yogyakarta, Indonesia. *ASEAN Engineering Journal AUN-SEED/Net*, 2011; **1**(3), 84-96.
[7] G Bouladon. 1991, La Mobilite en Zone Urbaine: Apprendre I'Economie de Transport, Document Diffusion Restreinte, Direction de I'Environnement, Paris: OECD-European Conference of Ministers of Transport (ECMT).
[8] E Quinet. 1994, *The Social Costs of Transport: Evaluation and Links with Internalization Policies, In Internalizing the Social Costs of Transport*, Paris: OECD-European Conference of Ministers of Transport (ECMT), pp. 31-75.
[9] G Santos. 1999, *Road Pricing on The Basis of Congestion Costs: Consistent Results from Two Historic UK Towns*. United Kingdom: Department of Applied Economics, Cambridge, pp.1-16.
[10] JD Harford. Congestion, pollution and benefit to cost ratios of US public transit system. *Transportation Research Part D: Environment*, 2006; **11**(1), 45-58.
[11] C Koopmans and E Kroes. 2004, *Estimation of Congestion Costs in The Netherlands. Discussion Paper*, no. 28 pp. 1-14, Amsterdam: Stichting voor Economisch Onderzoek, available from: http://www.seo.nl/assets/binaries/pdf/Dis%20paper%2028.pdf, accessed on March 4th, 2010.
[12] S Dikun. 2003, Transportation in New Global Era: Linking Asia through Better Transportation. *Keynote Speech of 5th EASTS International Conference*. Fukuoka. Japan (October 29th 2003).
[13] DM Newbery. 1998, *Fair Payment from Road-Users: A Review of the Evidence on Social and Environment Costs*, Basingstoke: The Automobile Association.
[14] G Sugiyanto, S Malkhamah, A Munawar, and H Sutomo. Estimation of Congestion Cost of Motorcycles Users in Malioboro, Yogyakarta. *International Journal of Civil and Environmental Engineering (IJCEE)*, 2011a; **11**(1), 56-63.
[15] H Armelius and L Hultkrantz. The Politico-economic link between public transport and congestion cost: an ex-ante study of the Stockholm trial-cost road. *Transport Policy*, 2006; **13**(2): Modeling of Urban Road Pricing and Its Implementation, 162-172.
[16] G Santos and J Bhakar. The impact of London congestion charging scheme on the generalized cost of car commuters to the city of London from a value of time savings perspective. *Transport Policy*, 2006; **13**(1), 22-33.
[17] G Sugiyanto, S Malkhamah, A Munawar, and H Sutomo. Modeling the Effect of Congestion Pricing on Mode Choice in Yogyakarta, Indonesia. *International Journal of Engineering and Technology (IJET)*, 2011b; **11**(1), 109-116.
[18] AD May and DS Milne. Effects of alternative road pricing systems on network performance. *Transportation Research Part A: Policy and Practice*, 2000; **34**(6), 407-436.
[19] P Olszewski and L Xie. Modeling the effects of road pricing on traffic in Singapore. *Transportation Research Part A: Policy and Practice*, 2005; 39(7-9), 755-772.
[20] J Eliasson, L Hultkrantz, L Nerhagen, and LS Rosqvist. The Stockholm congestion-charging trial 2006: Overview of effects. *Transportation Research Part A: Policy and Practice*, 2009; **43**(3), 240-250.
[21] B Bureau and M Glachant. Distributional effects of road pricing: Assessment of nine scenarios for Paris. *Transportation Research Part A: Policy and Practice*, 2008; **42**(7), 1994-1007.
[22] G Santos and D Newbery. 2001, *Urban Congestion Charging: Theory, Practice and Environmental Consequences*, CESifo Working Paper No. 568. Germany: Center for Economic Studies and Ifo

Institute for Economic Research, Munich. Available from: http://www.CESifo.de, accessed on February 15th 2009.
[23] S Grant-Muller and J Laird. 2006, *Costs of Congestion: Literature Based Review of Methodologies and Analytical Approaches*, Chapter VI: Measuring the costs of congestion. Final Report, London: Scottish Executive Social Research, pp. 35-44, Available at: http://www.scotland.gov.uk/Publications/2006/11/01103351, accessed on March 4th, 2010.
[24] PB Goodwin. 2004, The economic cost of road traffic congestion. *Discussion paper*. London: Rail Freight Group, Transport Studies Unit, University College London, available at: http://eprints.ucl.ac.uk/archive/00001259/, accessed on December 17th, 2009.
[25] Directorate General of Highways, Directorate of Urban Road Development. 1997, *Indonesian Highway Capacity Manual (IHCM) 1997*, Jakarta: Sweroad in Association with PT. Bina Karya (Persero).
[26] JICA and National Development Planning Agency (BAPPENAS). 2004, The Study on Integrated Transportation Master Plan (SITRAMP) for the Jabodetabek Phase 2. *Final Report.* Technical Report. PCI and ALMEC Corporation. Jakarta, Republic of Indonesia.
[27] DU Asri and B Hidayat. 2005, Current Transportation Issues in Jakarta and ITS Impacts on Environment. *Proceedings of Eastern Asia Society for Transportation Studies* (EASTS) 5, 1792-1798. Available at: http://www.jstage.jst.go.jp.
[28] J Dodgson and B Lane. 1997, *The Costs of Road Congestion in Great Britain: A NERA Briefing Paper*, National Economic Research Associates (NERA), London, available at: http://www.nera.com/publication.asp?p_ID=752.
[29] SD Beevers and DC Carslaw. The impact of congestion charging on vehicle speed and its implications for assessing vehicle emissions. *Journal Atmospheric Environment*, 2005; **39**(36), 6875-6884.
[30] AD Palma and R Lindsey. Modeling and evaluation of congestion pricing in Paris. *Transport Policy*, 2006; **13**(2), 115-126.
[31] S Afandizadeh, M Yadak and N Kalantari. Simultaneous determination of optimal toll locations and toll levels in cordon-based congestion pricing problem (case study of Mashhad city). *International Journal of Civil Engineering*, 2011; **9**(1), 33-40.
[32] S Soudmand, M Ghatee, and SM Hashemi. SA-IP method for congestion pricing based on level of service in urban network under fuzzy conditions. *International Journal of Civil Engineering Transaction A: Civil Engineering*, 2013; **11**(4), 281-291.
[33] PT Blythe. Congestion charging: challenges to meet the UK policy objectives. *Review of Network Economics*, 2004; **3**(4), 356-370.
[34] Official Transport for London and Congestion Charge, *Congestion Charging*. Available from: http://www.tfl.org.uk, accessed on December 19th, 2006.

Walailak Journal of Science and Technology

Referee Evaluation Form

Title: Impact of Congestion Pricing Scheme on the Generalized Cost and Speed of Motorcycle to the City of Yogyakarta, Indonesia.

Please evaluate the paper according to the following criteria.

	Poor	**Adequate**	**Good**	**Excellent**
Originality of the work			√	
Clarity and conciseness	√			
Standard of English			√	
Level of consistency	√			
Use of Tables and Figures	√			
Adequacy of the discussion	√			
Technical accuracy	√			
Suitability of references			√	
Overall	√			

Evaluation: Based on the above points please indicate your recommendation for this paper.

☐ Acceptable in its present form

☐ Acceptable after minor revision

√ Acceptable after major revision

☐ Unacceptable

If the paper requires any revision please give details of the suggested changes in the following referee's comment section. If the paper has been deemed unacceptable please indicate your reasons so that we may inform the authors.

Referee's Comments

1. It is not clear regarding to estimate the congestion cost of motorcycles.
2. How much cost for VOT and VOC and how to generated?
3. You must develop the step by step the calculation, to make the paper clear.
4. You says about Molioboro street, but in paper there are many street, that is confiusing. What contribution the other street to Molioboro street.
5. I don't see the methods for application of congestion pricing.
6. I don't see the methods for measuring the impact of congestion pricing scheme on the generalized cost and speed of motorcycle to the city of Yogyakarta
7. I don't see the discussion about the result and how to make the conclusion.

My Revision

No.	Referee's Comments (for reviewer)	Responses (for author)
1.	There is no methods to achieve the aim	**Revision in page 3, 9 to 10:** **Analysis approach** Generalized cost of travel can be calculated based on combination of cost paid by user, travel time cost, vehicle-operating cost and externality cost. The approach that is used to analyze the pollution cost is marginal-health cost per vehicle and fuel consumption of vehicle in actual condition and free-flow speed condition. **Data collection** a) In this paper, speed of motorcycles is counted in two conditions, the first is in free-flow speed condition and the second is in actual condition that potentially causes traffic jam. Motorcycles speed data based on travel time of vehicles and speed survey using speed gun. b) The travel time in free-flow speed condition of motorcycles in CBD Malioboro, Yogyakarta is obtained based on formula in Indonesian Highway Capacity Manual (IHCM) 1997. c) The travel time in actual cost condition is obtained from Moving Car Observer (MCO) survey in Central Business District (CBD) Malioboro, Yogyakarta. d) Value of time data for motorcycle users based on Gross Regional Domestic Product (GRDP) per capita in Yogyakarta city. e) The fuel consumption was obtained from the relationship between speed and dependent fuel consumption rates of motorcycles reported in the Study on Integrated Transportation Master Plan (SITRAMP) for the Jakarta-Bogor-Depok-Tangerang-Bekasi or Jabodetabek in 2004.

2.	It is not enough for discussion, (not only view data and result)	**Revision in page 1 to 3, 5 to 6, 8 to 9:** Relevance research: [2] A Broaddus, T Litman and G Menon. Transportation Demand Management, Training Document, gtz Transport Policy Advisory Services, Eschborn, Germany, 2009, p. 1-111. Available at: http://www.sutp.org. Solutions to these problems are possible, not only through improvement public transport condition, pedestrians and bicycle users, but also in the implementation of measures which promote a rational use of the automobile by means Transportation Demand Management (TDM). TDM aims to maximize the efficiency of the urban transport system by discouraging unnecessary private vehicle use and environmental-friendly modes of transport, in general being public transport and non-motorized transport [2]. [7] M Percoco. The effect of road pricing on traffic composition: Evidence from a natural experiment in Milan, Italy. *Transp. Policy*, 2014; **31**, 55-60 The road pricing scheme in Milan has had limited impact in terms of congestion and environmental quality because of the behavioral response of road users. In fact, we have found that the policy did not produce a reduction in the number of vehicles entering the city center, while it did lead to an increase in the number of motorbikes and, in part, LPG, bi-fuel and hybrid cars [7]. [15] A de Palma, R Lindsey and E Niskanen. Policy insights from the urban road pricing case studies. *Transp. Policy*, 2006; **13**, 149-61. The effect of congestion pricing has been long studied in transport policy area. In the cases of 4 European cities including Paris, Brussels, Oslo and Helsinki can get sizable amount of benefit from commuting time reduction, cost saving in vehicle management, or enhanced quality of public transportation when road pricing is introduced in each country [15]. [20] G Menon and S Guttikunda. Electronic Road Pricing: Experience & Lessons from Singapore. *SIM-Air Working Paper Series* **33**, 2010. Singapore's road pricing system reduced 20 % to 30 % of the downtown passenger car traffic and Stockholm's traffic volume decreased by at least 20 % [20]. [21] S Agarwal and KM Koo. Impact of electronic road pricing (ERP) changes on transport modal choice. *Regional Science and Urban Economics*, 2016; **60**, 1-11. Commuters switch to public bus services by 12% to 20% in the morning hours after S$1 increase and by approximately 10% in the evening after toll adjustment of S$0.50 to S$1.00 in the affected gantry area compared to the counterfactual through difference-in-difference method [21].

		[23] C O'Fallon, C Sullivan and D Hensher. Constraints affecting mode choices by morning car commuters. *Transp. Policy*, 2004; **11**, 17-29. In New Zealand was found that the 21 % of survey respondents were willing to choose to walk and to use public transportation, while 67% insisted that they would still drive cars when congestion pricing were to be introduced [23]. [24] S Hu and W Saleh. Impacts of congestion charging on shopping trips in Edinburgh. *Transp. Policy*, 2005; **12**, 443-450. Almost 37% of car users in Edinburg were willing to spend less or change the shopping destination if they had been asked to pay congestion tax for their shopping trip to the CBD [24].
3.	You must develop the research framework	Research framework Estimation of congestion pricing a) Speed of motorcycle in free-flow and actual condition b) Vehicle operating cost c) Travel time of motorcycle in CBD Malioboro d) Value of time of motorcycle users e) Travel time cost f) Marginal health cost g) Fuel consumption h) Pollution cost i) Generalized cost j) Congestion pricing Effect of application of congestion pricing a. on speed of motorcycle b. on generalized cost Figure 3 Distribution of traffic zone, node and link in EMME-2 software. Figure 4 Auto speeds from simulation results using EMME-2 in CBD Malioboro, Yogyakarta.
4.	The conclusion is not the result	**Revision in page 9:** **Conclusion:** 1. The generalized cost at CBD Malioboro, Yogyakarta for motorcycles in free-flow speed condition is IDR1,098 per trip and in actual cost condition is IDR2,767 per trip, giving the congestion pricing of motorcycle to the city of Yogyakarta as IDR1,669 per trip. 2. Effect of congestion pricing scheme on the generalized cost for motorcycles to the city of Yogyakarta will decrease to IDR53.51 per trip (6.63 %) in Malioboro Street and IDR34.33 per trip (6.11 %) in Ahmad Yani Street. 3. Effect of congestion pricing on vehicle speed will increase from 0.72 to 8.11 %. The highest increase of vehicle speed occured in Malioboro Street at 2.26 km/h (8.11 %) while the largest decrease occured in Mayor Suryotomo Street at north-south direction at 1.07 km/h (2.64 %) and in Bhayangkara Street at 0.88 km/h (2.78 %).

5.	The step by step the calculation	**Revision in page 3, 5 and 6:** The approach to estimate congestion cost in this study is similar to the approach of Dodgson and Lane [34] that study the costs of road congestion in Great Britain. Congestion costs as the difference between the level of costs in actual speed and the level of costs in free-flow speed. The originality of this research: 1) Vehicle operating cost 2) Value of time Gross Regional Domestic Product (GRDP) per capita in Yogyakarta city in October 2012 is IDR51,649,500. Value of time of motorcycles users in Yogyakarta city based on Gross Regional Domestic Product (GRDP) is IDR14,526.42/hour. 3) Travel time cost Based on moving car observer (MCO) survey. 4) Consumption of fuel The fuel consumption was obtained from the relationship between speed and fuel consumption rates of motorcycles reported in the Study on Integrated Transportation Master Plan (SITRAMP) for the Jakarta-Bogor-Depok-Tangerang-Bekasi or Jabodetabek in 2004. 5) Marginal Health Cost 6) Pollution cost Marginal health-cost (MHC) approach is used to calculate the pollution cost of motorcycle. This approach was the result of World Bank study in Jakarta in 1990. 7) Generalized cost: GC_{ij}^{m} = VOT (time $_{ij}^{m}$) + VOC (dist. $_{ij}^{m}$) + EC (dist. $_{ij}^{m}$)

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Referee Evaluation Form

Title: Impact of Congestion Pricing Scheme on the Generalized Cost and Speed of Motorcycle to the City of Yogyakarta, Indonesia.

Please evaluate the paper according to the following criteria.

	Poor	Adequate	Good	Excellent
Originality of the work			X	
Clarity and conciseness		X		
Standard of English			X	
Level of consistency		X		
Use of Tables and Figures		X		
Adequacy of the discussion		X		
Technical accuracy		X		
Suitability of references		X		
Overall		X		

Evaluation: Based on the above points please indicate your recommendation for this paper.

☐ Acceptable in its present form

☑ Acceptable after minor revision

☐ Acceptable after major revision

☐ Unacceptable

If the paper requires any revision please give details of the suggested changes in the following referee's comment section. If the paper has been deemed unacceptable please indicate your reasons so that we may inform the authors.

Referee's Comments

1) Equation (2) is not correct. Should it be $0.0921V^2$ - 8.6847V+555.51?
2) Please explain V in eq.2 is speed at 85 percentiles or average speed of MC.
3) It is easy to understand if author show O-D node inside Table 1 on the map in figure 1.

My revision

No.	Referee's Comments (for Reviewer)	Responses: Author's Revision (for Author)
1.	Equation (2) is not correct. Should it be $Y = 0.0921V^2 - 8.6847V+555.51$	**Equation (2) in page 5:** $y = 0.0921V^2 - 8.6847V + 555.51$ with $r^2 = 0.9686$ (2) In which V is speed of motorcycle (km per hour) and y is vehicle operating cost of motorcycles (IDR per kilometer).
2.	Please explain V in eq.2 is speed at 85 percentiles or average speed of MC	**Revision in page 5:** There are two value of speed: 1. Free-flow speed 2. Actual Speed of motorcycle in existing condition that potentially caused traffic jam Free-flow speed: based on the survey and the analysis of Indonesian Highway Capacity Manual (IHCM) 1997 the speed of motorcycles in free-flow speed condition is 42.42 km/h Actual speed: Based on the Moving Car Observer (MCO) survey, the average speed of motorcycles in actual cost condition that potentially caused traffic jam is 10.77 km/h.
3.	It is easy to understand if author show O-D node inside Table 1 on the map in figure 1	**Revision in page 6-7:** The simulation to estimate the effect of congestion pricing in CBD Malioboro using Equilibre Multimodal, Multimodal Equilibrium-2 (EMME-2) software. Distribution of traffic zone, node and link in EMME-2 to simulate the application of congestion pricing in CBD Malioboro can be seen in **Figure 3**. The result of simulation of congestion cost for motorcycle users in CBD Malioboro: include Malioboro Street (along 809 m) and Ahmad Yani Street (along 605 m) using EMME-2 software as presented on auto speed can be seen in **Figure 4**.

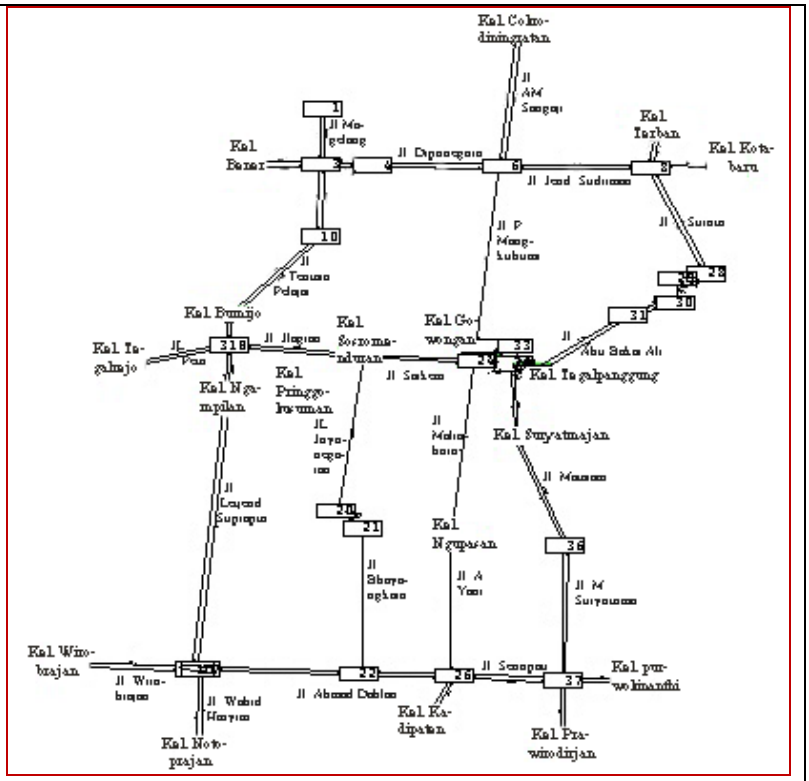

Figure 3 Distribution of traffic zone, node and link in EMME-2 software

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Referee Evaluation Form

Title: Impact of Congestion Pricing Scheme on the Generalized Cost and Speed of Motorcycle to the City of Yogyakarta, Indonesia.

Referee's Comments

1. This article needs proof reader to increase the English quality.
2. Please the author(s) explain in detail the scenario of congestion charging applied in the study area.
3. In the introduction section, I cannot find any information about the progress or situation of congestion charging applied in study area. Thus, I cannot find any reasons why the author(s) conducted this study. The authors are asked to explain the value added of this article for international reader.
4. The authors are asked to explain in more detail regarding the process of data collection (when, where, how, method, etc). The authors are requested to explain whether the location of survey can be judged as appropriate to represent Yogyakarta as a whole.
5. In page 3, it was stated that the free flow speed was obtained from based on IHCM. Could you explain the assumption and how the value can be obtained? Could you explain why the author(s) used this approach?
6. In page 5, the author stated that the VOT of motorcycle was obtained from GRDP. The authors are asked to explain why this value is suitable for motorcycle or the value from GRDP is not exclusively suitable for motorcycle only.
7. In page 6, it was stated that ..." The approach to estimate congestion cost in this study is similar with the approach of [9] and [28]."…. Could you explain the originality of this study compared to previous studies?
8. The authors are asked to provide discussion regarding the method and findings of this study.
9. Up to the end of this article, I cannot find any new things about the study that useful for international readers. The authors are requested to re-read and re-write the article to improve clarity and quality of this article.

My revision

No	Referee's Comments (for Reviewer)	Responses: Author's Revision (for Author)
1.	This article needs proof reader to increase the English quality.	This article had been proof reader. The revision is highlighted by blue colored font. **Revision in page 1 to 12.**
2.	Please the author(s) explain in detail the scenario of congestion charging applied in the study area.	**Revision in page 6 to 8:** The scenario of congestion pricing applied in CBD Malioboro using EMME-2 software. The simulation to estimate the effect of congestion pricing in CBD Malioboro using Equilibre Multimodal, Multimodal Equilibrium-2 (EMME-2) software. Distribution of traffic zone, node and link in EMME-2 to simulate the application of congestion pricing in CBD Malioboro can be seen in Figure 3. The result of simulation of congestion cost for motorcycle users in CBD Malioboro: include Malioboro Street (along 809 m) and Ahmad Yani Street (along 605 m) using EMME-2 software as presented on auto speed can be seen in Figure 4.
3.	In the introduction section, I cannot find any information about the progress or situation of congestion charging applied in study area. Thus, I cannot find any reasons why the author(s) conducted this study. The authors are asked to explain the value added of this article for international reader.	**Revision in page 1, 3, 9 to 10:** The congestion charging did not applied in CBD Malioboro. The tittle of the manuscript was change from the impact with the effect. Value added of this article for international reader is explain the method to calculate the amount of congestion pricing, explain the effect of application of congestion pricing for motorcycles users in speed and generalized cost. GC_{ij}^{m} = VOT (time $_{ij}^{m}$) + VOC (dist. $_{ij}^{m}$) + EC (dist. $_{ij}^{m}$) Congestion charging will increase the vehicle speeds 0.72 % to 8.11 % and decrease the generalized cost. Vehicle speed will increase by 2.26 km/h in Malioboro Street. The amount of generalized cost of motorcycles will decrease by 1.09 % to 6.63 %.
4.	The authors are asked to explain in more detail regarding the process of data collection (when, where, how, method, etc). The authors are requested to explain whether the location of survey can be judged as appropriate to represent Yogyakarta as a whole.	**Revision in page 3, 9 to 10:** **Analysis approach** Generalized cost of travel can be calculated based on combination of cost paid by user, travel time cost, vehicle-operating cost and externality cost. The approach that is used to analyze the pollution cost is marginal-health cost per vehicle and fuel consumption of vehicle in actual condition and free-flow speed condition. **Data collection** a) In this paper, speed of motorcycles is counted in two conditions, the first is in free-flow speed condition and the second is in actual condition that potentially causes traffic jam. Motorcycles speed data based on travel time of vehicles and speed survey using speed gun. b) The travel time in free-flow speed condition of

		motorcycles in CBD Malioboro, Yogyakarta is obtained based on formula in Indonesian Highway Capacity Manual (IHCM) 1997. c) The travel time in actual cost condition is obtained from Moving Car Observer (MCO) survey in Central Business District (CBD) Malioboro, Yogyakarta. d) Value of time data for motorcycle users based on Gross Regional Domestic Product (GRDP) per capita in Yogyakarta city. e) The fuel consumption was obtained from the relationship between speed and dependent fuel consumption rates of motorcycles reported in the Study on Integrated Transportation Master Plan (SITRAMP) for the Jakarta-Bogor-Depok-Tangerang-Bekasi or Jabodetabek in 2004. The street where data was collected in the study area in CBD Malioboro, Indonesia is shown in Figure 1 and Figure 2.
5.	In page 3, it was stated that the free-flow speed was obtained from based on IHCM. Could you explain the assumption and how the value can be obtained? Could you explain why the author(s) used this approach?	**Revision in page 3 and 5:** Free-flow speed was obtained based on Indonesian Highway Capacity Manual (IHCM) 1997. Based on the survey and the analysis of Indonesian Highway Capacity Manual (IHCM) 1997 the speed of motorcycles in free-flow speed condition is 42.42 km/hour. $FV = (FV_0 + FV_W) \times FFV_{SF} \times FFV_{CS}$ Malioboro Street two lane one-way direction undivided road (2/1 UD), 1.414 kilometers long from Malioboro Street to Ahmad Yani Street. Wide of Malioboro Street is 7.00 meter. FVo for light vehicle (LV) = 57 km/h FVo for motorcycle (MC) = 47 km/h FVw = 0, because the wide of street is 7.00 m. FFVsf = 0.95, because the side friction of road is medium. FFVcs = 0.95, because the amount of citizen size (500,000-1 million people). FV_{LV} = (57+0) x 0.95 x 0.95 = 51.44 km/h. FV_{MC} = 47-(57-51.44)*(47/57) = 42.42 km/h. So, the free-flow speed of motorcycle in Malioboro Street and Ahmad Yani Street is 42.42 km/h.
6.	In page 5, the author stated that the VOT of motorcycle was obtained from GRDP. The authors are asked to explain why this value is suitable for motorcycle or the value from GRDP is not exclusively suitable for motorcycle only.	**Revision in page 5:** Gross Regional Domestic Product (GRDP) per capita in Yogyakarta city in October 2012 is IDR51,649,500. Value of time of motorcycles users in Yogyakarta city based on Gross Regional Domestic Product (GRDP) is IDR14,526.42/hour. Calculation: GRDP percapita-month = IDR51,649,500/12 Number of workday = 25 day every month. Number of hour = 8 hour/day. Occupancy of motorcycle = 1.5 people/motorcycle. Percentage of worker = 45%. So, the value of time of motorcycle based on Gross Regional Domestic Product (GRDP) is IDR 14,526.42/hour.

7.	In page 6, it was stated that ..." The approach to estimate congestion cost in this study is similar with the approach of [9] and [28]."…. Could you explain the originality of this study compared to previous studies?	**Revision in page 3, 5 and 6:** The approach to estimate congestion cost in this study is similar to the approach of Dodgson and Lane [34] that study the costs of road congestion in Great Britain. Congestion costs as the difference between the level of costs in actual speed and the level of costs in free-flow speed. The originality of this research: 1) Generalized cost: GC_{ij}^{m} = VOT (time $_{ij}^{m}$) + VOC (dist. $_{ij}^{m}$) + EC (dist. $_{ij}^{m}$) 2) Travel time cost Based on moving car observer (MCO) survey. 3) Value of time Gross Regional Domestic Product (GRDP) per capita in Yogyakarta city in October 2012 is IDR51,649,500. Value of time of motorcycles users in Yogyakarta city based on Gross Regional Domestic Product (GRDP) is IDR14,526.42/hour. 4) Pollution cost Marginal health-cost (MHC) approach is used to calculate the pollution cost of motorcycle. This approach was the result of World Bank study in Jakarta in 1990. 5) Consumption of fuel The fuel consumption was obtained from the relationship between speed and fuel consumption rates of motorcycles reported in the Study on Integrated Transportation Master Plan (SITRAMP) for the Jakarta-Bogor-Depok-Tangerang-Bekasi or Jabodetabek in 2004.
8.	The authors are asked to provide discussion regarding the method and findings of this study.	**Revision in page 6, 8 and 9:** Generalized cost of motorcycles consists of vehicle operating cost, travel time cost and externality cost. From the result above, the generalized cost of motorcycles in actual cost condition is IDR2767/trip and generalized cost in free-flow speed condition is IDR1098/trip. Generalized cost of motorcycles in actual condition is more expensive (152%) than in free-flow speed condition. The value of travel time cost in actual cost condition is 69% from generalized cost but in free-flow speed condition only 44%. Generalized cost of motorcycle in CBD Malioboro can be seen in Table 1. Table 1 Generalized cost of motorcycle in CBD Malioboro. Effect of congestion pricing Table 2 Effect of congestion pricing of motorcycles users on vehicle speed. Table 3 Effect of congestion pricing of motorcycles users on generalized cost.
9.	Up to the end of this article, I cannot find any new things about the study that useful for international readers. The authors are requested to re-read and re-write the article to improve clarity and quality of this article.	**Revision in page 5 to 9:** Useful for international readers: 1) Generalized cost: GC_{ij}^{m} = VOT (time $_{ij}^{m}$) + VOC (dist. $_{ij}^{m}$) + EC (dist. $_{ij}^{m}$)

		2) The relationship between vehicle operating cost and speed of motorcycles $y = 0.0921V^2 - 8.6847V + 555.51$ with $r^2 = 0.9686$ 3) The relationship between consumption of fuel with speed of motorcycle $y = -0.008V^2 + 0.7991V + 9.6933$ with $r^2 = 0.8299$ 4) Effect of congestion pricing of motorcycles users on vehicle speed and generalized cost 5) Marginal health-cost (MHC) approach is used to calculate the pollution cost of motorcycle.

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The Effect of Congestion Pricing Scheme on the Generalized Cost and Speed of Motorcycle

Gito SUGIYANTO*

Civil Engineering Department, Faculty of Engineering, Jenderal Soedirman University Purwokerto, Mayjend Sungkono Street km.5, Blater, Kalimanah, Purbalingga, Central Java, Indonesia 53371, Phone +62 81802811941, Fax. +62 281 6596700

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Running title
Mechanical and Civil Engineering

Abstract

Traffic congestion is one of the significant transport problems in many cities in developing countries. Increased the economic growth and motorization have created more traffic congestion. One of the alternatives to reduce congestion is application of transportation demand management like the congestion pricing. The aim of this research is to estimate congestion cost of motorcycles and the effect of congestion pricing scheme on the generalized cost and speed of motorcycle to the city of Yogyakarta. The amount of congestion pricing is the difference between generalized cost in free-flow speed and actual generalized cost in traffic jam condition. Generalized costs of motorcycle from origin to destination consist of vehicle operating cost, travel time cost and externality cost (pollution cost). This study shows that while the free-flow speed of motorcycle to the city of Yogyakarta is 42.42 km/h, with corresponding generalized cost of IDR1098 per trip, the actual speed in traffic jam condition is 10.77 km/h producing the generalized cost of IDR2767 per trip, giving the congestion pricing of motorcycle as IDR1669 per trip. The effect of application of congestion pricing for motorcycles users will increase the vehicle speeds 0.72 % to 8.11 % and decrease the generalized cost. Vehicle speed will increase by 2.26 km/h in Malioboro Street. The amount of generalized cost of motorcycles will decrease by 1.09 % to 6.63 %.

Keywords: Congestion pricing, generalized cost, vehicle operating cost, motorcycle, speed

Introduction

Cities in developing countries need innovative and effective solutions to solve their transportation problem like the traffic congestion, accident and delays. The increase in car ownership, population growth, and urbanization has increased traffic congestion in many cities in developing countries like in Indonesia. Traffic congestion does not only occur in urban areas, but also in rural areas, especially during peak hours. Transport problems become more complex and give more effects to society in areas with high activities, such as in Yogyakarta, Indonesia. This situation happens because of the imbalance between the number of vehicles and the length of the road [1]. Solutions to these problems are possible, not only through improvement public transport condition, pedestrians and bicycle users, but also in the implementation of measures which promote a rational use of the automobile by means Transportation Demand Management (TDM). TDM aims to maximize the efficiency of the urban transport system by discouraging unnecessary private vehicle use and environmental-friendly modes of transport, in general being public transport and non-motorized transport [2].

The costs incurred by the society as a result of the effect of congestion on transportation include vehicle operating cost, travel time cost and externality cost [3]. Externality cost are the congestion cost [4,5], environmental cost, pollution cost, and traffic accident cost [6]. The internalization of transportation external costs is one of the most relevant issues policy makers in recent years. Congestion and air pollution are among the most relevant sources of externalities in urban centers and they are increasingly tackled through the adoption of road pricing schemes (7). Transportation Demand Management (TDM), application of pricing policy in charging zone, congestion pricing, road pricing, and traffic restraint are the alternatives to reduce the transportation cost [1,8]. TDM can provide many benefits, for example congestion reduction, road cost savings, parking savings, transportations cost savings to consumers, improved mobility options, increased the road safety, reduced per capita energy consumption, reduced per capita pollutions emissions, efficient land use and increased physical activity and associated health benefits [2].

The congestion costs in France, United Kingdom, United States, and Japan are respectively 2.1 %, 3.2 %, 1.3 %, and 2.0 % of the respective Gross National Product (GNP) of the countries [9,10]. The congestion cost for 85 cities in the United States of America was US$63.3 billion in 2002, for value of time US$13.45/hour [11]. The economic loss caused by the traffic congestion in the Jabodetabek region could be as much as US$68 million per year due to traffic congestion and this estimate excludes the impacts of traffic congestion and pollution on human health [12]. Marginal congestion costs for different types of roads in England, the last update being around 45 pence per passenger car unit (pcu)-km for urban roads at peak time [13]. Congestion cost in CBD Malioboro, Indonesia for private passenger car users were estimated as IDR2701 (US$0.257) per trip [1] and for motorcycle users as IDR522.77 (US$0.05) per trip [14].

The effect of congestion pricing has been long studied in transport policy area. In the cases of 4 European cities including Paris, Brussels, Oslo and Helsinki can get sizable amount of benefit from commuting time reduction, cost saving in vehicle management, or enhanced quality of public transportation when road pricing is introduced in each country [15]. Implementation of congestion charging for private vehicle users in urban centers in London increased the use of urban bus by 18 %, taxi users by 17 % and decreased the use of private cars by 33 % [16]. Application of road pricing in other countries have a positive impact on reducing the use of private vehicle users and increased the use of public transport. In Belgium, the use of public transport increased by 10 %. If there is application of road pricing with improved public transportation service quality, the use of public transport will increase by 23 % [17]. Based on the simulation, application of congestion charging as IDR 4000 per trip for motorcycle users as a through traffic in CBD Malioboro, Yogyakarta will shift 6.848 % motorcycle users to bus TransJogja [18]. Among 15 % - 20 %, reductions in generalized cost are surprisingly small for charge levels, which have achieved 15 % reduction in overall trip making [19]. Singapore's road pricing system reduced 20 % to 30 % of the downtown passenger car traffic and Stockholm's traffic volume decreased by at least 20 % [20]. Commuters switch to public bus services by 12% to 20% in the morning hours after S$1 increase and by approximately 10% in the evening after toll adjustment of S$0.50 to S$1.00 in the affected gantry area compared to the counterfactual through difference-in-difference method [21]. The effect of congestion cost in Stockholm, Sweden, a new Western bypass is estimated to reduce traffic across inner city bridges by 11 % [22]. In New Zealand was found that the 21 % of survey respondents were willing to choose to walk and to use public transportation, while 67% insisted that they would still drive cars when congestion pricing were to be introduced [23]. Almost 37% of car users in Edinburg were willing to spend less or change the shopping destination if they had been asked to pay congestion tax for their shopping trip to the CBD [24].

The aim of this paper is to estimate the congestion cost of motorcycle users and the effect of congestion pricing scheme on the generalized cost and speed of motorcycle to the city of Yogyakarta, Indonesia.

Materials and methods

Analysis approach

Generalized cost of travel can be calculated based on combination of cost paid by user, travel time cost, vehicle-operating cost and externality cost. Externalities arise when the activity of a group affects the welfare of the other groups without any compensation [25,26]. Externalities in transport include: congestion, accidents, emissions, pollution and noise [2,27]. In this study, the externality cost that was counted is pollution cost. The approach that is used to analyze the pollution cost is marginal-health cost per vehicle and fuel consumption of vehicle in actual condition and free-flow speed condition. The generalized cost by mode m from origin zone i to destination zone j was determined using Eq. (1).

$$GC_{ij}^{m} = VOT\ (time_{ij}^{m}) + VOC\ (dist._{ij}^{m}) + EC\ (dist._{ij}^{m}) \quad (1)$$

In which GC_{ij}^{m} is the generalized cost per Passenger Car Units (PCU) by mode m to go from origin zone i (O_i) to destination zone j (D_j), VOT is the value of time per-PCU-min, $time_{ij}^{m}$ is the time taken to complete the trip in minutes, VOC_{ij}^{m} the total vehicle operating cost per PCU-km, and $dist._{ij}^{m}$ is the distance travelled to go from origin zone i to destination zone j, in km, EC is externality cost per kilometer while i is origin zone and j destination zone.

Data collection

In this paper, speed of motorcycles is counted in two conditions, the first is in free-flow speed condition and the second is in actual condition that potentially causes traffic jam. Traffic is congested if there are so many vehicles that each one travels slower than it would do if the other vehicles were not there and traffic is congested if there are so many vehicles that they are brought to a standstill or can only crawl along [28]. Related with speed is traffic flow congestion which is defined as the impedance vehicles imposed on each other, due to the speed-flow relationship, in conditions where the use of a transport system approaches its capacity [29]. Motorcycles speed data based on travel time of vehicles and speed survey using speed gun.

The travel time in free-flow speed condition of motorcycles in CBD Malioboro, Yogyakarta is obtained based on formula in Indonesian Highway Capacity Manual (IHCM) 1997 [30]. The travel time in actual cost condition is obtained from Moving Car Observer (MCO) survey in Central Business District (CBD) Malioboro, Yogyakarta. The CBD Malioboro consist of two lane one-way direction undivided road (2/1 UD) 1.414 kilometers long from Malioboro Street to Ahmad Yani Street. Wide of Malioboro Street is 7.00 meter. Value of time data for motorcycle users based on Gross Regional Domestic Product (GRDP) per capita in Yogyakarta city. The fuel consumption was obtained from the relationship between speed and dependent fuel consumption rates of motorcycles reported in the Study on Integrated Transportation Master Plan (SITRAMP) for the Jakarta-Bogor-Depok-Tangerang-Bekasi or Jabodetabek in 2004 [31]. The street where data was collected in the study area in CBD Malioboro, Indonesia is shown in **Figure 1** and **Figure 2**.

Figure 1 Study area in CBD Malioboro, Indonesia [1,14,18].

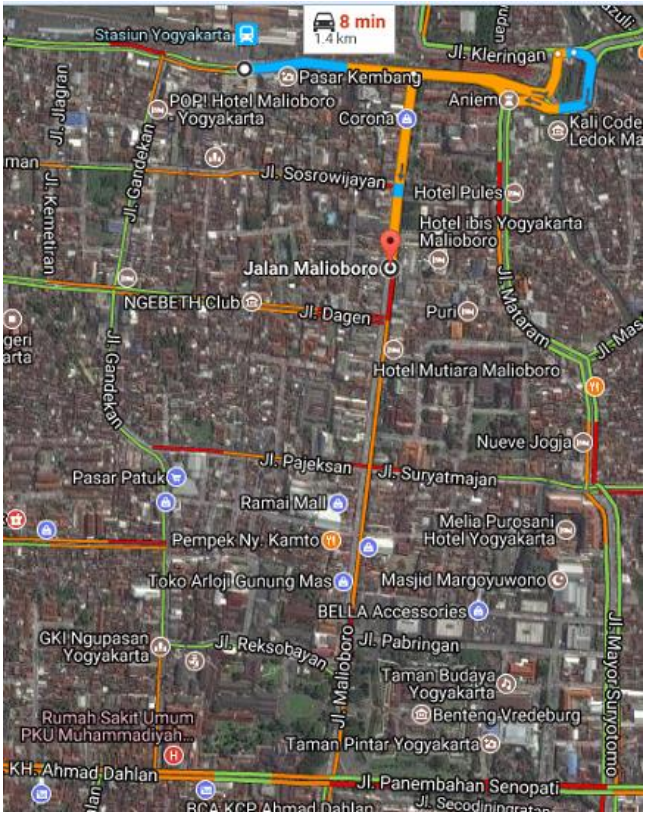

Figure 2 Street in the study area in CBD Malioboro.

Results and discussion

The generalized cost of motorcycle from origin to destination consists of three components of cost: the first is vehicle operating cost, the second is travel time cost and the third is pollution cost.

Vehicle operating cost

In this paper, vehicle operating cost (VOC) of motorcycles was counted in two conditions, based on travel cost in free-flow speed condition and travel cost in actual condition that potentially caused traffic jam. There are five components of vehicle operating costs of motorcycles: (a) consumption of fuel, (b) lubricating oil consumption, (c) tire consumption, (d) maintenance cost (spare part and repair), and (e) fixed cost. The fuel consumption was obtained from the relationship between speed and fuel consumption rates of motorcycles reported in the Study on Integrated Transportation Master Plan (SITRAMP) for the Jakarta-Bogor-Depok-Tangerang-Bekasi or Jabodetabek in 2004 [31]. Fuel economy improvement can be implemented by raising traveling speed and replacing overage vehicles with fuel saving ones like hybrid cars. For instance, traveling speed was reported to have a significant effect on fuel consumption and the lowest fuel consumption rates occur in a speed range of 40 km/h to 55 km/h [31,32].

Vehicle operating cost and speed relationship

Speed is the main factor to estimate the vehicle operating cost of motorcycles. The relationship between vehicle operating cost and speed of motorcycles for CBD Malioboro, Yogyakarta is presented in [14]. The optimum speed for motorcycles in CBD Malioboro along the 1.414 kilometer is 47.20 km/hour with vehicle operating cost of IDR350.77 per kilometer (IDR496 in CBD Malioboro). The vehicle-operating cost model for motorcycles was determined using Eq. (2).

$$y = 0.0921V^2 - 8.6847V + 555.51 \text{ with } r^2 = 0.9686 \quad (2)$$

In which V is speed of motorcycle (km per hour) and y is vehicle operating cost of motorcycles (IDR per kilometer).

Based on the survey and the analysis of Indonesian Highway Capacity Manual (IHCM) 1997 the speed of motorcycles in free-flow speed condition is 42.42 km/hour so the vehicle operating cost is IDR352.84/km (using Eq. 2). Based on the Moving Car Observer (MCO) survey, the average speed of motorcycles in actual cost condition that potentially caused traffic jam is 10.77 km/hour, so the vehicle-operating cost is IDR472.66/km (using Eq. 2). The vehicle operating cost of motorcycles at CBD Malioboro, Yogyakarta in free-flow speed and actual cost condition was calculated by multiplying with 1.414 km, the length of CBD Malioboro, the vehicle operating cost in free-flow speed condition is IDR499 per trip and in actual cost condition is IDR669 per trip.

Travel time cost

Gross Regional Domestic Product (GRDP) per capita in Yogyakarta city in October 2012 is IDR51,649,500 [33]. The approach in this research: number of workday is 25 day every month, number of hour is 8 hours/day, occupancy of motorcycle is 1.5 peoples per motorcycle and percentage of worker is 45%. Value of time of motorcycles users in Yogyakarta city based on Gross Regional Domestic Product (GRDP) is IDR14,526.42/hour. Based on the survey and analysis of speed of motorcycles in CBD Malioboro, travel time in free-flow speed condition is 2 minutes. Based on moving car observer (MCO) survey, the average of travel time in actual cost condition is 7 minutes 52.5 second. Travel time cost of motorcycles in CBD Malioboro, Yogyakarta was calculated by multiplying travel time with the value of time based on GRDP is IDR14,526.42/hour. The travel time cost (TTC) in free-flow speed condition is IDR485 per trip and in actual cost condition is IDR1,907 per trip.

Externality Cost: Pollution Cost

Marginal health-cost (MHC) approach is used to calculate the pollution cost of motorcycle. This approach was the result of World Bank study in Jakarta in 1990. MHC is value expressed in US$ cents per litre and cents/pass-kilometer [14]. In this study, was used MHC in cents per litre, then converted into

IDR per litre by using the exchange rate of currency 1 US$ = IDR10,500. The pollution cost for motorcycles was determined using Eq. (3).

Pollution cost (PC) = Marginal Health-cost (MHC) x Consumption of fuel (CF) (3)

In which PC is pollution cost (IDR/km), MHC is marginal health-cost of motorcycle (IDR/litre) and CF is consumption fuel of motorcycles (litre/km).

The relationship between consumption of fuel with speed of motorcycle based on the result of SITRAMP study by [31] and measurement in the field is formulated in quadratic function with Eq. (4).

$y = -0.008V^2 + 0.7991V + 9.6933$ with $r^2 = 0.8299$ (4)

In which y is consumption of fuel (km/litre) and V is speed of motorcycle (km/h). Coefficient determination (r^2) value 0.8299, indicate that between motorcycle speed and fuel consumption has a very high relationship. Fuel consumption of motorcycle used Eq. (4), 17.37 km/litre in actual condition with speed 10.77 km/h and 29.20 km/litre in free-flow speed condition with speed 42.42 km/h. Speed and fuel consumption are the main factor to determine pollution cost. Pollution cost of motorcycle in free-flow speed condition is IDR 80 and IDR135 in actual cost condition. Pollution cost of motorcycle in Malioboro along 1.414 km in actual condition with speed 10.77 km/h is IDR 191 and in free-flow speed condition with speed 42.42 km/h is IDR 114.

Generalized cost

Generalized cost of motorcycles consists of vehicle operating cost, travel time cost and externality cost. From the result above, the generalized cost of motorcycles in actual cost condition is IDR2767/trip and generalized cost in free-flow speed condition is IDR1098/trip. Generalized cost of motorcycles in actual condition is more expensive (152%) than in free-flow speed condition. The value of travel time cost in actual cost condition is 69% from generalized cost but in free-flow speed condition only 44%. Generalized cost of motorcycle in CBD Malioboro can be seen in **Table 1**.

Table 1 Generalized cost of motorcycle in CBD Malioboro.

Type of condition	VOC (IDR/trip)	Pollution cost (IDR/trip)	TTC (IDR/trip)	Generalized cost (IDR/trip)
Free-flow speed	499	114	485	1,098
Actual cost	669	191	1,907	2,767

Congestion cost

The approach to estimate congestion cost in this study is similar to the approach of Dodgson and Lane [34] that study the costs of road congestion in Great Britain. Congestion costs as the difference between the level of costs in actual speed and the level of costs in free-flow speed [34]. The amount of congestion cost of motorcycles is the difference between generalized cost in actual cost condition with speed of 10.77 km/hour and travel time of 7 minutes 52.5 second, and generalized cost in free-flow speed condition with speed of 42.42 km/hour and travel time of 2 minutes. From above, the generalized cost of motorcycles in actual cost condition is IDR2,767 per trip, and generalized cost in free-flow speed condition is IDR1,098 per trip, thus the congestion cost of motorcycles in CBD Malioboro, Yogyakarta is IDR1,669 per trip.

Effect of congestion pricing

The simulation to estimate the effect of congestion pricing in CBD Malioboro using Equilibre Multimodal, Multimodal Equilibrium-2 (EMME-2) software. Distribution of traffic zone, node and link in EMME-2 to simulate the application of congestion pricing in CBD Malioboro can be seen in **Figure 3**. The result of simulation of congestion cost for motorcycle users in CBD Malioboro: include Malioboro Street (along 809 m) and Ahmad Yani Street (along 605 m) using EMME-2 software as presented on auto speed can be seen in **Figure 4**.

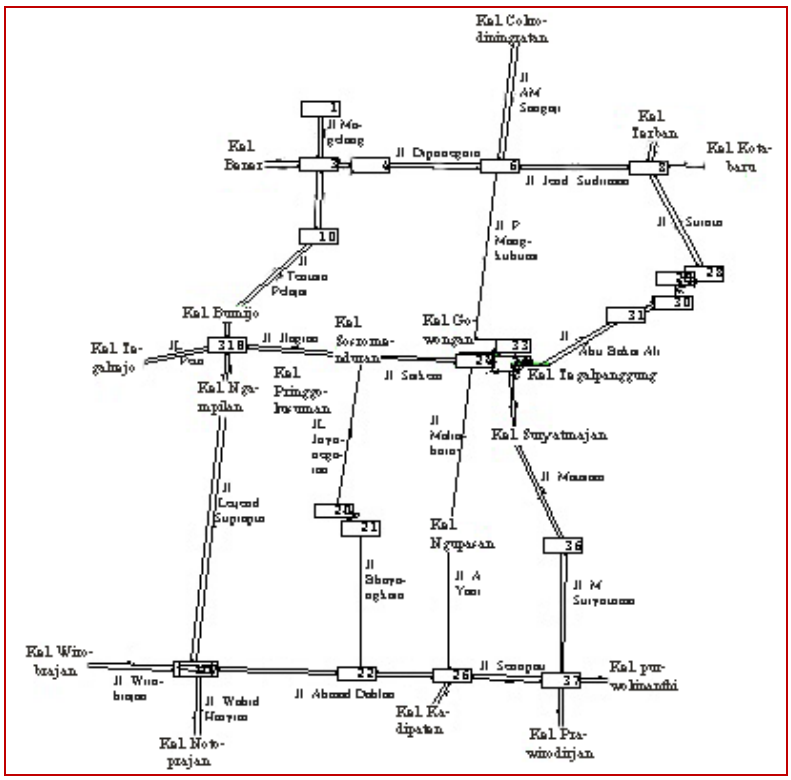

Figure 3 Distribution of traffic zone, node and link in EMME-2 software.

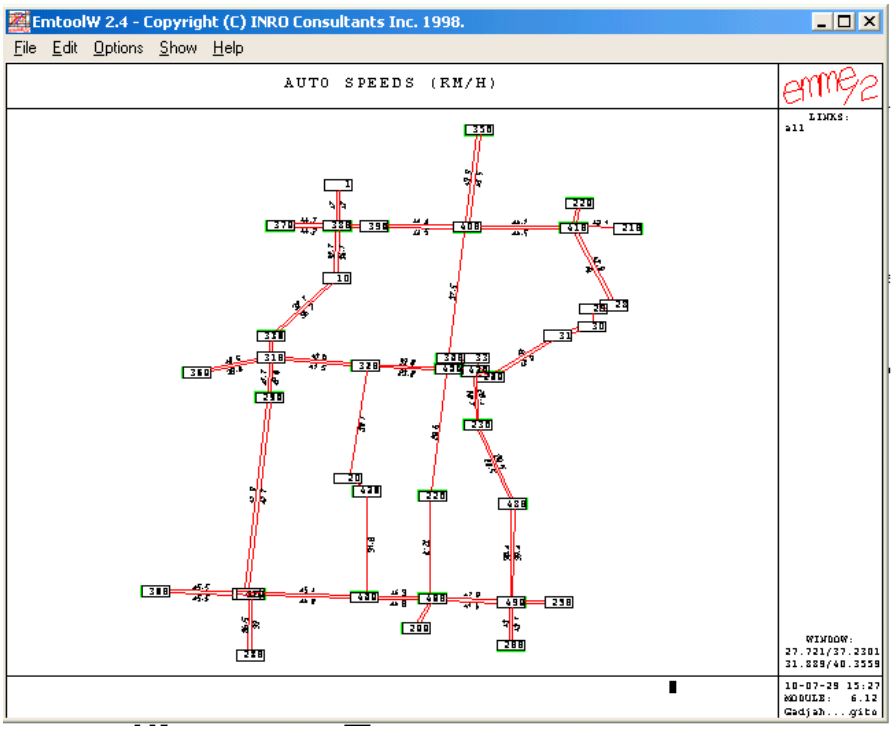

Figure 4 Auto speeds from simulation results using EMME-2 in CBD Malioboro, Yogyakarta.

Implementation of congestion pricing for motorcycles users at Malioboro Street and Ahmad Yani Street in Yogyakarta resulted in change of vehicle speed 0.72 % to 8.11 % (**Table 2**). Speed in some roads have increased like at Pangeran Diponegoro Street (W-E), Pangeran Mangkubumi Street, Malioboro Street, Ahmad Yani Street, Mataram Street (S-N) and Mayor Suryotomo Street (S-N), while in Jenderal Sudirman Street, Pangeran Diponegoro Street (E-W), Ahmad Dahlan Street, Pangeran Senopati Street and Mayor Suryotomo Street (N-S) the speed decreased. The highest increase of vehicle speed occured in Malioboro Street at 2.26 km/h (8.11 %) while the largest decrease occurred in Mayor Suryotomo Street at north-south direction as 1.07 km/h (2.64 %) and in Bhayangkara Street as 0.88 km/h (2.78 %). These results are similar with the research of [35] which examined the implementation of Electronic Road Pricing (ERP) in Paris, ERP increased the vehicle speed from 44.80 km/h to 45.40 km/h. Based on the results of the simulation of application of congestion pricing for motorcycles users in Malioboro, there was an improvement of road network performance. Application of congestion pricing increased the vehicle speed and decreased the generalized cost. These results are similar to the study of [36] that examined the application of congestion charging in central London that can increase the average speed of vehicle by ± 4 km/h. Within the Charging Zone (CZ), the Wilcoxon test has shown that the difference in speed between pre and post London's Congestion Charging Scheme (CCS) periods has increased on average of 2.1 km/h and that these changes are significant at the p = 0.05 level [36]. This result is in line with the findings of Percoco [7], the road pricing scheme in Milan has had limited impact in terms of congestion and environmental quality because of the behavioral response of road users. In fact, we have found that the policy did not produce a reduction in the number of vehicles entering the city center, while it did lead to an increase in the number of motorbikes and, in part, LPG, bi-fuel and hybrid cars [7]. Effect of congestion pricing of motorcycles users on vehicle speed in 16 links can be seen in **Table 2**.

Table 2 Effect of congestion pricing of motorcycles users on vehicle speed.

No.	Node Origin-Destination	Name of link and direction of movement	Vehicle speed (km/h)		Difference in vehicle speed (km/h)	Difference in vehicle speed (%)
			Without pricing	With pricing		
(1)	(2)	(3)	(4)	(5)	(6)=(5)-(4)	(7)=(6)/(4)
1.	3-4	Pangeran Diponegoro Street (W-E)	44.85	45.29	0.44	0.98%
2.	4-3	Pangeran Diponegoro Street (E-W)	44.89	44.43	-0.46	-1.02%
3.	6-8	Jenderal Soedirman Street (W-E)	45.24	44.51	-0.73	-1.61%
4.	8-6	Jenderal Soedirman Street (E-W)	45.09	44.13	-0.96	-2.13%
5.	6-23	Pangeran Mangkubumi Street	36.16	37.53	1.37	3.79%
6.	24-25	Malioboro Street	27.85	30.11	2.26	8.11%
7.	25-26	Ahmad Yani Street	31.09	32.34	1.25	4.02%
8.	26-22	Ahmad Dahlan Street (E-W)	45.16	44.30	-0.86	-1.90%
9.	22-26	Ahmad Dahlan Street (W-E)	45.53	44.95	-0.58	-1.27%
10.	22-21	Bhayangkara Street	31.63	30.75	-0.88	-2.78%
11.	26-37	Pangeran Senopati Street (W-E)	42.27	41.37	-0.90	-2.13%
12.	37-26	Pangeran Senopati Street (E-W)	42.38	41.63	-0.75	-1.77%
13.	36-35	Mataram Street (S-N)	30.19	30.48	0.29	0.96%
14.	35-36	Mataram Street (N-S)	30.23	29.47	-0.76	-2.51%
15.	36-37	Mayor Suryotomo Street (N-S)	40.48	39.41	-1.07	-2.64%
16.	37-36	Mayor Suryotomo Street (S-N)	40.39	40.68	0.29	0.72%

Note: W is west, E is east, S is south, and N is north.

Vehicle speed on Malioboro Street in existing condition without pricing is 27.85 km/h. In this condition, the amount of vehicle operating cost of motorcycles is IDR311.53 per trip, travel time cost is

IDR421.97 per trip, pollution cost is IDR73.42 per trip and therefore the generalized cost without congestion pricing is IDR806.92 per trip. Based on the results of the simulation, vehicle speed on Malioboro Street with congestion pricing is 30.11 km/h. In this condition, the amount of vehicle operating cost of motorcycles is IDR305.41 per trip, travel time cost is IDR390.30 per trip, pollution cost is IDR71.32 per trip and therefore the generalized cost in with pricing is IDR753.40 per trip. The amount of generalized cost in Malioboro Street will decrease to IDR53.51 per trip (6.63 %). Vehicle speed on Ahmad Yani Street in existing condition without pricing is 31.09 km/h. In this condition, the amount of vehicle operating cost of motorcycles is IDR226.59 per trip, travel time cost is IDR282.68 per trip, pollution cost is IDR52.73 per trip and therefore the generalized cost without pricing is IDR562 per trip. Based on the results of the simulation, vehicle speed on Ahmad Yani Street with congestion pricing is 32.34 km/h. In this condition, the amount of vehicle operating cost of motorcycles is IDR224.44 per trip, travel time cost is IDR271.76 per trip, pollution cost is IDR52.03 per trip and therefore the generalized cost in with pricing is IDR527.66 per trip. The amount of generalized cost in Ahmad Yani Street will decrease to IDR34.33 per trip (6.11 %). Effect of congestion pricing of motorcycles users on generalized cost in 16 links can be seen in **Table 3**.

Table 3 Effect of congestion pricing of motorcycles users on generalized cost.

No.	Name of link and direction movement	Length of link (km)	Generalized cost (IDR/trip)		Δ Generalized cost (IDR/trip)	Δ Generalized cost (IDR/trip)
			Without pricing	With pricing		
(1)	(2)	(3)	(4)	(5)	(6)=(5)-(4)	(7)=(6)/(4)
1.	Malioboro Street (N-S)	0.809	806.92	753.40	-53.51	-6.63%
2.	Ahmad Yani Street (N-S)	0.605	562.00	527.66	-34.33	-6.11%
3.	Jenderal Soedirman Street (W-E)	1.274	957.39	992.42	35.03	3.66%
4.	Jenderal Soedirman Street (E-W)	1.274	958.86	996.40	37.54	3.92%
5.	Pangeran Mangkubumi Street	0.814	689.20	662.01	-27.18	-3.94%
6.	Pangeran Diponegoro Street (W-E)	0.686	517.59	498.18	-19.41	-3.75%
7.	Pangeran Diponegoro Street (E-W)	0.686	517.38	502.78	-14.60	-2.82%
8.	Ahmad Dahlan Street (E-W)	1.022	768.64	777.40	8.76	1.14%
9.	Ahmad Dahlan Street (W-E)	1.022	765.77	772.09	6.32	0.83%
10.	Bhayangkara Street	0.574	527.42	515.55	-11.87	-2.25%
11.	Pangeran Senopati Street (W-E)	0.715	555.34	545.16	-10.17	-1.83%
12.	Pangeran Senopati Street (E-W)	0.715	554.60	543.35	-11.25	-2.03%
13.	Mataram Street (S-N)	0.564	533.83	508.98	-24.84	-4.65%
14.	Mataram Street (N-S)	0.564	533.37	520.34	-13.03	-2.44%
15.	Mayor Suryotomo Street (N-S)	0.750	595.86	589.36	-6.50	-1.09%
16.	Mayor Suryotomo Street (S-N)	0.750	596.57	579.16	-17.40	-2.92%

Note: W is west, E is east, S is south, and N is north.

This result is in line with the findings of May and Milne [19] that congestion pricing will reductions in generalized cost. Generalized cost in Malioboro Street, Ahmad Yani Street, Pangeran Mangkubuni Street, Pangeran Diponegoro Street, Bhayangkara Street, Pangeran Senopati Street, Mataram Street and Mayor Suryotomo Street will decreased, while the generalized cost in Jenderal Soedirman Street and Ahmad Dahlan Street will increased. The highest increase of generalized cost occurred in Malioboro Street as IDR53.51 per trip (6.63 %) while the largest decrease occurs in Jenderal Soedirman Street at east-west direction as IDR37.54 per trip (3.92 %). With this condition, there is a change of route from the commuter to the city of Yogyakarta.

Conclusion

The estimation of congestion cost for motorcycles users in CBD Malioboro, Yogyakarta and the effect of congestion pricing scheme on the generalized cost and speed of motorcycles to the city of Yogyakarta is presented in this paper. From the analysis and results, it can be concluded as follows:

1. The generalized cost at CBD Malioboro, Yogyakarta for motorcycles in free-flow speed condition is IDR1,098 per trip and in actual cost condition is IDR2,767 per trip, giving the congestion pricing of motorcycle to the city of Yogyakarta as IDR1,669 per trip.
2. Effect of congestion pricing scheme on the generalized cost for motorcycles to the city of Yogyakarta will decrease to IDR53.51 per trip (6.63 %) in Malioboro Street and IDR34.33 per trip (6.11 %) in Ahmad Yani Street.
3. Effect of congestion pricing on vehicle speed will increase from 0.72 to 8.11 %. The highest increase of vehicle speed occured in Malioboro Street at 2.26 km/h (8.11 %) while the largest decrease occured in Mayor Suryotomo Street at north-south direction at 1.07 km/h (2.64 %) and in Bhayangkara Street at 0.88 km/h (2.78 %).

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References

[1] G Sugiyanto, S Malkhamah, A Munawar and H Sutomo. Estimation of congestion cost of motorcycles users in Malioboro, Yogyakarta. *Civil Engineering Dimension*, 2010; **12**, 92-7.
[2] A Broaddus, T Litman and G Menon. Transportation Demand Management, Training Document, gtz Transport Policy Advisory Services, Eschborn, Germany, 2009, p. 1-111. Available at: http://www.sutp.org.
[3] JD Ortuzar and LG Willumsen. *Modeling Transport*. John Wiley and Sons Ltd., England, 2001, p. 1-75.
[4] PC Stubs, WJ Tyson and MQ Dalvi. *Transport Economics*. George Allen and Unwin (Publisher) Ltd., London, 1980.
[5] ET Verhoef. Second-best congestion pricing in general networks, Heuristic algorithms for finding second-best optimal toll levels and toll points. *Transport. Res. Part B*, 2002; **36**, 707-29.
[6] JF Tsai, CP Chu and SR Hu. Road pricing for congestion and accident externalities for mixed traffic of motorcycles and automobiles. *Transport. Res. Part A*, 2015; **71**, 153-66.
[7] M Percoco. The effect of road pricing on traffic composition: Evidence from a natural experiment in Milan, Italy. *Transp. Policy*, 2014; **31**, 55-60.
[8] G Sugiyanto. The effect of application of congestion cost for private passenger cars users as a through traffic in Yogyakarta, Indonesia. *ASEAN Eng. Journal AUN-SEED/Net*, 2011; **1**, 84-96.
[9] G Bouladon. La Mobilite en Zone Urbaine: Apprendre I'Economie de Transport, Document Diffusion Restreinte, Direction de I'Environnement. Organization for Economic Co-operation and Development (OECD)-European Conference of Ministers of Transport (ECMT), Paris, 1991, p. 10-17.
[10] E Quinet. *The Social Costs of Transport: Evaluation and Links with Internalization Policies, In Internalizing the Social Costs of Transport*. Organization for Economic Co-operation and Development (OECD)-European Conference of Ministers of Transport (ECMT), Paris, 1994, p. 31-75.
[11] JD Harford. Congestion, pollution and benefit to cost ratios of US public transit system. *Transport. Res. Part D*, 2006; **11**, 45-58.
[12] S Dikun. Transportation in New Global Era: Linking Asia through Better Transportation. *Keynote Speech of 5th EASTS International Conference*. Fukuoka, Japan, October 29th 2003.

[13] DM Newbery. *Fair Payment from Road-Users: A Review of the Evidence on Social and Environment Costs*. The Automobile Association, Basingstoke, 1998.
[14] G Sugiyanto, S Malkhamah, A Munawar, and H Sutomo. Estimation of congestion cost of motorcycles users in Malioboro, Yogyakarta. *International Journal of Civil and Environmental Engineering (IJCEE)*, 2011a; **11**, 56-63.
[15] A de Palma, R Lindsey and E Niskanen. Policy insights from the urban road pricing case studies. *Transp. Policy*, 2006; **13**, 149-61.
[16] G Santos and J Bhakar. The impact of London congestion charging scheme on the generalized cost of car commuters to the city of London from a value of time savings perspective. *Transp. Policy*, 2006; **13**, 22-33.
[17] H Armelius and L Hultkrantz. The Politico-economic link between public transport and congestion cost: an ex-ante study of the Stockholm trial-cost road. *Transp. Policy*, 2006; **13**, 162-72.
[18] G Sugiyanto, S Malkhamah, A Munawar and H Sutomo. Modeling the effect of congestion pricing on mode choice in Yogyakarta, Indonesia. *International Journal of Engineering and Technology (IJET)*, 2011b; **11**, 109-16.
[19] AD May and DS Milne. Effects of alternative road pricing systems on network performance. *Transport. Res. Part A*, 2000; **34**, 407-36.
[20] G Menon and S Guttikunda. Electronic Road Pricing: Experience & Lessons from Singapore. *SIM-Air Working Paper Series* **33**, 2010.
[21] S Agarwal and KM Koo. Impact of electronic road pricing (ERP) changes on transport modal choice. *Regional Science and Urban Economics*, 2016; **60**, 1-11.
[22] J Eliasson, L Hultkrantz, L Nerhagen and LS Rosqvist. The Stockholm congestion-charging trial 2006: Overview of effects. *Transport. Res. Part A*, 2009; **43**, 240-50.
[23] C O'Fallon, C Sullivan and D Hensher. Constraints affecting mode choices by morning car commuters. *Transp. Policy*, 2004; **11**, 17-29.
[24] S Hu and W Saleh. Impacts of congestion charging on shopping trips in Edinburgh. *Transp. Policy*, 2005; **12**, 443-450.
[25] JK Button. *Transport Economics 2nd Ed*. Cambridge University Press, United Kingdom, 1993.
[26] M Belhaj and E Fridle. *External Costs in the Transport Sector: A Literature Review*. 2010. Available at: http://www.cpm.chalmers.se/document/reports/08/CPM%20trsprt%20lit%20review2.3%20.pdf, accessed on December 8th, 2010.
[27] RA Derlin and RQ Grafton. *Economic Right and Environmental Wrongs*. Edward Elgar, Cheltenham, 1998.
[28] S Grant-Muller and J Laird. *Costs of Congestion: Literature Based Review of Methodologies and Analytical Approaches*, Chapter VI: Measuring the costs of congestion. Final Report. Scottish Executive Social Research, London, 2006, p. 35-44. Available at: http://www.scotland.gov.uk/Publications/2006/11/01103351, accessed on March 4th, 2010.
[29] PB Goodwin. *The economic cost of road traffic congestion*. *Discussion paper*. Rail Freight Group, Transport Studies Unit, University College London, London, 2004, p. 1-14. Available at: http://eprints.ucl.ac.uk/archive/00001259/, accessed on December 17th, 2009.
[30] Directorate General of Highways, Directorate of Urban Road Development. *Indonesian Highway Capacity Manual (IHCM) 1997*. Sweroad in Association with PT. Bina Karya (Persero), Jakarta, 1997, p. 1-99.
[31] JICA and National Development Planning Agency (BAPPENAS). *The Study on Integrated Transportation Master Plan (SITRAMP) for the Jabodetabek Phase 2. Final Report*. Technical Report. PCI and ALMEC Corporation, Jakarta, Republic of Indonesia, 2004, p. 36-55.
[32] DU Asri and B Hidayat. Current Transportation Issues in Jakarta and ITS Impacts on Environment. *Proceedings of Eastern Asia Society for Transportation Studies* (EASTS) 5, 2005, p. 1792-8. Available at: http://www.jstage.jst.go.jp.
[33] Badan Pusat Statistik Kota Yogyakarta. *Gross Regional Domestic Product of Yogyakarta City by Industrial Origin 2011-2015*. Badan Pusat Statistik, Yogyakarta, 2016, p. 1-80.

[34] J Dodgson and B Lane. *The Costs of Road Congestion in Great Britain: A NERA Briefing Paper*, National Economic Research Associates (NERA), London, 1997, p. 1-18. Available at: http://www.nera.com/publication.asp?p_ID=752.
[35] AD Palma and R Lindsey. Modeling and evaluation of congestion pricing in Paris. *Transp. Policy*, 2006; **13**, 115-26.
[36] SD Beevers and DC Carslaw. The impact of congestion charging on vehicle speed and its implications for assessing vehicle emissions. *J. Atmospheric Environment*, 2005; **39**, 6875-84.

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Title: The Effect of Congestion Pricing Scheme on Generalized Cost and Speed of a Motorcycle

No.	Before	After (Revision)
1.	**Abstract** page 1: Traffic congestion is one of the significant transport problems in many cities in developing countries. Increased economic growth and motorization have created more traffic congestion. One of the alternatives to reduce congestion is application of transportation demand management like the congestion pricing. The aim of this research is to estimate congestion cost of motorcycles and the effect of congestion pricing scheme on the generalized cost and speed of motorcycle ~~to the city of Yogyakarta~~. The amount of congestion pricing is the difference between generalized cost in free-flow speed and actual generalized cost in traffic jam condition. Generalized costs of motorcycle from origin to destination consist of vehicle operating cost, travel time cost and externality cost (pollution cost). This study shows that while the free-flow speed of a motorcycle to the city of Yogyakarta is 42.42 km/h, with corresponding generalized cost of IDR1098 per trip, the actual speed in traffic jams is 10.77 km/h producing the generalized cost of IDR2767 per trip, giving the congestion pricing of motorcycle as IDR1669 per trip. The effect of application of congestion pricing for motorcycles users will increase the vehicle speeds from 0.72 to 8.11 % and decrease the generalized cost. Vehicle speed will increase by 2.26 km/h in Malioboro Street. The amount of generalized cost of motorcycles will decrease by 1.09 to 6.63 %.	**Abstract** page 1: Traffic congestion is one of the significant transport problems in many cities in developing countries. Increased economic growth and motorization have created more traffic congestion. The application of transportation demand management like congestion pricing can reduce congestion, pollution and increase road safety. The aim of this research is to estimate the congestion cost of motorcycles and the effect of a congestion pricing scheme on the generalized cost and speed of a motorcycle. The amount of congestion pricing is the difference between actual generalized cost in traffic jams and generalized cost in free-flow speed. The analysis approach using three components of generalized costs of motorcycle: vehicle operating, travel time and externality cost (pollution cost). The simulation to estimate the effect of congestion pricing using *Equilibre* Multimodal, Multimodal Equilibrium-2 (EMME-2) software. The results of this study show that while the free-flow speed of a motorcycle to the city of Yogyakarta is 42.42 km/h, with corresponding generalized cost of IDR1098 per trip, the actual speed in traffic jams is 10.77 km/h producing a generalized cost of IDR2767 per trip, giving a congestion pricing for a motorcycle of IDR1669 per trip. Based on the simulation by using EMME-2, the effect of congestion pricing will increase on vehicle speed by 0.72 to 8.11 %. The highest increase of vehicle speed occurred in Malioboro Street at 2.26 km/h, while the largest decrease occurred in Mayor Suryotomo Street at north-south direction at 1.07 km/h. Another effect of this application for motorcycles users will decrease the generalized cost by 1.09 to 6.63 %
2.	**Vehicle operating cost and speed relationship page 5** Based on the survey and the analysis of Indonesian Highway Capacity Manual (IHCM) 1997 the speed of motorcycles in free-flow ~~speed~~ conditions is 42.42 km/hour so the vehicle operating cost is IDR352.84/km (using Eq. (2)).	**Vehicle operating cost and speed relationship page 5** Based on the survey and the analysis of Indonesian Highway Capacity Manual (IHCM) 1997 the speed of motorcycles in free-flow conditions is 42.42 km/hour so the vehicle operating cost is IDR352.84/km (using Eq. (2)).
3.	**Effect of congestion pricing page 7** The simulation to estimate the effect of congestion pricing in CBD Malioboro using Equilibre Multimodal, Multimodal Equilibrium-2 (EMME-2) software.	**Effect of congestion pricing page 7** The simulation to estimate the effect of congestion pricing in CBD Malioboro using *Equilibre* Multimodal, Multimodal Equilibrium-2 (EMME-2) software.

4.	**Page 8** Implementation of congestion pricing for motorcycles users at Malioboro Street and Ahmad Yani Street in Yogyakarta resulted in a change in vehicle speed 0.72 to 8.11 % (**Table 2**). The speed in some roads increased like at Pangeran Diponegoro Street (W-E), Pangeran Mangkubumi Street, Malioboro Street, Ahmad Yani Street, Mataram Street (S-N) and Mayor Suryotomo Street (S-N), while in Jenderal Sudirman Street, Pangeran Diponegoro Street (E-W), Ahmad Dahlan Street, Pangeran Senopati Street and Mayor Suryotomo Street (N-S) the speed decreased. The highest increase of vehicle speed occured in Malioboro Street at 2.26 km/h (8.11 %) while the largest decrease occurred in Mayor Suryotomo Street in north-south direction at 1.07 km/h (2.64 %) and in Bhayangkara Street at 0.88 km/h (2.78 %). These results are similar with the research of [35] which examined the implementation of Electronic Road Pricing (ERP) in Paris, ERP increased the vehicle speed from 44.80 ~~km/h~~ to 45.40 km/h.	**Page 8** Implementation of congestion pricing for motorcycles users at Malioboro Street and Ahmad Yani Street in Yogyakarta resulted in a change in vehicle speed 0.72 to 8.11 % (**Table 2**). The speed in some roads increased like at Pangeran Diponegoro Street (W-E), Pangeran Mangkubumi Street, Malioboro Street, Ahmad Yani Street, Mataram Street (S-N) and Mayor Suryotomo Street (S-N), while in Jenderal Sudirman Street, Pangeran Diponegoro Street (E-W), Ahmad Dahlan Street, Pangeran Senopati Street and Mayor Suryotomo Street (N-S) the speed decreased. The highest increase of vehicle speed occurred in Malioboro Street at 2.26 km/h (8.11 %) while the largest decrease occurred in Mayor Suryotomo Street in north-south direction at 1.07 km/h (2.64 %) and in Bhayangkara Street at 0.88 km/h (2.78 %). These results are similar with the research of [35] which examined the implementation of Electronic Road Pricing (ERP) in Paris, ERP increased the vehicle speed from 44.80 to 45.40 km/h.
5.	**Page 9** The vehicle speed on Malioboro Street in existing conditions without pricing is 27.85 km/h. In these conditions, the vehicle operating cost of motorcycles is IDR311.53 per trip, travel time cost is IDR421.97 per trip, pollution cost is IDR73.42 per trip and therefore the generalized cost without congestion pricing is IDR806.92 per trip. Based on the results of the simulation, vehicle speed on Malioboro Street with congestion pricing is 30.11 km/h.	**Page 9** The vehicle speed on Malioboro Street in existing conditions without pricing is 27.85 km/h. In these conditions, the vehicle operating cost of motorcycles is IDR311.53 per trip, travel time cost is IDR421.97 per trip, pollution cost is IDR73.42 per trip and therefore the generalized cost without congestion pricing is IDR806.92 per trip. Based on the simulation by using EMME-2, vehicle speed on Malioboro Street with congestion pricing is 30.11 km/h.
6.	**Page 10** This results are in line with the findings of May and Milne [19] that congestion pricing will yield reductions in generalized cost.	**Page 10** These results are in line with the findings of May and Milne [19] and Sugiyanto [37] that congestion pricing will yield reductions in generalized cost.
7.	**Page 10 Conclusion** 2. The effect of the congestion pricing scheme on the generalized cost for motorcycles ~~to the city of Yogyakarta~~ will decrease to IDR53.51 per trip (6.63 %) in Malioboro Street and IDR34.33 per trip (6.11 %) in Ahmad Yani Street. 3. The effect of the congestion pricing on vehicle speed will increase from 0.72 to 8.11 %. The highest increase of vehicle speed occurred in Malioboro Street at 2.26 km/h (8.11 %) while the	**Page 10 Conclusion** 2. Based on the simulation by using EMME-2, the effect of the application of congestion pricing will increase vehicle speed by 0.72 to 8.11 %. The highest increase of vehicle speed occurred in Malioboro Street at 2.26 km/h (8.11 %) while the largest decrease occurred in Mayor Suryotomo Street at north-south direction at 1.07 km/h (2.64 %) and in Bhayangkara Street at 0.88 km/h (2.78 %).

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8.	**References page 11-12** [12] S Dikun. Transportation in New Global Era: Linking Asia through Better Transportation. *In:* Proceeding of the 5th Eastern Asia Society for Transportation Studies ~~International Conference~~. Fukuoka, Japan, 2003. [31] JICA and National Development Planning Agency (BAPPENAS). *The Study on Integrated Transportation Master Plan (SITRAMP) for the Jabodetabek Phase 2*. Final Report. Technical Report. PCI and ALMEC Corporation, Jakarta, Republic of Indonesia, 2004, p. 36-55. [32] DU Asri and B Hidayat. Current transportation issues in Jakarta and ITS impacts on environment. Proc. Eastern Asia Soc. Transport. Stud. 2005; **5**, 1792-8. [33] Badan Pusat Statistik Kota Yogyakarta. *Gross Regional Domestic Product of Yogyakarta City by Industrial Origin 2011-2015*. Badan Pusat Statistik, Yogyakarta, 2016, p. 1-80. [37] -	**References page 11-12** [12] S Dikun. Transportation in new global era: Linking Asia through better transportation. *In:* Proceeding of the 4th Eastern Asia Society for Transportation Studies. Fukuoka, Japan, 2003. [31] JICA and National Development Planning Agency (*BAPPENAS*). *The Study on Integrated Transportation Master Plan (SITRAMP) for the Jabodetabek Phase 2*. Final Report. Technical Report. PCI and ALMEC Corporation, Jakarta, Republic of Indonesia, 2004, p. 36-55. [32] DU Asri and B Hidayat. Current transportation issues in Jakarta and ITS impacts on environment. *In*: Proceeding of the 5th Eastern Asia Society for Transportation Studies. Fukuoka, Japan, 2005, p. 1792-8. [33] Central Bureau of Statistics of Yogyakarta City. *Gross Regional Domestic Product of Yogyakarta City by Industrial Origin 2011-2015*. Central Bureau of Statistics, Yogyakarta, 2016, p. 1-80. [37] G Sugiyanto. Impact of congestion pricing scheme on the generalized cost and speed of motorcycle (case study in Yogyakarta, Indonesia). *J. Eng. Applied Sci.* 2016; **11**, 1740-6.

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The Effect of Congestion Pricing Scheme on the Generalized Cost and Speed of a Motorcycle

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Abstract

Traffic congestion is one of the significant transport problems in many cities in developing countries. Increased economic growth and motorization have created more traffic congestion. The application of transportation demand management like congestion pricing can reduce congestion, pollution and increase road safety. The aim of this research is to estimate the congestion pricing of motorcycles and the effect of a congestion pricing scheme on the generalized cost and speed of a motorcycle. The amount of congestion pricing is the difference between actual generalized cost in traffic jams and in free-flow speed conditions. The analysis approach using three components of generalized costs of motorcycle: vehicle operating, travel time and externality cost (pollution cost). The approach to analyze the pollution cost is marginal-health cost and fuel consumption in traffic jams and free-flow speed conditions. The value of time based on Gross Regional Domestic Product per capita in Yogyakarta City in October 2012. The simulation to estimate the effect of congestion pricing using *Equilibre* Multimodal, Multimodal Equilibrium-2 (EMME-2) software. The results of this study show that while the free-flow speed of a motorcycle to the city of Yogyakarta is 42.42 km/h, with corresponding generalized cost of IDR1098 per trip, the actual speed in traffic jams is 10.77 km/h producing a generalized cost of IDR2767 per trip, giving a congestion pricing for a motorcycle of IDR1669 per trip. Based on the simulation by using EMME-2, the effect of congestion pricing will increase on vehicle speed by 0.72 to 8.11 %. The highest increase of vehicle speed occurred in Malioboro Street at 2.26 km/h, while the largest decrease occurred in Mayor Suryotomo Street at north-south direction at 1.07 km/h. Another effect of this application for motorcycles users will decrease the generalized cost by 1.09 to 6.63 %.

Keywords: Congestion pricing, motorcycle, marginal-health cost, generalized cost, EMME-2

Introduction

Cities in developing countries need innovative and effective solutions to solve their transportation problems like the traffic congestion, accident and delays. The increase in car ownership, population growth, and urbanization has increased traffic congestion in many cities in developing countries like in Indonesia. Traffic congestion does not only occur in urban areas, but also in rural areas, especially during peak hours. Transport problems become more complex and have more effects on society in areas with high activities, such as in Yogyakarta, Indonesia. This situation happens because of the imbalance between the number of vehicles and the length of the road [1]. Solutions to these problems are possible, not only through improvement of public transport, increased pedestrians and bicycle users, but also in the implementation of measures which promote a rational use of the automobile by means Transportation Demand Management (TDM). TDM aims to maximize the efficiency of the urban transport system by discouraging unnecessary private vehicle use and environmental-friendly modes of transport, in general being public transport and non-motorized transport [2].

The costs incurred by society as a result of the effect of congestion on transportation include vehicle operating, travel time, and externality costs [3]. Externality costs are the congestion [4,5], environmental, pollution, and traffic accident cost [6]. The internalization of transportation external costs is one of the most relevant issues policy makers in recent years. Congestion and air pollution are among the most relevant sources of externalities in urban centers and they are increasingly tackled through the adoption of road pricing schemes (7). TDM, application of pricing policy in charging zone, congestion pricing, road pricing, and traffic restraint are the alternatives to reduce the transportation cost [1,8]. TDM can provide many benefits, for example congestion reduction, road cost savings, parking savings, transportations cost savings to consumers, improved mobility options, increased the road safety, reduced per capita energy consumption, reduced per capita pollutions emissions, efficient land use and increased physical activity and associated health benefits [2].

The congestion costs in France, United Kingdom, United States, and Japan are respectively 2.1, 3.2, 1.3 and 2 % of the respective Gross National Product (GNP) of the countries [9,10]. The congestion cost for 85 cities in the United States was US$63.3 billion in 2002, for a value of time US$13.45/hour [11]. The economic loss caused by the traffic congestion in the Jabodetabek region could be as much as US$68 million per year due to traffic congestion and this estimate excludes the impacts of traffic congestion and pollution on human health [12]. Marginal congestion costs for different types of roads in England, for the last update were around 45 pence per passenger car unit (pcu)-km for urban roads at peak time [13]. The congestion cost in CBD Malioboro, Indonesia for private passenger car users are estimated to be IDR2701 (US$0.257) per trip [1] and for motorcycle users as IDR522.77 (US$0.05) per trip [14].

The effect of congestion pricing has been long studied in transport policy area. In the cases of 4 European cities Paris, Brussels, Oslo and Helsinki can get a sizable amount of benefit from commuting time reduction, cost saving in vehicle management, or enhanced quality of public transportation when road pricing was introduced in each country [15]. Implementation of congestion charging for private vehicle users in urban centers in London increased the use of urban bus transport by 18 %, taxi users by 17 % and decreased the use of private cars by 33 % [16]. Application of road pricing in other countries has had a positive impact on reducing the use of private vehicle users and increased the use of public transport. In Belgium, the use of public transport increased by 10 %. If there is application of road pricing with improved public transportation service quality, the use of public transport will increase by 23 % [17]. Based on the simulation, application of a congestion charge of IDR 4000 per trip for motorcycle users as a through traffic in CBD Malioboro, Yogyakarta will shift 6.848 % motorcycle users to bus TransJogja [18]. Among 15 - 20 %, reductions in generalized cost are surprisingly small for charge levels, which have achieved 15 % reduction in overall trips [19]. Singapore's road pricing system reduced 20 to 30 % of the downtown passenger car traffic and Stockholm's traffic volume decreased by at least 20 % [20]. Commuters switch to public bus services by 12 to 20 % in the morning hours after a S$1 increase and by approximately 10 % in the evening after toll adjustment of S$0.50 to S$1.00 in the affected gantry area compared to the counterfactual through difference-in-difference method [21]. The effect of congestion cost in Stockholm, Sweden, a new Western bypass is estimated to reduce traffic across inner city bridges by 11 % [22]. In New Zealand it was found that the 21 % of survey respondents were willing to choose to walk and to use public transportation, while 67 % insisted that they would still drive cars when congestion pricing were to be introduced [23]. Almost 37 % of car users in Edinburg were willing to spend less or change the shopping destination if they had been asked to pay a congestion tax for their shopping trip to the CBD [24].

The aim of this paper is to estimate the congestion cost of motorcycle users and the effect of the congestion pricing scheme on the generalized cost and speed of motorcycle to the city of Yogyakarta, Indonesia.

Materials and methods

Analysis approach

Generalized cost of travel can be calculated based on combination of cost paid by the user, travel time cost, vehicle operating cost and externality cost. Externalities arise when the activity of a group

affects the welfare of the other groups without any compensation [25,26]. Externalities in transport include: congestion, accidents, emissions, pollution and noise [2,27]. In this study, the externality cost that was considered was the pollution cost. The approach that is used to analyze the pollution cost is marginal-health cost per vehicle and fuel consumption of vehicle in actual conditions and free-flow speed conditions. The generalized cost by mode *m* from the origin, zone *i* to the destination, zone *j* was determined using Eq. (1).

$$GC_{ij}^{m} = VOT\ (time_{ij}^{m}) + VOC\ (dist._{ij}^{m}) + EC\ (dist._{ij}^{m}) \quad (1)$$

In which GC_{ij}^{m} is the generalized cost per Passenger Car Units (PCU) by mode *m* to go from the origin, zone *i* (O_i) to the destination, zone *j* (D_j), VOT is the value of time per-PCU-min, $time_{ij}^{m}$ is the time taken to complete the trip in minutes, VOC_{ij}^{m} the total vehicle operating cost per PCU-km, and $dist._{ij}^{m}$ is the distance travelled to go from zone *i* to zone *j*, in km, EC is externality cost per kilometer while *i* is origin zone and *j* destination zone.

Data collection

In this paper, the speed of motorcycles was counted in 2 conditions, the first is in free-flow speed conditions and the second in actual conditions that potentially causes traffic jams. Traffic is congested if there are so many vehicles that each one travels slower than it would do if the other vehicles were not there and traffic is congested if there are so many vehicles that they are brought to a standstill or can only crawl along [28]. Related with speed is traffic flow congestion which is defined as the impedance vehicles imposed on each other, due to the speed-flow relationship, in conditions where the use of a transport system approaches its capacity [29]. Motorcycle speed data was based on travel time of vehicles and a speed survey using speed gun.

The travel time in free-flow conditions for motorcycles in CBD Malioboro, Yogyakarta is obtained based on the formula in the Indonesian Highway Capacity Manual (IHCM) 1997 [30]. The actual travel time cost conditions were obtained from a Moving Car Observer (MCO) survey in Central Business District (CBD) Malioboro, Yogyakarta. The CBD Malioboro consists of a 2 lane one-way direction undivided road (2/1 UD) 1.414 kilometers long from Malioboro Street to Ahmad Yani Street. The width of Malioboro Street is 7.00 meter. The value of time data for motorcycle users is based on Gross Regional Domestic Product (GRDP) per capita in Yogyakarta City. The fuel consumption was obtained from the relationship between speed and dependent fuel consumption rates of motorcycles reported in the Study on Integrated Transportation Master Plan (SITRAMP) for the Jakarta-Bogor-Depok-Tangerang-Bekasi or Jabodetabek in 2004 [31]. The street where data was collected in the study area in CBD Malioboro, Indonesia is shown in **Figures 1** and **2**.

Figure 1 Study area in CBD Malioboro, Indonesia [1,14,18].

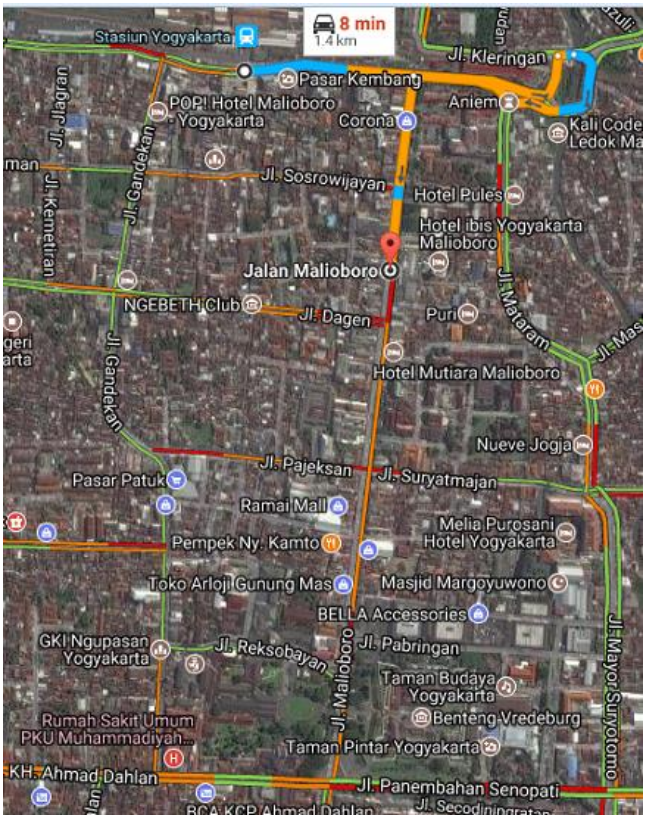

Figure 2 Street in the study area in CBD Malioboro, Yogyakarta.

Results and discussion

The generalized cost of a motorcycle from origin to destination consists of 3 components of cost: the first is the vehicle operating cost, the second is the travel time cost and the third is the pollution cost.

Vehicle operating cost

In this paper, the vehicle operating cost (VOC) of motorcycles was counted in 2 conditions, based on travel cost in free-flow conditions and travel cost in actual conditions that potentially involved traffic jams. There are 5 components of vehicle operating costs of motorcycles: (a) consumption of fuel, (b) lubricating oil consumption, (c) tire consumption, (d) maintenance cost (spare part and repair), and (e) fixed cost. The fuel consumption was obtained from the relationship between speed and fuel consumption rates of motorcycles reported in the Study on Integrated Transportation Master Plan (SITRAMP) for the Jakarta-Bogor-Depok-Tangerang-Bekasi or Jabodetabek in 2004 [31]. Fuel economy improvement can be implemented by raising traveling speed and replacing average vehicles with fuel saving ones like hybrid cars. For instance, traveling speed was reported to have a significant effect on fuel consumption and the lowest fuel consumption rates occur in a speed range of 40 to 55 km/h [31,32].

Vehicle operating cost and speed relationship

Speed is the main factor to estimate the vehicle operating cost of motorcycles. The relationship between vehicle operating cost and speed of motorcycles for CBD Malioboro, Yogyakarta is presented in [14]. The optimum speed for motorcycles in CBD Malioboro along the 1.414 km is 47.2 km/h with vehicle operating cost of IDR350.77 per km (IDR496 in CBD Malioboro). The vehicle operating cost model for motorcycles was determined using Eq. (2).

$$y = 0.0921V^2 - 8.6847V + 555.51 \text{ with } r^2 = 0.9686 \quad (2)$$

in which V is the speed of the motorcycle (km per hour) and y is vehicle operating cost of motorcycles (IDR per km).

Based on the survey and the analysis of Indonesian Highway Capacity Manual (IHCM) 1997 the speed of motorcycles in free-flow conditions is 42.42 km/h so the vehicle operating cost is IDR352.84/km (using Eq. (2)). Based on the Moving Car Observer survey, the average speed of motorcycles under actual conditions is 10.77 km/h, so the vehicle-operating cost is IDR472.66/km (using Eq. (2)). The vehicle operating cost of motorcycles at CBD Malioboro, Yogyakarta in free-flow speed and actual conditions was calculated by multiplying by 1.414 km, the length of CBD Malioboro, the vehicle operating cost in free-flow speed condition is IDR499 per trip and the actual conditions were IDR669 per trip.

Travel time cost

Gross Regional Domestic Product (GRDP) per capita in Yogyakarta city in October 2012 is IDR51,649,500 [33]. The approach in this research was 25 workdays every month, 8 hours/day, a motorcycle occupancy of 1.5 peoples per motorcycle and percentage of workers 45%. The value of time of motorcycle users in Yogyakarta city based on Gross Regional Domestic Product (GRDP) is IDR14,526.42 per hour. Based on the survey and analysis of the speed of motorcycles in CBD Malioboro, the travel time in free-flow conditions is 2 min. Based on the moving car observer survey, the average of travel time in actual conditions is 7 min 52.5 s. The travel time cost of motorcycles in CBD Malioboro, Yogyakarta was calculated by multiplying the travel time with the value of time based on GRDP is IDR14,526.42 per hour. The travel time cost (TTC) in free-flow conditions is IDR485 per trip while the actual cost is IDR1,907 per trip.

Externality Cost: Pollution Cost

The marginal health-cost (MHC) approach is used to calculate the pollution cost per motorcycle. This approach was the result of a World Bank study in Jakarta in 1990. MHC is value expressed in US cents per litre and cents/pass-kilometer [14]. In this study, we used MHC in cents per litre, then converted

into IDR per litre using an exchange rate of 1 US$ = IDR10,500. The pollution cost for motorcycles was determined using Eq. (3).

Pollution cost (PC) = Marginal Health-cost (MHC) x Consumption of fuel (CF) (3)

In which PC is pollution cost (IDR/km), MHC is marginal health-cost of motorcycle (IDR/litre) and CF is the fuel consumption (litre/km).

The relationship between fuel consumption and the speed of the motorcycle based on the result of SITRAMP study by [31] and measurement in the field is formulated in the quadratic function with Eq. (4).

$y = -0.008V^2 + 0.7991V + 9.6933$ with $r^2 = 0.8299$ (4)

In which y is fuel consumption (km/litre) and V is speed of motorcycle (km/h). The coefficient determination (r^2) value 0.8299, indicated that there was a strong correlation between motorcycle speed and fuel consumption. Fuel consumption using Eq. (4), was 17.37 km/litre in actual conditions with a speed 10.77 km/h and 29.20 km/litre in free-flow conditions with a speed 42.42 km/h. Speed and fuel consumption are the main factors in determining pollution cost. The pollution cost of motorcycle in free-flow conditions was IDR 80 and IDR135 in actual conditions. The pollution cost of motorcycles in Malioboro along 1.414 km in actual conditions at 10.77 km/h is IDR 191 and in free-flow conditions at 42.42 km/h is IDR 114.

Generalized cost

The generalized cost of motorcycles consists of vehicle operating cost, travel time cost and externality cost. From the results above, the generalized cost of motorcycles in actual condition is IDR2767/trip and generalized cost in free-flow condition is IDR1098/trip. The generalized cost of motorcycles in actual conditions is more expensive (152%) than in free-flow conditions. The value of travel time cost in actual conditions is 69 % of the generalized cost but in free-flow conditions is only 44 %. The generalized cost of the motorcycle in CBD Malioboro is shown in **Table 1**.

Table 1 Generalized cost of motorcycle in CBD Malioboro, Yogyakarta.

Type of condition	VOC (IDR/trip)	Pollution cost (IDR/trip)	TTC (IDR/trip)	Generalized cost (IDR/trip)
Free-flow speed	499	114	485	1,098
Actual cost	669	191	1,907	2,767

Congestion cost

The approach to estimate congestion cost in this study is similar to the approach of Dodgson and Lane [34] in their study on the costs of road congestion in Great Britain. Congestion costs as the difference between the level of costs in actual and the level of costs in free-flow conditions [34]. The amount of congestion cost of motorcycles is the difference between the generalized cost in actual conditions at 10.77 km/h and a travel time of 7 min 52.5 s, and the generalized cost in free-flow conditions at 42.42 km/h and a travel time of 2 min. From above, the generalized cost of motorcycles in actual conditions is IDR2,767 per trip, and the generalized cost in free-flow conditions is IDR1,098 per trip, thus the congestion cost of motorcycles in CBD Malioboro, Yogyakarta is IDR1,669 per trip.

Effect of congestion pricing

The simulation to estimate the effect of congestion pricing in CBD Malioboro using *Equilibre* Multimodal, Multimodal Equilibrium-2 (EMME-2) software. Distribution of the traffic zones, nodes, and links in EMME-2 to simulate the application of congestion pricing in CBD Malioboro can be seen in **Figure 3**. The result of the simulation of congestion cost for motorcycle users in CBD Malioboro includes Malioboro Street (along 809 m) and Ahmad Yani Street (along 605 m) using EMME-2 software as presented on auto speed can be seen in **Figure 4**.

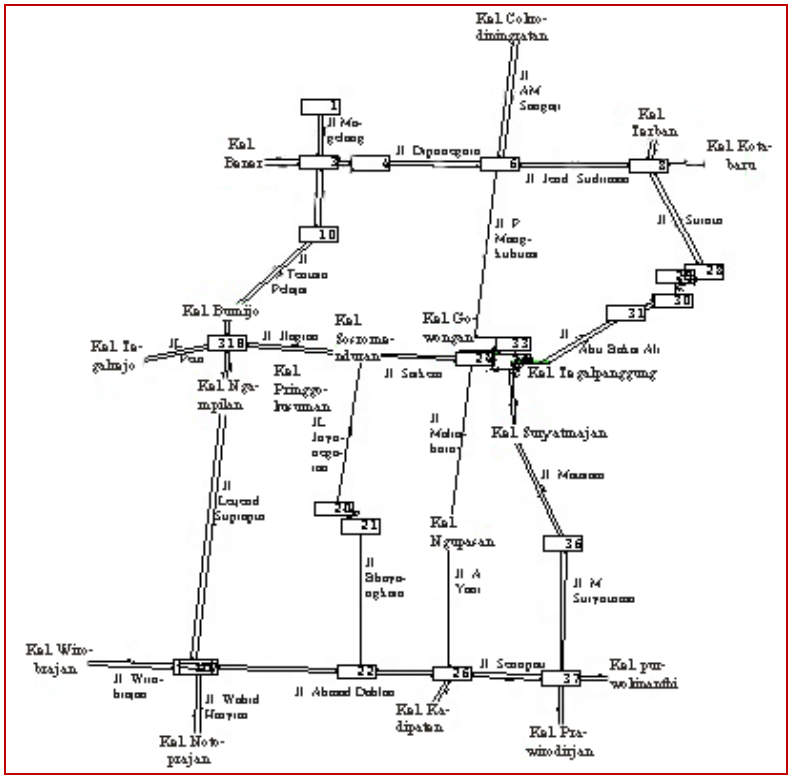

Figure 3 Distribution of traffic zones, nodes and links in EMME-2 software.

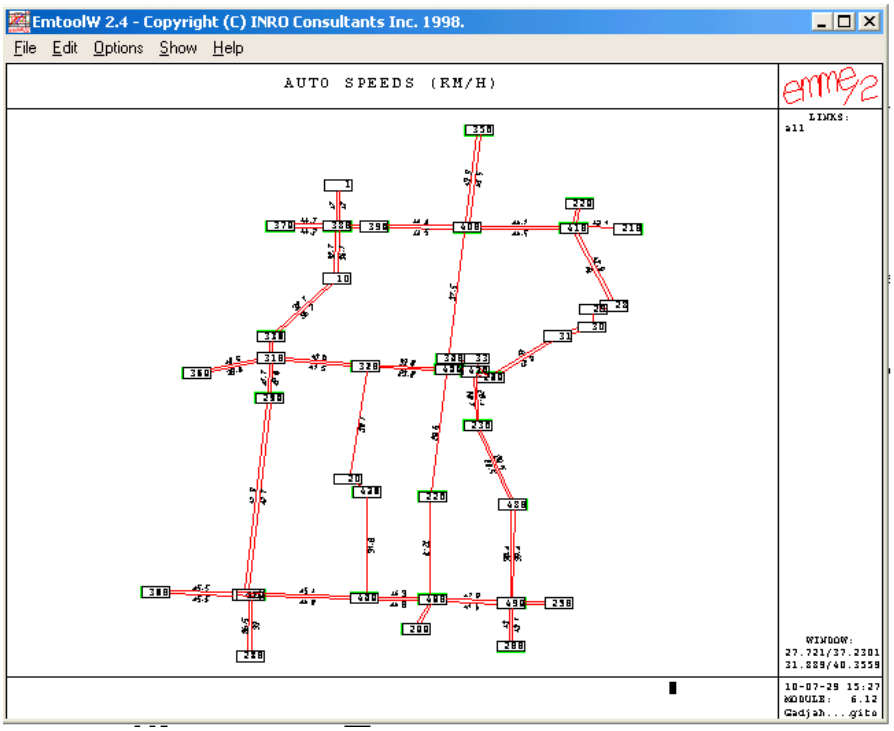

Figure 4 Auto speeds from simulation results using EMME-2 in CBD Malioboro, Yogyakarta.

Implementation of congestion pricing for motorcycles users at Malioboro Street and Ahmad Yani Street in Yogyakarta resulted in a change in vehicle speed 0.72 to 8.11 % (**Table 2**). The speed in some roads increased like at Pangeran Diponegoro Street (W-E), Pangeran Mangkubumi Street, Malioboro Street, Ahmad Yani Street, Mataram Street (S-N) and Mayor Suryotomo Street (S-N), while in Jenderal Sudirman Street, Pangeran Diponegoro Street (E-W), Ahmad Dahlan Street, Pangeran Senopati Street and Mayor Suryotomo Street (N-S) the speed decreased. The highest increase of vehicle speed occurred in Malioboro Street at 2.26 km/h (8.11 %) while the largest decrease occurred in Mayor Suryotomo Street in north-south direction at 1.07 km/h (2.64 %) and in Bhayangkara Street at 0.88 km/h (2.78 %). These results are similar with the research of [35] which examined the implementation of Electronic Road Pricing (ERP) in Paris, ERP increased the vehicle speed from 44.8 to 45.4 km/h. Based on the results of the simulation of application of congestion pricing for motorcycles users in Malioboro, there was an improvement in the road network performance. Application of congestion pricing increased the vehicle speed and decreased the generalized cost. These results are similar to the study of [36] that examined the application of congestion charging in central London that can increase the average speed of vehicle by ± 4 km/h. Within the Charging Zone (CZ), the Wilcoxon test has shown that the difference in speed between pre and post London's Congestion Charging Scheme (CCS) periods has increased on average of 2.1 km/h and that these changes are significant at the p = 0.05 level [36]. This result is in line with the findings of Percoco [7], the road pricing scheme in Milan has had limited impact in terms of congestion and environmental quality because of the behavioral response of road users. In fact, we have found that the policy did not produce a reduction in the number of vehicles entering the city center, while it did lead to an increase in the number of motorbikes and, in part, LPG, bi-fuel and hybrid cars [7]. The effect of congestion pricing of motorcycles users on vehicle speed in 16 links can be seen in **Table 2**.

Table 2 Effect of congestion pricing of motorcycles users on vehicle speed.

No.	Node Origin-Destination	Name of link and direction of movement	Vehicle speed (km/h)		Difference in vehicle speed (km/h)	Difference in vehicle speed (%)
			Without pricing	With pricing		
(1)	(2)	(3)	(4)	(5)	(6)=(5)-(4)	(7)=(6)/(4)
1.	3-4	Pangeran Diponegoro Street (W-E)	44.86	45.30	0.44	0.98%
2.	4-3	Pangeran Diponegoro Street (E-W)	44.90	44.44	-0.46	-1.02%
3.	6-8	Jenderal Soedirman Street (W-E)	45.23	44.50	-0.73	-1.61%
4.	8-6	Jenderal Soedirman Street (E-W)	45.10	44.14	-0.96	-2.13%
5.	6-23	Pangeran Mangkubumi Street	36.18	37.55	1.37	3.79%
6.	24-25	Malioboro Street	27.85	30.11	2.26	8.11%
7.	25-26	Ahmad Yani Street	31.09	32.34	1.25	4.02%
8.	26-22	Ahmad Dahlan Street (E-W)	45.16	44.30	-0.86	-1.90%
9.	22-26	Ahmad Dahlan Street (W-E)	45.53	44.95	-0.58	-1.27%
10.	22-21	Bhayangkara Street	31.63	30.75	-0.88	-2.78%
11.	26-37	Pangeran Senopati Street (W-E)	42.27	41.37	-0.90	-2.13%
12.	37-26	Pangeran Senopati Street (E-W)	42.38	41.63	-0.75	-1.77%
13.	36-35	Mataram Street (S-N)	30.19	30.48	0.29	0.96%
14.	35-36	Mataram Street (N-S)	30.23	29.47	-0.76	-2.51%
15.	36-37	Mayor Suryotomo Street (N-S)	40.48	39.41	-1.07	-2.64%
16.	37-36	Mayor Suryotomo Street (S-N)	40.39	40.68	0.29	0.72%

Note: W is west, E is east, S is south, and N is north.

The vehicle speed on Malioboro Street in existing conditions without pricing is 27.85 km/h. In these conditions, the vehicle operating cost of motorcycles is IDR311.53 per trip, travel time cost is IDR421.97 per trip, pollution cost is IDR73.42 per trip and therefore the generalized cost without congestion pricing is IDR806.92 per trip. Based on the simulation by using EMME-2, vehicle speed on Malioboro Street with congestion pricing is 30.11 km/h. Under these conditions, the vehicle operating cost of motorcycles is IDR305.41 per trip, travel time cost is IDR390.30 per trip, pollution cost is IDR71.32 per trip and therefore the generalized cost in with pricing is IDR753.40 per trip. The generalized cost in Malioboro Street will decrease to IDR53.51 per trip (6.63 %). Vehicle speed on Ahmad Yani Street under existing conditions without pricing is 31.09 km/h. Under these conditions, the vehicle operating cost of a motorcycle is IDR226.59 per trip, travel time cost is IDR282.68 per trip, pollution cost is IDR52.73 per trip and therefore the generalized cost without pricing is IDR562 per trip. Based on the results of the simulation, vehicle speed on Ahmad Yani Street with congestion pricing would be 32.34 km/h. Under these conditions, the vehicle operating cost of a motorcycle is IDR224.44 per trip, travel time cost is IDR271.76 per trip, pollution cost is IDR52.03 per trip and therefore the generalized cost with pricing is IDR527.66 per trip. The generalized cost in Ahmad Yani Street will decrease to IDR34.33 per trip (6.11 %). The effect of congestion pricing of motorcycles users on generalized cost in 16 links can be seen in **Table 3**.

Table 3 Effect of congestion pricing of motorcycles users on generalized cost.

No.	Name of link and direction movement	Length of link (km)	Generalized cost (IDR/trip)		Δ Generalized cost (IDR/trip)	Δ Generalized cost (IDR/trip)
			Without pricing	With pricing		
(1)	(2)	(3)	(4)	(5)	(6)=(5)-(4)	(7)=(6)/(4)
1.	Malioboro Street (N-S)	0.809	806.92	753.40	-53.51	-6.63%
2.	Ahmad Yani Street (N-S)	0.605	562.00	527.66	-34.33	-6.11%
3.	Jenderal Soedirman Street (W-E)	1.274	957.39	992.42	35.03	3.66%
4.	Jenderal Soedirman Street (E-W)	1.274	958.86	996.40	37.54	3.92%
5.	Pangeran Mangkubumi Street	0.814	689.20	662.01	-27.18	-3.94%
6.	Pangeran Diponegoro Street (W-E)	0.686	517.59	498.18	-19.41	-3.75%
7.	Pangeran Diponegoro Street (E-W)	0.686	517.38	502.78	-14.60	-2.82%
8.	Ahmad Dahlan Street (E-W)	1.022	768.64	777.40	8.76	1.14%
9.	Ahmad Dahlan Street (W-E)	1.022	765.77	772.09	6.32	0.83%
10.	Bhayangkara Street	0.574	527.42	515.55	-11.87	-2.25%
11.	Pangeran Senopati Street (W-E)	0.715	555.34	545.16	-10.17	-1.83%
12.	Pangeran Senopati Street (E-W)	0.715	554.60	543.35	-11.25	-2.03%
13.	Mataram Street (S-N)	0.564	533.83	508.98	-24.84	-4.65%
14.	Mataram Street (N-S)	0.564	533.37	520.34	-13.03	-2.44%
15.	Mayor Suryotomo Street (N-S)	0.750	595.86	589.36	-6.50	-1.09%
16.	Mayor Suryotomo Street (S-N)	0.750	596.57	579.16	-17.40	-2.92%

Note: W is west, E is east, S is south, and N is north.

These results are in line with the findings of May and Milne [19] and Sugiyanto [37] that congestion pricing will yield reductions in generalized cost. The generalized cost in Malioboro Street, Ahmad Yani Street, Pangeran Mangkubuni Street, Pangeran Diponegoro Street, Bhayangkara Street, Pangeran Senopati Street, Mataram Street and Mayor Suryotomo Street will decrease, while the generalized cost in Jenderal Soedirman Street and Ahmad Dahlan Street will increase. The highest increase in generalized cost occurred in Malioboro Street at IDR53.51 per trip (6.63 %) while the largest decrease occurs in Jenderal Soedirman Street in the east-west direction at IDR37.54 per trip (3.92 %). Under these conditions, there is a change of route from the commuter to the city of Yogyakarta.

Conclusion

The estimation of congestion cost for motorcycles users in CBD Malioboro, Yogyakarta and the effect of congestion pricing scheme on the generalized cost and speed of motorcycles to the city of Yogyakarta is presented in this paper. From the analysis and results, it can be concluded that:

1. The generalized cost at CBD Malioboro, Yogyakarta for motorcycles in free-flow speed conditions is IDR1,098 per trip and in actual cost conditions is IDR2,767 per trip, giving a congestion pricing for motorcycle to the city of Yogyakarta of IDR1,669 per trip.
2. Based on the simulation by using EMME-2, the effect of the application of congestion pricing will increase vehicle speed by 0.72 to 8.11 %. The highest increase of vehicle speed occurred in Malioboro Street at 2.26 km/h (8.11 %) while the largest decrease occurred in Mayor Suryotomo Street at north-south direction at 1.07 km/h (2.64 %) and in Bhayangkara Street at 0.88 km/h (2.78 %).
3. The effect of the congestion pricing scheme on the generalized cost for motorcycles will decrease to IDR53.51 per trip (6.63 %) in Malioboro Street and IDR34.33 per trip (6.11 %) in Ahmad Yani Street.

Acknowledgements

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References

[1] G Sugiyanto, S Malkhamah, A Munawar and H Sutomo. Estimation of congestion cost of motorcycles users in Malioboro, Yogyakarta. *Civil Eng. Dimension* 2010; **12**, 92-7.
[2] A Broaddus, T Litman and G Menon. *Transportation Demand Management, Training Document, gtz Transport Policy Advisory Services*. Eschborn, Germany, 2009, p. 1-111.
[3] JD Ortuzar and LG Willumsen. *Modeling Transport*. John Wiley and Sons, England, 2001, p. 1-75.
[4] PC Stubs, WJ Tyson and MQ Dalvi. *Transport Economics*. George Allen and Unwin, London, 1980.
[5] ET Verhoef. Second-best congestion pricing in general networks, Heuristic algorithms for finding second-best optimal toll levels and toll points. *Transport. Res. Part B* 2002; **36**, 707-29.
[6] JF Tsai, CP Chu and SR Hu. Road pricing for congestion and accident externalities for mixed traffic of motorcycles and automobiles. *Transport. Res. Part A* 2015; **71**, 153-66.
[7] M Percoco. The effect of road pricing on traffic composition: Evidence from a natural experiment in Milan, Italy. *Transport Pol.* 2014; **31**, 55-60.
[8] G Sugiyanto. The effect of application of congestion cost for private passenger cars users as a through traffic in Yogyakarta, Indonesia. *ASEAN Eng. J.* 2011; **1**, 84-96.
[9] G Bouladon. La Mobilite en Zone Urbaine: Apprendre I'economie de transport, document diffusion restreinte, direction de I'environnement. *In*: Proceeding of the European Conference of Ministers of Transport. Paris, 1991, p. 10-17.
[10] E Quinet. *The social costs of transport: Evaluation and links with internalization policies, In internalizing the social costs of transport*. *In*: Proceeding of the European Conference of Ministers of Transport. Paris, 1994, p. 31-75.
[11] JD Harford. Congestion, pollution and benefit to cost ratios of US public transit system. *Transport. Res. Part D* 2006; **11**, 45-58.
[12] S Dikun. Transportation in new global era: Linking Asia through better transportation. *In:* Proceeding of the 4th Eastern Asia Society for Transportation Studies. Fukuoka, Japan, 2003.
[13] DM Newbery. *Fair Payment from Road-Users: A Review of the Evidence on Social and Environment Costs*. The Automobile Association, Basingstoke, 1998.
[14] G Sugiyanto, S Malkhamah, A Munawar, and H Sutomo. Estimation of congestion cost of motorcycles users in Malioboro, Yogyakarta. *Int. J. Civil Environ. Eng.* 2011; **11**, 56-63.
[15] A de Palma, R Lindsey and E Niskanen. Policy insights from the urban road pricing case studies. *Transport Pol.* 2006; **13**, 149-61.
[16] G Santos and J Bhakar. The impact of London congestion charging scheme on the generalized cost of car commuters to the city of London from a value of time savings perspective. *Transport Pol.* 2006; **13**, 22-33.
[17] H Armelius and L Hultkrantz. The Politico-economic link between public transport and congestion cost: an ex-ante study of the Stockholm trial-cost road. *Transport Pol.* 2006; **13**, 162-72.
[18] G Sugiyanto, S Malkhamah, A Munawar and H Sutomo. Modeling the effect of congestion pricing on mode choice in Yogyakarta, Indonesia. *Int. J. Eng. Tech.* 2011; **11**, 109-16.
[19] AD May and DS Milne. Effects of alternative road pricing systems on network performance. *Transport. Res. Part A* 2000; **34**, 407-36.
[20] G Menon and S Guttikunda. Electronic road pricing: Experience & lessons from Singapore. *SIM Air Work. Pap. Series* 2010; **33**, 1-15.
[21] S Agarwal and KM Koo. Impact of electronic road pricing (ERP) changes on transport modal choice. *Reg. Sci. Urban Econ.* 2016; **60**, 1-11.

[22] J Eliasson, L Hultkrantz, L Nerhagen and LS Rosqvist. The Stockholm congestion-charging trial 2006: Overview of effects. *Transport. Res. Part A* 2009; **43**, 240-50.
[23] C O'Fallon, C Sullivan and D Hensher. Constraints affecting mode choices by morning car commuters. *Transport Pol.* 2004; **11**, 17-29.
[24] S Hu and W Saleh. Impacts of congestion charging on shopping trips in Edinburgh. *Transport Pol.* 2005; **12**, 443-50.
[25] JK Button. *Transport Economics*, 2nd ed. Cambridge University Press, United Kingdom, 1993.
[26] M Belhaj and E Fridle. *External Costs in the Transport Sector: A Literature Review*. Available at: http://www.cpm.chalmers.se/document/reports/08/CPM%20trsprt%20lit%20review2 .3%20.pdf, accessed December 2010.
[27] RA Derlin and RQ Grafton. *Economic Right and Environmental Wrongs*. Edward Elgar, Cheltenham, 1998.
[28] S Grant-Muller and J Laird. *Costs of Congestion: Literature Based Review of Methodologies and Analytical Approaches*, Final Report, Scottish Executive Social Research, London, 2006, p. 35-44.
[29] PB Goodwin. *The Economic Cost of Road Traffic Congestion*. Rail Freight Group, Transport Studies Unit, University College London, London, 2004, p. 1-14.
[30] Directorate General of Highways, Directorate of Urban Road Development. *Indonesian Highway Capacity Manual (IHCM) 1997*. Sweroad in Association with PT. Bina Karya (Persero), Jakarta, 1997, p. 1-99.
[31] JICA and National Development Planning Agency (*BAPPENAS*). *The Study on Integrated Transportation Master Plan (SITRAMP) for the Jabodetabek Phase 2*. Final Report. Technical Report. PCI and ALMEC Corporation, Jakarta, Republic of Indonesia, 2004, p. 36-55.
[32] DU Asri and B Hidayat. Current transportation issues in Jakarta and ITS impacts on environment. *In*: Proceeding of the 5th Eastern Asia Society for Transportation Studies. Fukuoka, Japan, 2005, p. 1792-8.
[33] Central Bureau of Statistics of Yogyakarta City. *Gross Regional Domestic Product of Yogyakarta City by Industrial Origin 2011-2015*. Central Bureau of Statistics, Yogyakarta, 2016, p. 1-80.
[34] J Dodgson and B Lane. *The Costs of Road Congestion in Great Britain: A NERA Briefing Paper*, National Economic Research Associates, London, 1997, p. 1-18.
[35] AD Palma and R Lindsey. Modeling and evaluation of congestion pricing in Paris. *Transport Pol.* 2006; **13**, 115-26.
[36] SD Beevers and DC Carslaw. The impact of congestion charging on vehicle speed and its implications for assessing vehicle emissions. *J. Atmos. Environ.* 2005; **39**, 6875-84.
[37] G Sugiyanto. Impact of congestion pricing scheme on the generalized cost and speed of motorcycle (case study in Yogyakarta, Indonesia). *J. Eng. Applied Sci.* 2016; **11**, 1740-6.

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Dear Professor Gito SUGIYANTO:

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We have reached a decision regarding your submission to Walailak Journal of Science and Technology (WJST), "Impact of Congestion Pricing Scheme on the Generalized Cost and Speed of Motorcycle to the City of Yogyakarta, Indonesia". Please revise the manuscript carefully. The manuscript should be resubmitted along with point-by-point explanation according to reviewers'comments. If you disagree with any of the comments, please state your reasons. All corrections are mandatory and must be differentiated with red colour and submit it.

We request that you send a revised manuscript within 60 days, otherwise it may be considered withdrawn.

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Originality of the work
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Use of Tables and Figures
:
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:
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Technical accuracy
:
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Referee's Comments
:
The paper estimates the cost/benefit of introducing a congestion pricing scheme in Yogyakarta, Indonesia.

The paper is adequate and should be accepted, but first a few minor issues should probably be treated:
- Although I said the English language is adequate, improvements should be done. I suggest the authors to have a revision from a mother tongue. Especially, avoid the use of (eg) "weren't". Use "were not" instead.
- The abstract and the introduction start with the same sentences. Please change one of the two.
- Many different currencies are used in the paper, making difficult to make comparisons. Since the main results are in IDR, I would suggest to add for each value the IDR equivalent in brackets.
- Is it TTC or VOT?
- In Figure 2 scales are required.
- In "Impact of congestion pricing" you have "+-4 km/h". I think you meant "circa 4 km/h".
- Table 1: more comments on the reason of reduction in speed in some cases has to be introduced, otherwise the paper opens questions instead of providing answers...
- Have you considered that if you introduce congestion charges, people will change the path consequently for your results? Please clarify (the paper is good anyway).

Reviewer E:

Originality of the work
:
Adequate

Clarity and conciseness
:
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Standard of English
:
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Level of consistency
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Use of Tables and Figures
:
Poor

Adequacy of the discussion
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Dear Authors
Based on your revision completed with point-by-point response to reviewers, I am pleased to inform that your manuscript "Impact of Congestion Pricing Scheme on the Generalized Cost and Speed of Motorcycle to the City of Yogyakarta, Indonesia" is accepted and scheduled to publish in Information Technology issue of Walailak Journal of Science and Technology in March 2018.
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Sincerelly yours,

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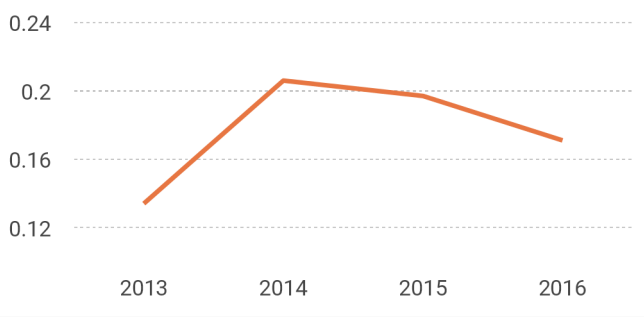

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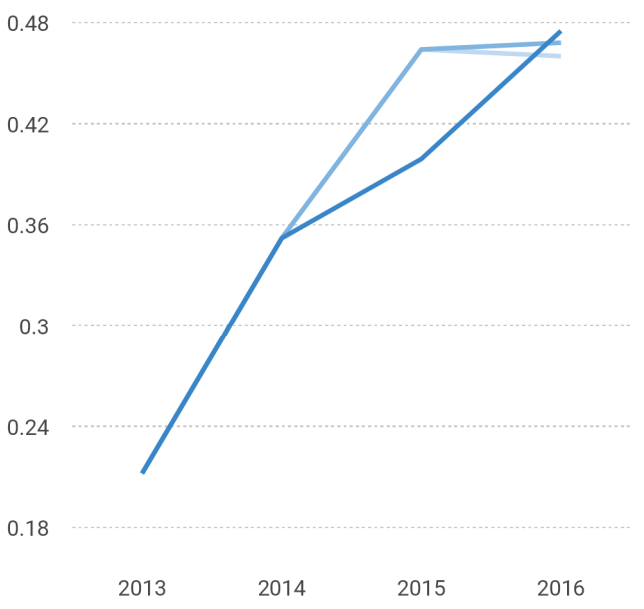

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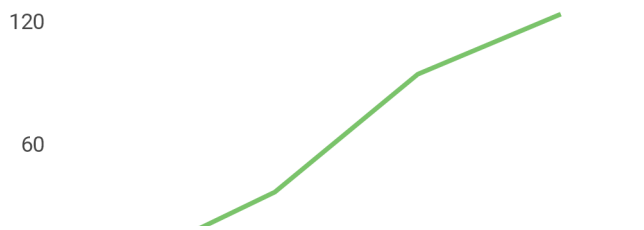

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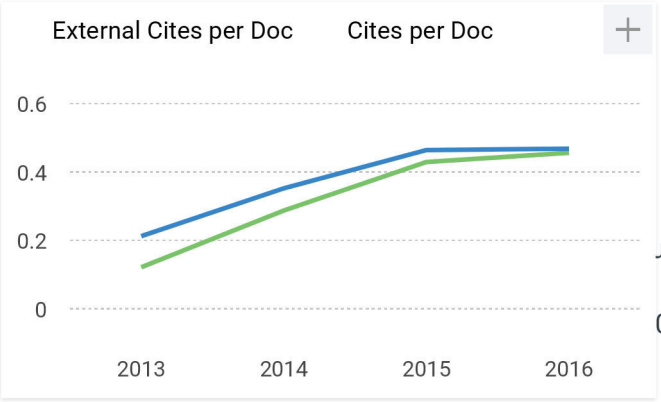

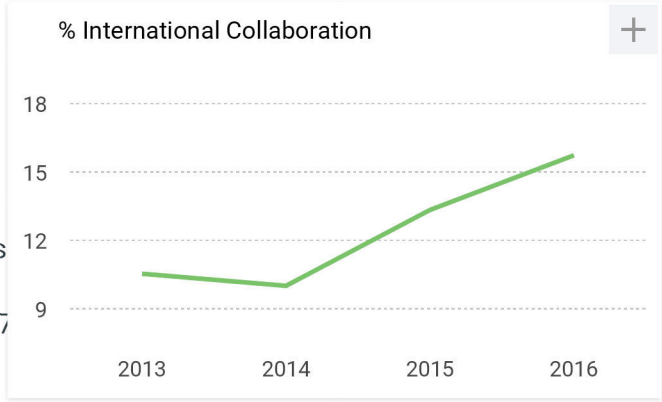

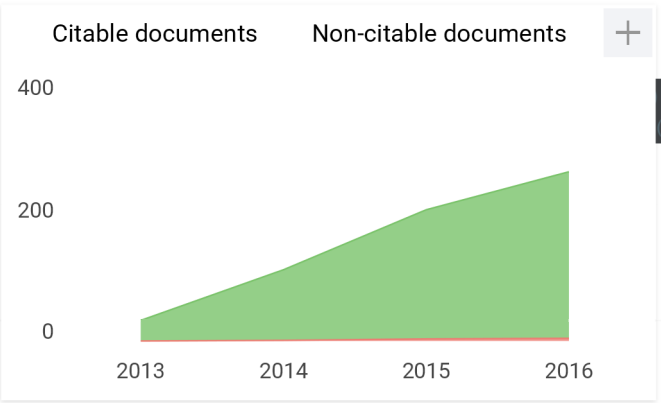

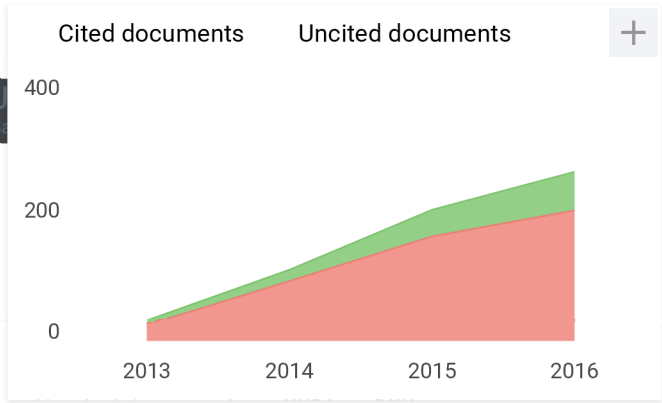

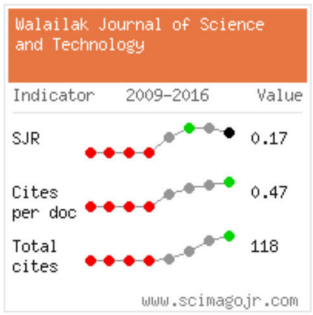

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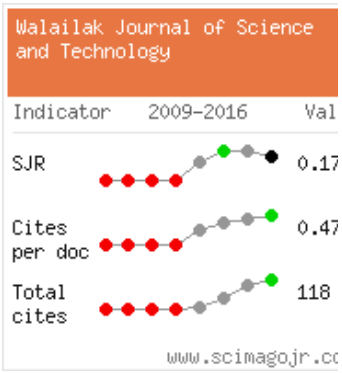

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The Effect of Congestion Pricing Scheme on the Generalized Cost and Speed of a Motorcycle

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Abstract

Traffic congestion is one of the significant transport problems in many cities in developing countries. Increased economic growth and motorization have created more traffic congestion. The application of transportation demand management like congestion pricing can reduce congestion, pollution and increase road safety. The aim of this research is to estimate the congestion pricing of motorcycles and the effect of a congestion pricing scheme on the generalized cost and speed of a motorcycle. The amount of congestion pricing is the difference between actual generalized cost in traffic jams and in free-flow speed conditions. The analysis approach using 3 components of generalized costs of motorcycle: vehicle operating, travel time and externality cost (pollution cost). The approach to analyze the pollution cost is marginal-health cost and fuel consumption in traffic jams and free-flow speed conditions. The value of time based on Gross Regional Domestic Product per capita in Yogyakarta City in October 2012. The simulation to estimate the effect of congestion pricing using *Equilibre* Multimodal, Multimodal Equilibrium-2 (EMME-2) software. The results of this study show that while the free-flow speed of a motorcycle to the city of Yogyakarta is 42.42 km/h, with corresponding generalized cost of IDR1098 per trip, the actual speed in traffic jams is 10.77 km/h producing a generalized cost of IDR2767 per trip, giving a congestion pricing for a motorcycle of IDR1669 per trip. Based on the simulation by using EMME-2, the effect of congestion pricing will increase on vehicle speed by 0.72 to 8.11 %. The highest increase of vehicle speed occurred in Malioboro Street at 2.26 km/h, while the largest decrease occurred in Mayor Suryotomo Street at north-south direction at 1.07 km/h. Another effect of this application for motorcycles users will decrease the generalized cost by 1.09 to 6.63 %.

Keywords: Congestion pricing, motorcycle, marginal-health cost, generalized cost, EMME-2

Introduction

Cities in developing countries need innovative and effective solutions to solve their transportation problems like the traffic congestion, accident and delays. The increase in car ownership, population growth, and urbanization has increased traffic congestion in many cities in developing countries like in Indonesia. Traffic congestion does not only occur in urban areas, but also in rural areas, especially during peak hours. Transport problems become more complex and have more effects on society in areas with high activities, such as in Yogyakarta, Indonesia. This situation happens because of the imbalance between the number of vehicles and the length of the road [1]. Solutions to these problems are possible, not only through improvement of public transport, increased pedestrians and bicycle users, but also in the implementation of measures which promote a rational use of the automobile by means Transportation Demand Management (TDM). TDM aims to maximize the efficiency of the urban transport system by discouraging unnecessary private vehicle use and environmental-friendly modes of transport, in general being public transport and non-motorized transport [2].

The costs incurred by society as a result of the effect of congestion on transportation include vehicle operating, travel time and externality costs [3]. Externality costs are the congestion [4,5], environmental, pollution, and traffic accident costs [6]. The internalization of transportation external costs is one of the most relevant issues for policy makers in recent years. Congestion and air pollution are among the most relevant sources of externalities in urban centers and they are increasingly tackled through the adoption of road pricing schemes [7]. TDM, application of pricing policy in charging zone, congestion pricing, road pricing, and traffic restraint are the alternatives to reduce the transportation cost [1,8]. TDM can provide many benefits, for example congestion reduction, road cost savings, parking savings, transportation cost savings to consumers, improved mobility options, increased road safety, reduced per capita energy consumption, reduced per capita pollutions emissions, efficient land use and increased physical activity and associated health benefits [2].

The congestion costs in France, United Kingdom, United States, and Japan are respectively 2.1, 3.2, 1.3 and 2.0 % of the respective Gross National Product (GNP) of the countries [9,10]. The congestion cost for 85 cities in the United States was US$63.3 billion in 2002, for a value of time of US$13.45/hour [11]. The economic loss caused by the traffic congestion in the Jabodetabek region could be as much as US$68 million per year due to traffic congestion and this estimate excludes the impacts of traffic congestion and pollution on human health [12]. Marginal congestion costs for different types of roads in England, for the last update were around 45 pence per passenger car unit (pcu)-km for urban roads at peak time [13]. The congestion cost in CBD Malioboro, Indonesia for private passenger car users are estimated to be IDR2701 (US$0.257) per trip [1] and for motorcycle users IDR522.77 (US$0.05) per trip [14].

The effect of congestion pricing has been long studied in the transport policy area. In the cases of 4 European cities Paris, Brussels, Oslo and Helsinki can get a sizable amount of benefit from commuting time reduction, cost saving in vehicle management, or enhanced quality of public transportation when road pricing was introduced in each country [15]. Implementation of congestion charging for private vehicle users in urban centers in London increased the use of urban bus transport by 18 %, taxi users by 17 % and decreased the use of private cars by 33 % [16]. Application of road pricing in other countries has had a positive impact on reducing the use of private vehicle users and increased the use of public transport. In Belgium, the use of public transport increased by 10 %. If there is application of road pricing with improved public transportation service quality, the use of public transport will increase by 23 % [17]. Based on the simulation, application of a congestion charge of IDR4000 per trip for motorcycle users as through traffic in CBD Malioboro, Yogyakarta will shift 6.848 % motorcycle users to bus TransJogja [18]. Among 15 - 20 %, reductions in generalized cost are surprisingly small for charge levels, which have achieved 15 % reduction in overall trips [19]. Singapore's road pricing system reduced 20 to 30 % of the downtown passenger car traffic and Stockholm's traffic volume decreased by at least 20 % [20]. Commuters switch to public bus services by 12 to 20 % in the morning hours after a S$1 increase and by approximately 10 % in the evening after toll adjustment of S$0.50 to S$1.00 in the affected gantry area compared to the counterfactual through difference-in-difference method [21]. The effect of congestion cost in Stockholm, Sweden, a new Western bypass is estimated to reduce traffic across inner city bridges by 11 % [22]. In New Zealand it was found that the 21 % of survey respondents were willing to choose to walk and to use public transportation, while 67 % insisted that they would still drive cars were congestion pricing to be introduced [23]. Almost 37 % of car users in Edinburgh were willing to spend less or change the shopping destination if they had been asked to pay a congestion tax for their shopping trip to the CBD [24].

The aim of this paper is to estimate the congestion cost of motorcycle users and the effect of the congestion pricing scheme on the generalized cost and speed of motorcycle to the city of Yogyakarta, Indonesia.

Materials and methods

Analysis approach

Generalized cost of travel can be calculated based on a combination of cost paid by the user, travel time cost, vehicle-operating cost and externality cost. Externalities arise when the activity of a group affects the welfare of the other groups without any compensation [25,26]. Externalities in transport include: congestion, accidents, emissions, pollution and noise [2,27]. In this study, the externality cost that was considered was the pollution cost. The approach that is used to analyze the pollution cost is marginal-health cost per vehicle and fuel consumption of vehicle in actual conditions and free-flow speed conditions. The generalized cost by mode *m* from the origin, zone *i* to the destination, zone *j* was determined using Eq. (1).

$$GC_{ij}^{m} = VOT\ (time_{ij}^{m}) + VOC\ (dist._{ij}^{m}) + EC\ (dist._{ij}^{m}) \quad (1)$$

In which GC_{ij}^{m} is the generalized cost per Passenger Car Units (PCU) by mode *m* to go from the origin, zone *i* (O_i) to the destination, zone *j* (D_j), VOT is the value of time per-PCU-min, $time_{ij}^{m}$ is the time taken to complete the trip in minutes, VOC_{ij}^{m} the total vehicle operating cost per PCU-km, and $dist._{ij}^{m}$ is the distance travelled to go from zone *i* to zone *j*, in km, EC is the externality cost per kilometer while *i* is the origin zone and *j* the destination zone.

Data collection

In this paper, the speed of motorcycles was counted in 2 conditions, the first in free-flow speed conditions and the second in actual conditions that potentially cause traffic jams. Traffic is congested if there are so many vehicles that each one travels slower than it would do if the other vehicles were not there and traffic is congested if there are so many vehicles that they are brought to a standstill or can only crawl along [28]. Related with speed is traffic flow congestion which is defined as the impedance vehicles imposed on each other, due to the speed-flow relationship, in conditions where the use of a transport system approaches its capacity [29]. Motorcycle speed data was based on travel time of vehicles and a speed survey using speed gun.

The travel time in free-flow conditions for motorcycles in CBD Malioboro, Yogyakarta is obtained based on the formula in the Indonesian Highway Capacity Manual (IHCM) 1997 [30]. The actual travel time cost conditions were obtained from a Moving Car Observer (MCO) survey in the Central Business District (CBD) Malioboro, Yogyakarta. The CBD Malioboro consists of a 2 lane one-way direction undivided road (2/1 UD) 1.414 kilometers long from Malioboro Street to Ahmad Yani Street. The width of Malioboro Street is 7.00 m. The value of time data for motorcycle users is based on Gross Regional Domestic Product (GRDP) per capita in Yogyakarta city. The fuel consumption was obtained from the relationship between speed and dependent fuel consumption rates of motorcycles reported in the Study on Integrated Transportation Master Plan (SITRAMP) for the Jakarta-Bogor-Depok-Tangerang-Bekasi or Jabodetabek in 2004 [31]. The street where data was collected in the study area in CBD Malioboro, Indonesia is shown in **Figures 1** and **2**.

Figure 1 Study area in CBD Malioboro, Indonesia [1,14,18].

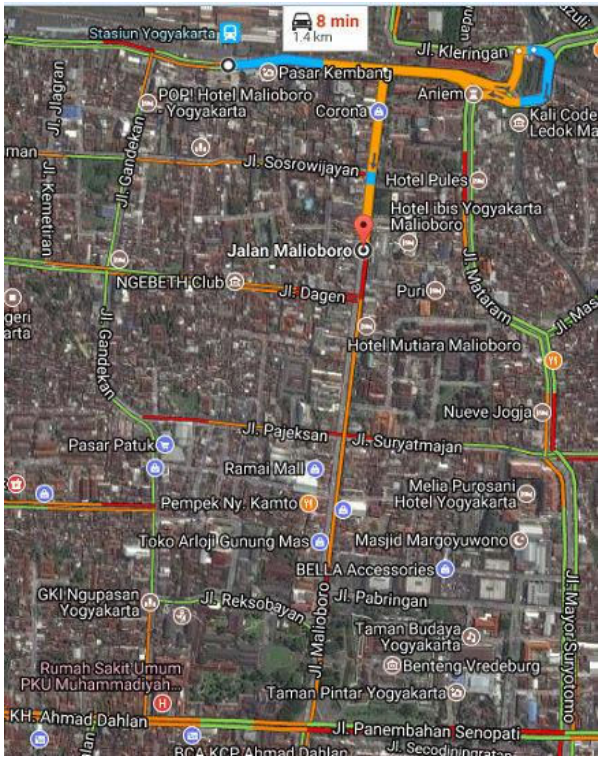

Figure 2 Street in the study area in CBD Malioboro.

Results and discussion

The generalized cost of a motorcycle from origin to destination consists of 3 components of cost: the first is the vehicle operating cost, the second is the travel time cost and the third is the pollution cost.

Vehicle operating cost

In this paper, the vehicle operating cost (VOC) of motorcycles was counted in 2 conditions, based on travel cost in free-flow conditions and travel cost in actual conditions that potentially involved traffic jams. There are 5 components of vehicle operating costs of motorcycles: (a) consumption of fuel, (b) lubricating oil consumption, (c) tire consumption, (d) maintenance cost (spare parts and repair), and (e) fixed cost. The fuel consumption was obtained from the relationship between speed and fuel consumption rates of motorcycles reported in the Study on Integrated Transportation Master Plan (SITRAMP) for the Jakarta-Bogor-Depok-Tangerang-Bekasi or Jabodetabek in 2004 [31]. Fuel economy improvement can be implemented by raising traveling speed and replacing average vehicles with fuel saving ones like hybrid cars. For instance, traveling speed was reported to have a significant effect on fuel consumption and the lowest fuel consumption rates occur in a speed range of 40 km/h to 55 km/h [31,32].

Vehicle operating cost and speed relationship

Speed is the main factor to estimate the vehicle operating cost of motorcycles. The relationship between vehicle operating cost and speed of motorcycles for CBD Malioboro, Yogyakarta is presented in [14]. The optimum speed for motorcycles in CBD Malioboro along the 1.414 km is 47.20 km/h with vehicle operating cost of IDR350.77 per km (IDR496 in CBD Malioboro). The vehicle-operating cost model for motorcycles was determined using Eq. (2).

$$y = 0.0921V^2 - 8.6847V + 555.51 \text{ with } r^2 = 0.9686 \quad (2)$$

in which V is the speed of the motorcycle (km per hour) and y is vehicle operating cost of motorcycles (IDR per km).

Based on the survey and the analysis of Indonesian Highway Capacity Manual (IHCM) 1997 the speed of motorcycles in free-flow conditions is 42.42 km/h so the vehicle operating cost is IDR352.84/km (using Eq. (2)). Based on the Moving Car Observer (MCO) survey, the average speed of motorcycles under actual conditions is 10.77 km/h, so the vehicle-operating cost is IDR472.66/km (using Eq. (2)). The vehicle operating cost of motorcycles at CBD Malioboro, Yogyakarta in free-flow speed and actual conditions was calculated by multiplying by 1.414 km, the length of CBD Malioboro, the vehicle operating cost in free-flow speed condition is IDR499 per trip and the actual conditions were IDR669 per trip.

Travel time cost

Gross Regional Domestic Product (GRDP) per capita in Yogyakarta city in October 2012 is IDR51,649,500 [33]. The approach in this research was 25 workdays every month, 8 hours/day, a motorcycle occupancy of 1.5 peoples per motorcycle and percentage of workers 45 %. The value of time of motorcycle users in Yogyakarta city based on Gross Regional Domestic Product (GRDP) is IDR14,526.42 per hour. Based on the survey and analysis of the speed of motorcycles in CBD Malioboro, the travel time in free-flow conditions is 2 min. Based on the moving car observer (MCO) survey, the average of travel time in actual conditions is 7 min 52.5 s. The travel time cost of motorcycles in CBD Malioboro, Yogyakarta was calculated by multiplying the travel time with the value of time based on GRDP is IDR14,526.42 per hour. The travel time cost (TTC) in free-flow conditions is IDR485 per trip while the actual cost is IDR1,907 per trip.

Externality Cost: Pollution Cost

The marginal health-cost (MHC) approach is used to calculate the pollution cost per motorcycle. This approach was the result of a World Bank study in Jakarta in 1990. MHC is value expressed in US cents per litre and cents/pass-kilometer [14]. In this study, we used MHC in cents per litre, then converted

into IDR per litre using an exchange rate of 1 US$ = IDR10,500. The pollution cost for motorcycles was determined using Eq. (3).

Pollution cost (PC) = Marginal Health-cost (MHC) × Consumption of fuel (CF) (3)

In which PC is pollution cost (IDR/km), MHC is marginal health-cost of motorcycle (IDR/litre) and CF is the fuel consumption (litre/km).

The relationship between fuel consumption and the speed of the motorcycle is based on the result of the SITRAMP study by [31] and measurements in the field is formulated in the quadratic function of Eq. (4).

$y = -0.008V^2 + 0.7991V + 9.6933$ with $r^2 = 0.8299$ (4)

In which y is fuel consumption (km/litre) and V is speed of motorcycle (km/h). The coefficient determination (r^2) value 0.8299, indicated that there was a strong correlation between motorcycle speed and fuel consumption. Fuel consumption using Eq. (4), was 17.37 km/litre in actual conditions with a speed 10.77 km/h and 29.20 km/litre in free-flow conditions with a speed 42.42 km/h. Speed and fuel consumption are the main factors in determining pollution cost. The pollution cost of motorcycle in free-flow conditions was IDR 80 and IDR135 in actual conditions. The pollution cost of motorcycles in Malioboro along 1.414 km in actual conditions at 10.77 km/h is IDR 191 and in free-flow conditions at 42.42 km/h is IDR 114.

Generalized cost

The generalized cost of motorcycles consists of vehicle operating cost, travel time cost and externality cost. From the results above, the generalized cost of motorcycles in actual conditions is IDR2767/trip and generalized cost in free-flow conditions is IDR1098/trip. The generalized cost of motorcycles in actual conditions is more expensive (152 %) than in free-flow conditions. The value of travel time cost in actual conditions is 69 % of the generalized cost but in free-flow conditions is only 44 %. The generalized cost of the motorcycle in CBD Malioboro is shown in **Table 1**.

Table 1 Generalized cost of motorcycle in CBD Malioboro.

Type of condition	VOC (IDR/trip)	Pollution cost (IDR/trip)	TTC (IDR/trip)	Generalized cost (IDR/trip)
Free-flow speed	499	114	485	1,098
Actual cost	669	191	1,907	2,767

Congestion cost

The approach to estimate congestion cost in this study is similar to the approach of Dodgson and Lane [34] in their study on the costs of road congestion in Great Britain. Congestion costs as the difference between the level of costs in actual and the level of costs in free-flow conditions [34]. The amount of congestion cost of motorcycles is the difference between the generalized cost in actual conditions at 10.77 km/h and a travel time of 7 min 52.5 s, and the generalized cost in free-flow conditions at 42.42 km/h and a travel time of 2 min. From above, the generalized cost of motorcycles in actual conditions is IDR2,767 per trip, and the generalized cost in free-flow conditions is IDR1,098 per trip, thus the congestion cost of motorcycles in CBD Malioboro, Yogyakarta is IDR1,669 per trip.

Effect of congestion pricing

The simulation to estimate the effect of congestion pricing in CBD Malioboro using *Equilibre* Multimodal, Multimodal Equilibrium-2 (EMME-2) software. Distribution of traffic zones, nodes and links in EMME-2 to simulate the application of congestion pricing in CBD Malioboro can be seen in **Figure 3**. The result of the simulation of congestion cost for motorcycle users in CBD Malioboro includes Malioboro Street (along 809 m) and Ahmad Yani Street (along 605 m) using EMME-2 software as presented on auto speed can be seen in **Figure 4**.

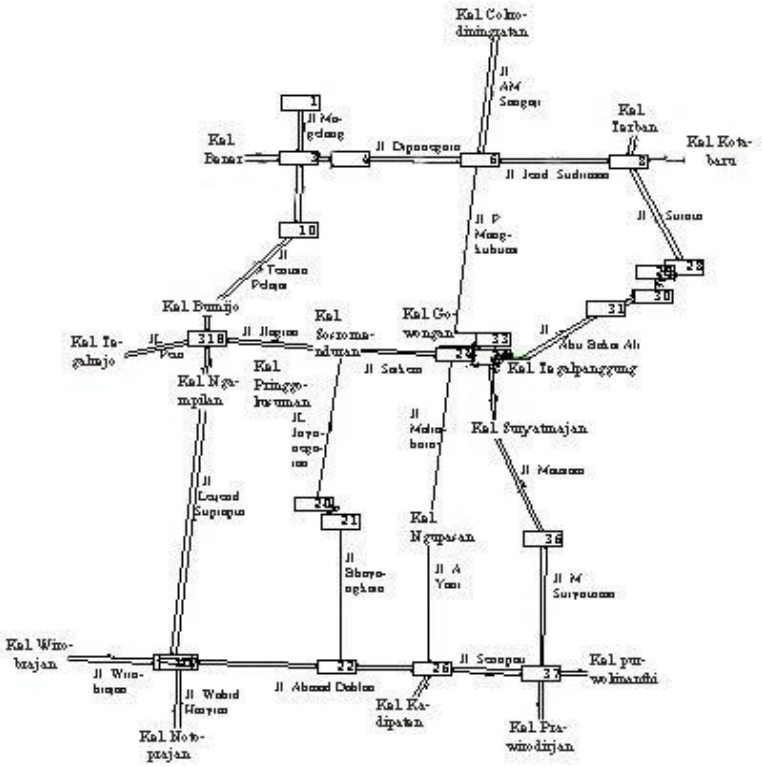

Figure 3 Distribution of traffic zones, nodes and links in EMME-2 software.

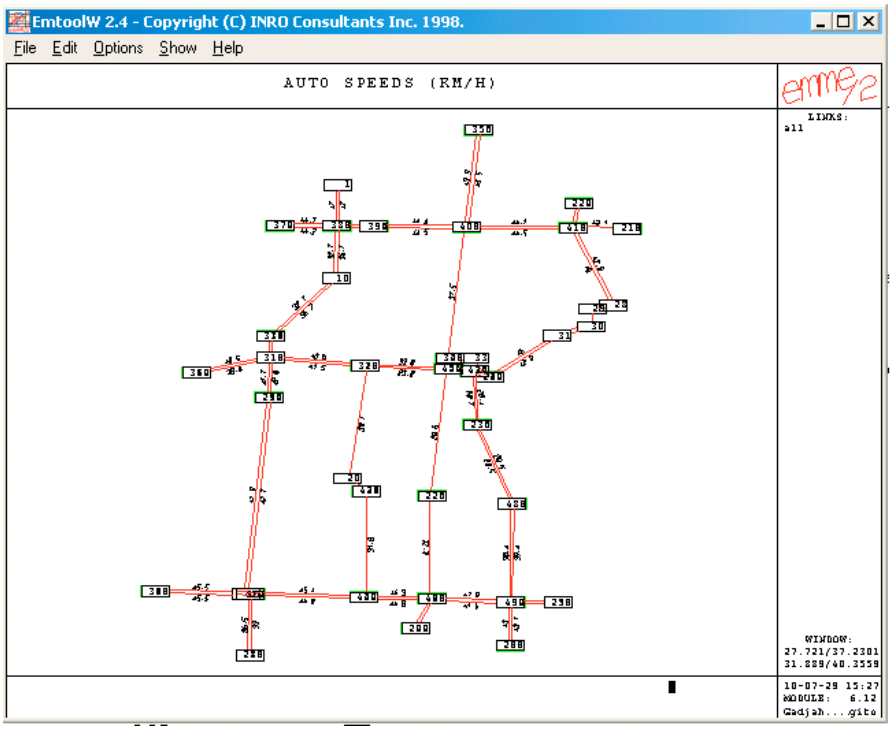

Figure 4 Auto speeds from simulation results using EMME-2 in CBD Malioboro, Yogyakarta.

Implementation of congestion pricing for motorcycles users at Malioboro Street and Ahmad Yani Street in Yogyakarta resulted in a change in vehicle speed of 0.72 to 8.11 % (**Table 2**). The speed in some roads increased like at Pangeran Diponegoro Street (W-E), Pangeran Mangkubumi Street, Malioboro Street, Ahmad Yani Street, Mataram Street (S-N) and Mayor Suryotomo Street (S-N), while in Jenderal Sudirman Street, Pangeran Diponegoro Street (E-W), Ahmad Dahlan Street, Pangeran Senopati Street and Mayor Suryotomo Street (N-S) the speed decreased. The highest increase of vehicle speed occurred in Malioboro Street at 2.26 km/h (8.11 %) while the largest decrease occurred in Mayor Suryotomo Street in the north-south direction at 1.07 km/h (2.64 %) and in Bhayangkara Street at 0.88 km/h (2.78 %). These results are similar with the research of [35] which examined the implementation of Electronic Road Pricing (ERP) in Paris, ERP increased the vehicle speed from 44.80 to 45.40 km/h. Based on the results of the simulation of application of congestion pricing for motorcycles users in Malioboro, there was an improvement in the road network performance. Application of congestion pricing increased the vehicle speed and decreased the generalized cost. These results are similar to the study of [36] that examined the application of congestion charging in central London that can increase the average speed of vehicle by ±4 km/h. Within the Charging Zone (CZ), the Wilcoxon test has shown that the difference in speed between pre and post London□s Congestion Charging Scheme (CCS) periods has increased on average of 2.1 km/h and that these changes are significant at the p = 0.05 level [36]. This result is in line with the findings of Percoco [7], the road pricing scheme in Milan has had limited impact in terms of congestion and environmental quality because of the behavioral response of road users. In fact, we have found that the policy did not produce a reduction in the number of vehicles entering the city center, while it did lead to an increase in the number of motorbikes and, in part, LPG, bi-fuel and hybrid cars [7]. The effect of congestion pricing of motorcycles users on vehicle speed in 16 links can be seen in **Table 2**.

Table 2 Effect of congestion pricing of motorcycles users on vehicle speed.

No.	Node Origin-Destination	Name of link and direction of movement	Vehicle speed (km/h)		Difference in vehicle speed (km/h)	Difference in vehicle speed (%)
			Without pricing	With pricing		
(1)	(2)	(3)	(4)	(5)	(6) = (5) - (4)	(7) = (6)/(4)
1.	3 - 4	Pangeran Diponegoro Street (W-E)	44.85	45.29	0.44	0.98 %
2.	4 - 3	Pangeran Diponegoro Street (E-W)	44.89	44.43	-0.46	-1.02 %
3.	6 - 8	Jenderal Soedirman Street (W-E)	45.24	44.51	-0.73	-1.61 %
4.	8 - 6	Jenderal Soedirman Street (E-W)	45.09	44.13	-0.96	-2.13 %
5.	6 - 23	Pangeran Mangkubumi Street	36.16	37.53	1.37	3.79 %
6.	24 - 25	Malioboro Street	27.85	30.11	2.26	8.11 %
7.	25 - 26	Ahmad Yani Street	31.09	32.34	1.25	4.02 %
8.	26 - 22	Ahmad Dahlan Street (E-W)	45.16	44.30	-0.86	-1.90 %
9.	22 - 26	Ahmad Dahlan Street (W-E)	45.53	44.95	-0.58	-1.27 %
10.	22 - 21	Bhayangkara Street	31.63	30.75	-0.88	-2.78 %
11.	26 - 37	Pangeran Senopati Street (W-E)	42.27	41.37	-0.90	-2.13 %
12.	37 - 26	Pangeran Senopati Street (E-W)	42.38	41.63	-0.75	-1.77 %
13.	36 - 35	Mataram Street (S-N)	30.19	30.48	0.29	0.96 %
14.	35 - 36	Mataram Street (N-S)	30.23	29.47	-0.76	-2.51 %
15.	36 - 37	Mayor Suryotomo Street (N-S)	40.48	39.41	-1.07	-2.64 %
16.	37 - 36	Mayor Suryotomo Street (S-N)	40.39	40.68	0.29	0.72 %

Note: W is west, E is east, S is south, and N is north.

The vehicle speed on Malioboro Street in existing conditions without pricing is 27.85 km/h. In these conditions, the vehicle operating cost of motorcycles is IDR311.53 per trip, travel time cost is IDR421.97 per trip, pollution cost is IDR73.42 per trip and therefore the generalized cost without congestion pricing is IDR806.92 per trip. Based on the simulation by using EMME-2, vehicle speed on Malioboro Street with congestion pricing is 30.11 km/h. Under these conditions, the vehicle operating cost of motorcycles is IDR305.41 per trip, travel time cost is IDR390.30 per trip, pollution cost is IDR71.32 per trip and therefore the generalized cost with pricing is IDR753.40 per trip. The generalized cost in Malioboro Street will decrease to IDR53.51 per trip (6.63 %). Vehicle speed on Ahmad Yani Street under existing conditions without pricing is 31.09 km/h. Under these conditions, the vehicle operating cost of a motorcycle is IDR226.59 per trip, travel time cost is IDR282.68 per trip, pollution cost is IDR52.73 per trip and therefore the generalized cost without pricing is IDR562 per trip. Based on the results of the simulation, vehicle speed on Ahmad Yani Street with congestion pricing would be 32.34 km/h. Under these conditions, the vehicle operating cost of a motorcycle is IDR224.44 per trip, travel time cost is IDR271.76 per trip, pollution cost is IDR52.03 per trip and therefore the generalized cost with pricing is IDR527.66 per trip. The generalized cost in Ahmad Yani Street will decrease to IDR34.33 per trip (6.11 %). The effect of congestion pricing of motorcycles users on generalized cost in 16 links can be seen in **Table 3**.

Table 3 Effect of congestion pricing of motorcycles users on generalized cost.

No.	Name of link and direction movement	Length of link (km)	Generalized cost (IDR/trip)		Δ Generalized cost (IDR/trip)	Δ Generalized cost (IDR/trip)
			Without pricing	With pricing		
(1)	(2)	(3)	(4)	(5)	(6) = (5) - (4)	(7) = (6)/(4)
1.	Malioboro Street (N-S)	0.809	806.92	753.40	-53.51	-6.63 %
2.	Ahmad Yani Street (N-S)	0.605	562.00	527.66	-34.33	-6.11 %
3.	Jenderal Soedirman Street (W-E)	1.274	957.39	992.42	35.03	3.66 %
4.	Jenderal Soedirman Street (E-W)	1.274	958.86	996.40	37.54	3.92 %
5.	Pangeran Mangkubumi Street	0.814	689.20	662.01	-27.18	-3.94 %
6.	Pangeran Diponegoro Street (W-E)	0.686	517.59	498.18	-19.41	-3.75 %
7.	Pangeran Diponegoro Street (E-W)	0.686	517.38	502.78	-14.60	-2.82 %
8.	Ahmad Dahlan Street (E-W)	1.022	768.64	777.40	8.76	1.14 %
9.	Ahmad Dahlan Street (W-E)	1.022	765.77	772.09	6.32	0.83 %
10.	Bhayangkara Street	0.574	527.42	515.55	-11.87	-2.25 %
11.	Pangeran Senopati Street (W-E)	0.715	555.34	545.16	-10.17	-1.83 %
12.	Pangeran Senopati Street (E-W)	0.715	554.60	543.35	-11.25	-2.03 %
13.	Mataram Street (S-N)	0.564	533.83	508.98	-24.84	-4.65 %
14.	Mataram Street (N-S)	0.564	533.37	520.34	-13.03	-2.44 %
15.	Mayor Suryotomo Street (N-S)	0.750	595.86	589.36	-6.50	-1.09 %
16.	Mayor Suryotomo Street (S-N)	0.750	596.57	579.16	-17.40	-2.92 %

Note: W is west, E is east, S is south, and N is north.

These results are in line with the findings of May and Milne [19] and Sugiyanto [37] that congestion pricing will yield reductions in generalized cost. The generalized cost in Malioboro Street, Ahmad Yani Street, Pangeran Mangkubuni Street, Pangeran Diponegoro Street, Bhayangkara Street, Pangeran Senopati Street, Mataram Street and Mayor Suryotomo Street will decrease, while the generalized cost in Jenderal Soedirman Street and Ahmad Dahlan Street will increase. The highest increase in generalized cost occurred in Malioboro Street at IDR53.51 per trip (6.63 %) while the largest decrease occurs in Jenderal Soedirman Street in the east-west direction at IDR37.54 per trip (3.92 %). Under these conditions, there is a change of route from the commuter to the city of Yogyakarta.

Conclusions

The estimation of congestion cost for motorcycles users in CBD Malioboro, Yogyakarta and the effect of a congestion pricing scheme on the generalized cost and speed of motorcycles to the city of Yogyakarta is presented in this paper. From the analysis and results, it can be concluded that:

1. The generalized cost at CBD Malioboro, Yogyakarta for motorcycles in free-flow conditions is IDR1,098 per trip and in actual conditions is IDR2,767 per trip, giving a congestion pricing for motorcycles to the city of Yogyakarta of IDR1,669 per trip.
2. Based on the simulation by using EMME-2, the effect of the application of congestion pricing will increase vehicle speed by 0.72 to 8.11 %. The highest increase of vehicle speed occurred in Malioboro Street at 2.26 km/h (8.11 %) while the largest decrease occurred in Mayor Suryotomo Street at north-south direction at 1.07 km/h (2.64 %) and in Bhayangkara Street at 0.88 km/h (2.78 %).
3. The effect of the congestion pricing scheme on the generalized cost for motorcycles will decrease to IDR53.51 per trip (6.63 %) in Malioboro Street and IDR34.33 per trip (6.11 %) in Ahmad Yani Street.

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References

[1] G Sugiyanto, S Malkhamah, A Munawar and H Sutomo. Estimation of congestion cost of motorcycles users in Malioboro, Yogyakarta. *Civil Eng. Dimension* 2010; **12**, 92-7.
[2] A Broaddus, T Litman and G Menon. *Transportation Demand Management, Training Document, gtz Transport Policy Advisory Services*. Eschborn, Germany, 2009, p. 1-111.
[3] JD Ortuzar and LG Willumsen. *Modeling Transport*. John Wiley and Sons, England, 2001, p. 1-75.
[4] PC Stubs, WJ Tyson and MQ Dalvi. *Transport Economics*. George Allen and Unwin, London, 1980.
[5] ET Verhoef. Second-best congestion pricing in general networks, Heuristic algorithms for finding second-best optimal toll levels and toll points. *Transport. Res. Part B* 2002; **36**, 707-29.
[6] JF Tsai, CP Chu and SR Hu. Road pricing for congestion and accident externalities for mixed traffic of motorcycles and automobiles. *Transport. Res. Part A* 2015; **71**, 153-66.
[7] M Percoco. The effect of road pricing on traffic composition: Evidence from a natural experiment in Milan, Italy. *Transport Pol.* 2014; **31**, 55-60.
[8] G Sugiyanto. The effect of application of congestion cost for private passenger cars users as a through traffic in Yogyakarta, Indonesia. *ASEAN Eng. J.* 2011; **1**, 84-96.
[9] G Bouladon. La Mobilite en Zone Urbaine: Apprendre l□économie de transport, document diffusion restreinte, direction de l□environnement. *In*: Proceeding of the European Conference of Ministers of Transport. Paris, 1991, p. 10-7.
[10] E Quinet. The social costs of transport: Evaluation and links with internalization policies, In internalizing the social costs of transport. *In*: Proceeding of the European Conference of Ministers of Transport. Paris, 1994, p. 31-75.
[11] JD Harford. Congestion, pollution and benefit to cost ratios of US public transit system. *Transport. Res. Part D* 2006; **11**, 45-58.
[12] S Dikun. Transportation in new global era: Linking Asia through better transportation. *In*: Proceeding of the 4th Eastern Asia Society for Transportation Studies. Fukuoka, Japan, 2003.
[13] DM Newbery. *Fair Payment from Road-Users: A Review of the Evidence on Social and Environment Costs*. The Automobile Association, Basingstoke, 1998.
[14] G Sugiyanto, S Malkhamah, A Munawar and H Sutomo. Estimation of congestion cost of motorcycles users in Malioboro, Yogyakarta. *Int. J. Civil Environ. Eng.* 2011; **11**, 56-63.
[15] A de Palma, R Lindsey and E Niskanen. Policy insights from the urban road pricing case studies. *Transport Pol*. 2006; **13**, 149-61.
[16] G Santos and J Bhakar. The impact of London congestion charging scheme on the generalized cost of car commuters to the city of London from a value of time savings perspective. *Transport Pol*. 2006; **13**, 22-33.
[17] H Armelius and L Hultkrantz. The Politico-economic link between public transport and congestion cost: an ex-ante study of the Stockholm trial-cost road. *Transport Pol*. 2006; **13**, 162-72.
[18] G Sugiyanto, S Malkhamah, A Munawar and H Sutomo. Modeling the effect of congestion pricing on mode choice in Yogyakarta, Indonesia. *Int. J. Eng. Tech.* 2011; **11**, 109-16.
[19] AD May and DS Milne. Effects of alternative road pricing systems on network performance. *Transport. Res. Part A* 2000; **34**, 407-36.
[20] G Menon and S Guttikunda. Electronic road pricing: Experience & lessons from Singapore. *SIM Air Work. Pap. Series* 2010; **33**, 1-15.
[21] S Agarwal and KM Koo. Impact of electronic road pricing (ERP) changes on transport modal choice. *Reg. Sci. Urban Econ.* 2016; **60**, 1-11.

[22] J Eliasson, L Hultkrantz, L Nerhagen and LS Rosqvist. The Stockholm congestion-charging trial 2006: Overview of effects. *Transport. Res. Part A* 2009; **43**, 240-50.
[23] C O'Fallon, C Sullivan and D Hensher. Constraints affecting mode choices by morning car commuters. *Transport Pol.* 2004; **11**, 17-29.
[24] S Hu and W Saleh. Impacts of congestion charging on shopping trips in Edinburgh. *Transport Pol.* 2005; **12**, 443-50.
[25] JK Button. *Transport Economics*. 2nd ed. Cambridge University Press, United Kingdom, 1993.
[26] M Belhaj and E Fridle. *External Costs in the Transport Sector: A Literature Review*. Available at: http://www.cpm.chalmers.se/document/reports/08/CPM%20trsprt%20lit%20review2 .3%20.pdf, accessed December 2010.
[27] RA Derlin and RQ Grafton. *Economic Right and Environmental Wrongs*. Edward Elgar, Cheltenham, 1998.
[28] S Grant-Muller and J Laird. *Costs of Congestion: Literature Based Review of Methodologies and Analytical Approaches*. Final Report, Scottish Executive Social Research, London, 2006, p. 35-44.
[29] PB Goodwin. *The Economic Cost of Road Traffic Congestion*. Rail Freight Group, Transport Studies Unit, University College London, London, 2004, p. 1-14.
[30] Directorate General of Highways, Directorate of Urban Road Development. *Indonesian Highway Capacity Manual (IHCM) 1997*. Sweroad in Association with PT. Bina Karya (Persero), Jakarta, 1997, p. 1-99.
[31] JICA and National Development Planning Agency (*BAPPENAS*). *The Study on Integrated Transportation Master Plan (SITRAMP) for the Jabodetabek Phase 2.* Final Report, Technical Report. PCI and ALMEC Corporation, Jakarta, Republic of Indonesia, 2004, p. 36-55.
[32] DU Asri and B Hidayat. Current transportation issues in Jakarta and ITS impacts on environment. *In*: Proceeding of the 5th Eastern Asia Society for Transportation Studies. Fukuoka, Japan, 2005, p. 1792-8.
[33] Central Bureau of Statistics of Yogyakarta City. *Gross Regional Domestic Product of Yogyakarta City by Industrial Origin 2011-2015*. Central Bureau of Statistics, Yogyakarta, 2016, p. 1-80.
[34] J Dodgson and B Lane. *The Costs of Road Congestion in Great Britain: A NERA Briefing Paper*. National Economic Research Associates, London, 1997, p. 1-18.
[35] AD Palma and R Lindsey. Modeling and evaluation of congestion pricing in Paris. *Transport Pol.* 2006; **13**, 115-26.
[36] SD Beevers and DC Carslaw. The impact of congestion charging on vehicle speed and its implications for assessing vehicle emissions. *J. Atmos. Environ.* 2005; **39**, 6875-84.
[37] G Sugiyanto. Impact of congestion pricing scheme on the generalized cost and speed of motorcycle (case study in Yogyakarta, Indonesia). *J. Eng. Appl. Sci.* 2016; **11**, 1740-6.

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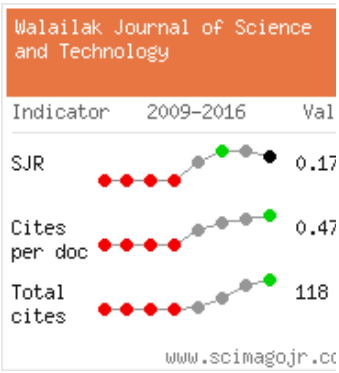

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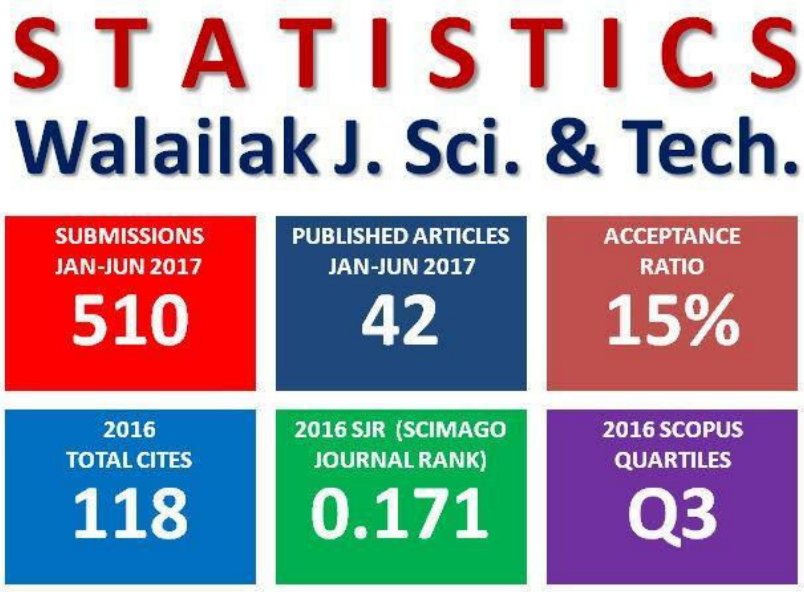

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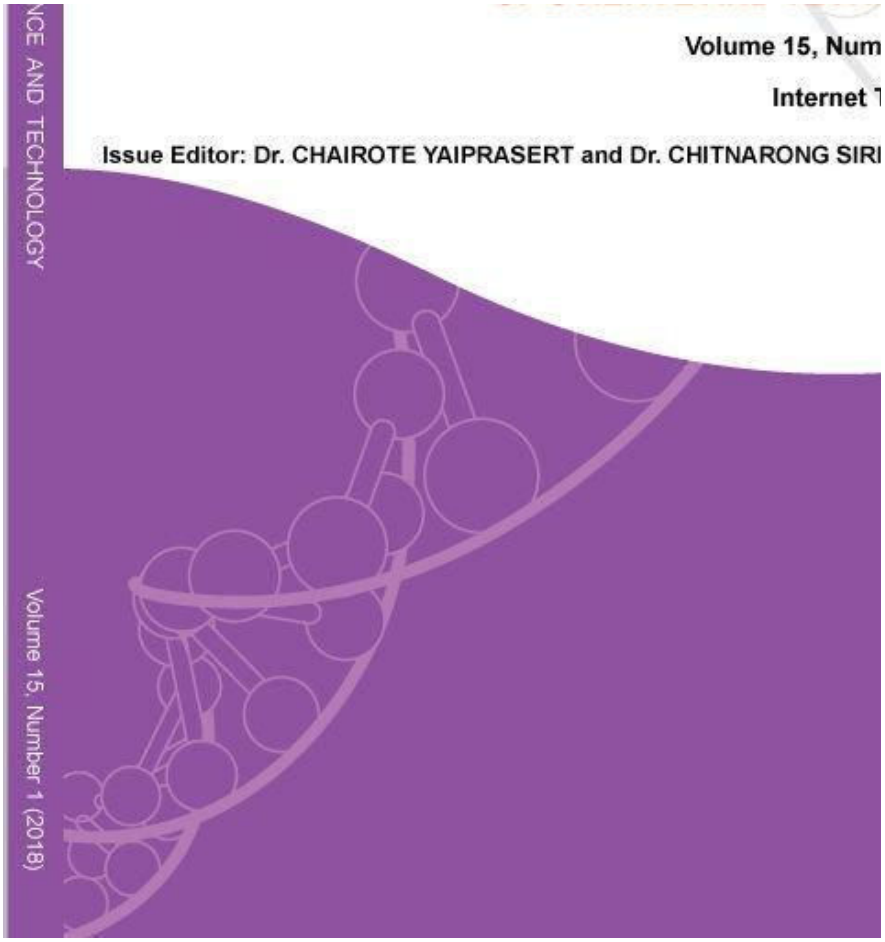

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