Exploring Driver’s Response to Variable Road Pricing (VRP) Scheme: An Insight into Policy Implementation in Indonesia

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Abstract

In the last few decades, road pricing scheme have been known to hold a central role in actualizing sustainable and integrated transport systems. Road pricing has been implemented in various forms and price structures in many cities in the world. Although the road pricing and price structures were generally designed based on the rational actor approach, some studies provided evidences that, in reality, drivers have bounded rationality. It can be argued that limited cognitive ability of drivers gave significant effect towards their decision. In developing countries like Indonesia, road pricing seems to be an alternative solution for traffic congestion problems. This research aims to explore the cognitive responses of drivers, particularly on their ways of making decision and learning, to complexity and variability of road pricing, and also to give valuable contribution to the government on making policy towards traffic issues. The initial results indicate that policy makers in Indonesia need to consider how drivers behave in response to road pricing scheme before implementing any road pricing policy. Moreover, multiple factors from the point of view of drivers (travel time, safety, comfort, etc.) should be taken into consideration as integral parts of the road pricing scheme design.

Keywords: driver behaviour, experiment, road pricing, road pricing policy

Introduction

Transportation system has become a central part which holds and linked all different parts in a modern society’s life. Furthermore, in an industrialised economic realm, transportation system can be considered as the source of life for the world (Somuyiwa, Fadare and Ayantoyinbo 2015). With the continuous increase of vehicle quantity, followed by the limited remaining space to build new road or motorways, many countries all over the world face the same problem related to its transportation system, traffic congestion. According to Daachis (2011), congestion occurs when demand for the road exceeds its capacity. Alternatively, Goodwin, Dargay & Hanly (2004) defines congestion 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.

As a problem in many countries, traffic congestion causes various external costs. Furthermore, Somuyiwa et al. (2015) stated that there are three main ways that delays caused by congestion could affect the productivity of industrialised economies: by causing the increase of delivery operations cost; by reducing the effective market size which in the end followed by the reduction of sales; and by causing loss of opportunities for scale economies in the operation processes, which lies heavily on
production and delivery processes, as the result of unit costs’ increase. Thus, it can be seen that congestion do have a significant impact to multiple parts of modern day society, this includes the business or economy sector and also the environment, and it holds an important role and position on the policy makers’ agenda.

Traffic congestion problems occur in big cities, not only in developing countries but also in developed countries such as US and Canada. According to TomTom (2017)’s Traffic Index for 2016, these five cities are categorized as most traffic-congested cities which have extra travel time more than 50% that caused by traffic congestion: Mexico City, Bangkok, Jakarta, Chongqing, and Bucharest. In many cases, Moriarty (2000) emphasized that congested cities would stress heavy rail which is not only far more land-use and fuel efficient than car travel, but also will often be faster. However, for less congested cities, bus exclusive lane (in Indonesia, it is called as “busway”) is considered as suitable solution. Moreover, urban and rural areas need urban road pricing and encouragement of the already high levels of non-motorised travel. In Asia, Japan has applied some strategies to solve traffic congestion problems such as transportation demand management with toll discount (2007-2008), which reduced total delay by 27-33% (Xing et al, 2010). Under the congested conditions typical of large Asian cities, heavy-rail is at least an order of magnitude more land-use efficient than private car travel, as implemented in Tokyo and Hongkong (Moriarty, 2000). Meanwhile, China implemented non-motorized transport such as bicycle to reduce traffic congestion, however, policies are needed to ensure the safety of non-motorized transport (Moriarty, 2000). Malaysia, Japan, and Singapore have created integrated bus and train transportation, as well as subways. Furthermore, in South East Asia, Mass Rapid Transportation (MRT) has been implemented in Singapore, Kuala Lumpur, Bangkok, and Manila to solve congestion.

Different from other countries in Asia, Singapore has been implementing congestion charges or ERP (Electronic Road Pricing) for about 40 years. Adopting pricing policies along with providing adequate public transport system in Singapore has resulted in traffic reduction by 40%, public transport share increment by 20%, traffic speed improvement by 10 km/h, and significant reduction in CO2 emission (Kaffashi et al, 2016). According to Carnevale and Crawford (2008), ERP has been applied in several big cities in some countries such as Singapore, London (UK), San Diego (USA), San Fransisco (USA), New York (USA), and Stockholm (Sweden). ERP or congestion charges involve assigning a price to a road based on the demand for using that road, which the charges are generally set to discourage the use of private car rather than raise revenue, although they do the latter as well (Carnevale and Crawford, 2008). In case of London, initiating a congestion fee (of £8 daily) in central London in 2003 reduced the traffic by 20% while travel speed inside the zone increased by 37%, congestion delays were reduced by 30 %, bus ridership was increased by 14% and CO2 emissions were reduced by 20% (Kaffashi et al, 2016).

As the most populated country in East Asia, Indonesia also have traffic congestion problems especially in big cities such as Jakarta, Bandung, Surabaya, Bogor, and Denpasar. These cities are considered as most congested cities in Indonesia based on a survey by Waze (2016). Some programs have been implemented to solve congestion
problems such as building new roads, toll roads, flyovers, high occupancy vehicle (HOV) lane, and busway. An HOV scheme called the “three-in-one” zone (a road zone for at least three occupants per vehicle) aimed to limit passengers in a car, however this program was not effective to reduce traffic congestion because most drivers tend to hire ‘jockeys’ or fake passengers before entering the zone. Some projects are still in developments such as LRT (light rail transit), MRT (mass rapid transit), and ERP. Unfortunately, those public transport developments alone may not be enough to reduce congestion. Therefore, ERP is also being considered to solve congestion problems in big cities in Indonesia.

Road pricing is based on price structures which are generally designed based on the rational actor approach with the assumption that drivers are *homo economicus*. When facing changes in price, whether it is free or less costly at first, drivers may change their decision-making behaviour. A well-designed mechanism of road pricing could increase road users’ decision-making efficiency and reduce overwhelming traffic congestions and environmental costs. Several researches in transportation stated that cognitive limitation of drivers had a significant impact towards their decision-making behaviour. Cognitive limitation and systematic errors (e.g. irrationality, biases, and cognitive illusions) may constraint the mind and affect judgment and decision making (Gärling, 1998).

Drivers’ choices, such as preferred route choice or departure time, were made in a dynamic and uncertain environment. Avineri and Prashker (2004, 2005, 2006) stated that drivers are very sensitive towards level of complexity and uncertainty which exist in their transportation choices. Bonsall et al. (2007) reported various responses from drivers on complex prices. Based on a qualitative study, they stated that, for different reasons, respondents feel uncomfortable with complex pricing system and many respondents unwilling or not capable to deal with complexity. When information complexity cannot be contained, it resulted in disengagement as a form of cognitive and emotional response. The findings of Bonsall et.al (2007) stated above was in-line with the general economic paradigm regarding risk-averse behaviour: decision makers tend to see themselves as risk-averse when they were asked to describe their attitude towards uncertainty, and behaving as a rational individual when they made stated-preference choices. Rationality assumption in this case means that travellers always choose the best available choice. On the other hand, the study also found that in repeated decision making situations (repeated-choice situations), the tendency of choosing alternatives was highly affected by psychological factors and human ability to perform as rational actor was limited by cognitive limitation. Our ability to explore this mechanism and better understanding in response towards complex system can be increased if we study more about response rather than about attitude.

Inspired by studies of cognitive psychologists also its applications in consumer and travel behaviour context, this research aims to explore the cognitive responses of drivers, particularly on their ways of making decision and learning, to road pricing’s complexity and variability. Furthermore, the objective of this research is to identify the cognitive aspects that can reveal in-depth comprehension regarding driver’s responses
in a complex situation, especially in Indonesia. This research is also intended to give valuable contribution to government on making policy towards traffic issues. This research will be the first step of a continuous process to generate a thorough understanding of VRP’s design issues by focusing on the ways to understand and predict responses from drivers towards transportation-related policy to solve road traffic issues. The results of this research are expected to provide insights for the decision maker in securing a successful implementation of road pricing system in Indonesia since policy making to tackle congestion in this country usually focus on infrastructure development and lack of emphasis to human factors

**Literature review**

In this section, we review some recent studies on traffic management methods and road pricing approaches in different countries along with their results and contributions. Tavares and Bazzan (2012) assessed driver and infrastructure co-adaptation in road pricing's traffic enhancement. They applied an agent-based approach that uses variable road pricing to improve traffic efficiency. By assuming the drivers have different preferences, caring either about their travel time (being hasty) or credit expenditure (being economic), they applied three pricing scenario method for link managers: fixed, incremental, and greedy. The experiment was conducted in Singapore, assuming Singapore's ERP (automated toll charging while vehicle is moving) was working. The study concluded that driver's preference and adaptation to the road networks is an important factor on traffic optimization.

Meanwhile in Italy, Percoco (2013) proposed different road pricing method. He estimated the effect of road pricing policy introduced in Milan in 2008 on pollutants concentration charge every weekday from 07.00-07.30 am, varying from €2 to €10 depending on vehicles' engine emission standard. Free access was granted to motorbikes, several alternative fuel vehicles, and conventional fuel vehicles compliant with Euro 3 and Euro 4 standards. The study revealed that some pollutants concentration decreased few days after the road pricing implemented but only for one-week period. This was interpreted as inefficient policy design where motorbikes are not charged, hence the incentive is for using motorbikes. The result of this study showed how important it is to understand how road users behave and their learning process in response to road pricing policy to make sure the success of the policy’s implementation in reaching its objectives.

Likewise, Kristoffersson and Engelson (2009) described the implementation of an urban transportation application for Stockholm (Sweden) which includes departure time choice and using transportation model to forecast the effect of congestion charges, intelligent transport systems and infrastructure investment on departure time choice. They applied time dependent congestion charges, ranging from 0 to 20 SEK. This study was aimed to help practitioners and policy makers to make a better implementation of road pricing policy as traffic management, specifically, peak spreading policies in large road networks. It can be concluded that the study viewed how road users choose their departure time choice in response to the road pricing scheme as a deciding factor in the success of road pricing policy implementation.
Furthermore, Maerivoet et al. (2012) demonstrated new technology, which is smart mobility, and smart road charging scheme that could serve as a personalised instrument that steered people's mobility behavior. Their pricing mechanism focuses on the use and not the ownership of the vehicle by using price per kilometer based on type of road, time of day, type of vehicle (based on external costs to society made by passenger cars). The experiment was carried out in Leuven and Brussels, Belgium, which revealed that road pricing based on external costs and vehicle usage forces people to think about their travel behaviour. Moreover, road pricing also offers fairer taxation of vehicle usage. In conclusion, the study showed that road pricing policy is able to steer the road users’ behaviour when incorporating new technology and external costs to society in the road pricing scheme design.

On the other hand, other study concluded that the success of road pricing implementation is decided more by the effective linking of pricing technologies and the pricing objectives, both politically and economically (Iseki and Demisch, 2012). The study also found that the geographical scale of the road network tolled and the complexity of fee calculation are two policy factors which usually determine the adoption of roadway tolling technologies.

Another method was proposed by Borger and Proost (2012), which is a political economy model of road pricing. The model allows for different types of uncertainty and considers different uses of the toll revenues. Their study found that individual uncertainty with respect to modal substitution costs may imply that a majority votes against road pricing ex ante, although a majority would have been in favour after its introduction ex post. Also, political uncertainty with respect to the use of the revenues corroborates the finding that ex ante more voters will be against the introduction of tolls. Furthermore, both types of uncertainty suggest that fewer voters are against road pricing when toll revenues are used to subsidize public transport than when they are redistributed to all voters. This study showed us that the use of road pricing should result in apparent and concrete benefits for the general public, but still the development of the road pricing model has not incorporated the views of road users, in this case the drivers’ point of view.

Bar-Gera et al. (2013) applied a method for precise computations of equilibrium derivatives which are utilized in the search for link tolls and network design in traffic networks. Numerical experiments on a small network are used for two evaluations: precision of computed equilibrium derivatives; and the impact of precise derivatives on the quality of network design solutions. Using highly precise equilibrium solutions (average excess cost $10^{-15}$ or better), the result shows that the gradient evaluations computed by the proposed method are very precise as well (relative error of $10^{-9}$ or better). In contrast, a re-evaluation of past experiments reveals imprecise computations of equilibria, and hence design objective values.

Meanwhile, Tsekeris and Vob (2008) conducted an in-depth review of the state-of-the-art and described methodological advances in the design and evaluation of road network pricing schemes. The study concluded that the crucial role of the joint...
consideration of pricing strategies with optimal capacity provision and several network management measures is manifested and an integrated evaluation framework is suggested to incorporate a wide range of road pricing impacts into the scheme design process.

Agarwal and Koo (2016) analysed the effect of the adjustment of ERP in Singapore towards the commuters’ transport modal choice. The study found that in the morning hours and evening hours after the toll increased by the government, bus ridership has increased significantly ranging from 12% to 20%. The study suggested that road pricing policy has the potential to solve traffic problems not only by dispersing the use of private vehicle throughout the available road networks and time, but also by influencing the road users’ behaviour in terms of their transport modal choice.

**Experiment**

In order to see how Indonesian drivers respond to the implementation of VRP, pilot experiment was conducted. Generally, there are two main objectives that the experiment wants to explore: (1) How the drivers respond on different type of route, between VRP implemented route and “Alternative” route with no road pricing applied; (2) How the drivers respond on different price applied based on time in the VRP road. Before and after the experiment conducted, participants were given a pre-experiment and a post-experiment survey about their travel habit and their experiences from the experiment.

There were 10 participants involved in this experiment with ages ranging from 21 to 38 years old. All of the participants mainly resided in Bandung at least for the past 3 years and some of them had experience living or working in Jakarta before. Bandung can be considered as a less congested city in Indonesia compared to Jakarta although it is increasingly congested. This condition might affect the experiment results which will be discussed later in this paper. In the experiment, participants were regarded as car drivers, next will be referred to as drivers, who own and use their car as their only mode of transportation, and from the pre-experiment survey, all of the participants were considered suitable for the experiment since they already had the experiences in using personal driven vehicle as their mode of travel.

The experiment itself was divided into two sessions with 10 rounds of decision making for each session. In the first session, drivers were asked to choose between two options, VRP route and Alternative route. While for the second session, drivers were asked to choose between three options of departure time using the VRP route: “Low traffic departure time” (L), “Peak traffic departure time” (P), and “After peak traffic departure time” (A). In the beginning of each session, every driver was given IDR500,000 (equivalent to around USD40) of experimental money as their transportation budget. The objective for them was to minimize the transportation cost for each session; in return, they will receive a fraction of their remaining transportation budget in cash plus IDR20,000 as participation fee.
First session of experiment

For the first session, all drivers simultaneously made a decision regarding which route they chose on each round. After all the drivers made their decision, their choices were tallied in order to see whether there is overcapacity occurred in a route that will result in additional cost for every driver in the route. The result was then given back to each driver so they will include the final cost for the round on their experiment form. All drivers were asked to imagine themselves and other people in the experiment were employees/college students where the offices/campuses were located in the same building. Each of the drivers has one car which they always drive to their office/campus because it is the most convenient way of travel for them to reach the office/campus. All of the drivers are living in the same hypothetical housing complex, so that all of the drivers have the same two route choices to reach the office building where the first route implements VRP (VRP Route) and another alternative route which does not implement VRP (Alternative route). Each route has their advantage and disadvantage regarding the Road Price and Road Capacity.

The VRP route costs was assumed at its peak level which was IDR 30,000,- per car and the maximum capacity was 7 cars. While the Alternative route has no cost at all but the capacity was strictly limited only for 3 cars. If the capacity of one of the routes was exceeded, additional cost would be applied to every car in the said route (over capacity cost). For every car exceeding the capacity of each route, an additional cost of IDR 10,000,- is imposed. In each round, the over capacity cost was accumulated and distributed evenly to every car who chose the same route which then will be subtracted from the drivers’ initial budget along with the road price (if applicable).

Second session of experiment

For the second session, the mechanism of drivers’ decision making was the same with the first session. The difference lies on the background scenario and choices to be chosen. All of the drivers were still asked to imagine themselves living in the same hypothetical housing complex, but for the second session all of them have the same one-and-only route to reach the office building which implement VRP on three different periods of time. In each round of drivers have to choose between Low Traffic departure time (L), Peak Traffic departure time (P) and After Peak Traffic departure time (A). “L” costs was IDR15,000,- per car with maximum capacity 3 cars. “P” costs was IDR 30,000,- per car with the maximum capacity was 5 cars. And “A” costs was IDR 10,000,- with the maximum capacity was only 2 cars. The over capacity cost calculation was the same with the first session of the experiment.

From the condition and scenario setup of the experiment, it can be said that the VRP route in the first session and the Peak Traffic departure time in the second session was portrayed explicitly as the most expensive choice in order to see how the drivers would respond to this condition and to investigate whether the drivers were rational or not, in other words homo economicus or not. In the second session, additional condition was that, other than the peak traffic departure time, the cost and capacity of the other two options were almost the same with After Peak Traffic departure time had slightly lower
cost and capacity. This was conducted in order to see whether the difference in price and capacity could help distribute the traffic more evenly to reduce congestions or not.

**Results and findings**

Before the first session of experiment started, each participant was asked to fill a short pre-experiment questionnaire to obtain insights about each participant’s initial habit and point of view. The results are as follow:

**Table 1. Pre-experiment questionnaire results**

<table>
<thead>
<tr>
<th>Gender /Age</th>
<th>ID</th>
<th>Usual mode of travel</th>
<th>Other ways of travel</th>
<th>Travels in a week</th>
<th>Level of Importance of Travel Factors (0 = unimportant; 4 = Important)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Time Taken</td>
</tr>
<tr>
<td>M/38</td>
<td>1</td>
<td>Motorcycle</td>
<td>Bus, train, walking</td>
<td>&gt; 5</td>
<td>3</td>
</tr>
<tr>
<td>M/33</td>
<td>2</td>
<td>Car</td>
<td>Cycling</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>M/22</td>
<td>3</td>
<td>Motorcycle</td>
<td>All except motorcycle</td>
<td>&gt; 5</td>
<td>4</td>
</tr>
<tr>
<td>M/21</td>
<td>4</td>
<td>Motorcycle</td>
<td>Car, Paratransit.</td>
<td>&gt; 5</td>
<td>4</td>
</tr>
<tr>
<td>M/24</td>
<td>5</td>
<td>Motorcycle</td>
<td>Paratransit.</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>M/21</td>
<td>6</td>
<td>Paratransit</td>
<td>Car, bus, motorcycle</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>M/37</td>
<td>7</td>
<td>Motorcycle</td>
<td>Car, Paratransit</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>M/34</td>
<td>8</td>
<td>Car</td>
<td>Paratransit, taxi</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>M/29</td>
<td>9</td>
<td>Motorcycle</td>
<td>All except motorcycle</td>
<td>&gt; 5</td>
<td>0</td>
</tr>
<tr>
<td>F/27</td>
<td>10</td>
<td>Car</td>
<td>Paratransit</td>
<td>&gt; 5</td>
<td>3</td>
</tr>
<tr>
<td>Avg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.1</td>
</tr>
</tbody>
</table>

The pre-experiment survey results showed that all participants have driving experience which made them eligible for the experiment. Based on the average response of participants for the “Level of Importance of Travel Factors” questions, time taken reliability and safety are the most important factors with the average score of more than 3.1 (from maximum of 4 points) of level of importance. While for the other factors, except “Environmental concerns” which can be considered as a neutral factor based on the average score of 2, the participants also tend to view them as important factors with the average scores of more than 2. An additional factor that one participant answered was “social impact”. This additional factor might be considered for future study.
Route Choice Decision Making

The first result analysed from the experiment was the drivers’ responses when they were asked to choose between VRP implemented route and alternative route without road pricing (see Fig. 1.a.).

![Route Choice comparison per round](image1)

![1st Session’s Total cost](image2)

Fig 1. (a) Route choice comparison in the first session; (b) First session’s total cost per round

In the first round of the experiment’s first session, drivers who chose the VRP route were slightly higher than who chose alternative route. This condition changed instantly in the following rounds where the number of drivers who chose to use the alternative route is significantly higher than those who chose to use the VRP route with only one exception at the sixth round of experiment alternative route users are slightly lower than the VRP route users. This condition can be seen as drivers’ willingness to take risk in order to experience first. From the result description, it can be seen that in the initial stage of experiment, drivers are more willing to try the VRP route in order to gain some user experience so they could use it as benchmark in future similar conditions. The user experience mentioned before was mainly related to the economic side of the drivers, which was cost of travel. This condition was depicted more clearly on figure 1.b. which further shows that the drivers generally more willing to spend more from their budget in the first stage of the experiment.

Drivers’ route choice decisions throughout the first session of experiment are inconsistent in general, although Alternative route is the most common choice for all drivers due to its inviting cheap cost.
Table 2. Drivers’ route choice per round

<table>
<thead>
<tr>
<th>Round</th>
<th>Driver 1</th>
<th>Driver 2</th>
<th>Driver 3</th>
<th>Driver 4</th>
<th>Driver 5</th>
<th>Driver 6</th>
<th>Driver 7</th>
<th>Driver 8</th>
<th>Driver 9</th>
<th>Driver 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ALT</td>
<td>VRP</td>
<td>VRP</td>
<td>VRP</td>
<td>ALT</td>
<td>ALT</td>
<td>VRP</td>
<td>VRP</td>
<td>VRP</td>
<td>VRP</td>
</tr>
<tr>
<td>2</td>
<td>ALT</td>
<td>ALT</td>
<td>ALT</td>
<td>VRP</td>
<td>ALT</td>
<td>VRP</td>
<td>ALT</td>
<td>VRP</td>
<td>VRP</td>
<td>ALT</td>
</tr>
<tr>
<td>3</td>
<td>ALT</td>
<td>ALT</td>
<td>ALT</td>
<td>VRP</td>
<td>ALT</td>
<td>VRP</td>
<td>ALT</td>
<td>ALT</td>
<td>ALT</td>
<td>ALT</td>
</tr>
<tr>
<td>4</td>
<td>ALT</td>
<td>ALT</td>
<td>ALT</td>
<td>ALT</td>
<td>ALT</td>
<td>ALT</td>
<td>ALT</td>
<td>VRP</td>
<td>ALT</td>
<td>ALT</td>
</tr>
<tr>
<td>5</td>
<td>ALT</td>
<td>VRP</td>
<td>ALT</td>
<td>ALT</td>
<td>ALT</td>
<td>ALT</td>
<td>ALT</td>
<td>ALT</td>
<td>ALT</td>
<td>ALT</td>
</tr>
<tr>
<td>6</td>
<td>VRP</td>
<td>VRP</td>
<td>VRP</td>
<td>VRP</td>
<td>ALT</td>
<td>VRP</td>
<td>VRP</td>
<td>ALT</td>
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<tr>
<td>7</td>
<td>ALT</td>
<td>ALT</td>
<td>ALT</td>
<td>ALT</td>
<td>ALT</td>
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<td>ALT</td>
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<td>8</td>
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<td>ALT</td>
<td>ALT</td>
<td>ALT</td>
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<td>ALT</td>
<td>ALT</td>
</tr>
<tr>
<td>9</td>
<td>ALT</td>
<td>ALT</td>
<td>VRP</td>
<td>VRP</td>
<td>ALT</td>
<td>ALT</td>
<td>VRP</td>
<td>ALT</td>
<td>ALT</td>
<td>ALT</td>
</tr>
<tr>
<td>10</td>
<td>VRP</td>
<td>ALT</td>
<td>ALT</td>
<td>VRP</td>
<td>ALT</td>
<td>ALT</td>
<td>ALT</td>
<td>VRP</td>
<td>ALT</td>
<td>ALT</td>
</tr>
</tbody>
</table>

The table for drivers’ route decision showed that there is only one driver (Driver 5) who consistently chose “Alternative route” throughout the first session of experiment. There are two drivers that showed almost the same consistency of Driver 5, Driver 7 and Driver 10, but both chosen VRP route once which caused them to spend more travel cost than Driver 5. Regardless the lack of incentive for driver to choose the VRP route, and the absence of social dilemma in the experiment scenario that would encourage driver to switch his/her choice to VRP if they have chosen Alternative route before, there was still one driver who chose to use VRP route in most of the rounds which was Driver 4 who only chose to use Alternative route 3 times throughout the first session of experiment.

Departure Time Choice Decision Making

Figure 2 shows the results from second session of the experiment related to the drivers’ responses when they were asked to choose among three departure time choices on a VRP implemented route. The three different departure times were each coded with a single letter abbreviation “Low Traffic Departure Time” was coded as “L”, Peak Traffic Departure Time” was coded as “P”, and “After Peak Departure Time” was coded as “A”. The overall result per round can be seen on the figure below.
In the second session of the experiment, the number of drivers who chose the “P” departure time was generally lower than who chose other departure time from early on. Although the “A” departure time, which was the cheapest option for the second session, was not always the highest chosen option, this condition indicates that the drivers were more concerned towards the options with cheaper cost. But, this can also be affected by their past experience in the first session which helped them in identifying the “P” departure time as the costliest option to be avoided.

Drivers’ departure time choice decisions throughout the second session of experiment are quite vary in general, although Peak Traffic departure time is the least favourite of all. The complete results of the first session of experiment can be seen at the table below (Table 3).

![Fig 2. (a) Departure time choice comparison per round; (b) Second session’s total cost per round](image)

Table 3. Drivers’ departure time choice per round

<table>
<thead>
<tr>
<th>Round</th>
<th>Driver 1</th>
<th>Driver 2</th>
<th>Driver 3</th>
<th>Driver 4</th>
<th>Driver 5</th>
<th>Driver 6</th>
<th>Driver 7</th>
<th>Driver 8</th>
<th>Driver 9</th>
<th>Driver 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>A</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>A</td>
<td>P</td>
<td>A</td>
<td>L</td>
</tr>
<tr>
<td>2</td>
<td>L</td>
<td>A</td>
<td>L</td>
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There were two drivers which showed consistent choice throughout the second session of the experiment. Driver 2 consistently chose After-Peak traffic departure time (A), while Driver 5 always chose Low traffic departure time (L). Driver 3 showed an almost
consistent departure time pattern of Low traffic departure time and only once chose After-Peak traffic departure time at the third round of the second session of experiment. Driver 7 and 9 showed a similar pattern but with different choices where they consistently chose After-Peak traffic departure time and only once chosen Low traffic departure time at the second session of the experiment. The rest of the drivers showed an almost random pattern of departure time choice, and there are 3 drivers who have chosen Peak traffic departure time minimum once in the second session of the experiment.

Although Driver 5 consistently chose Low Traffic Departure time, the total cost spent was still higher than driver 2 who chose After Peak Traffic departure time, which it was the most efficient choice potential cost-wise. While there were drivers who still chose Peak Traffic departure time regardless of its highest cost compare to the other two choices, the rest of the drivers’ choice, generally, varied between Low Traffic and After Peak Traffic departure time which resulted the cost per round for them in an almost random pattern.

Conclusions

Various types of drivers were captured from the pilot experiment. In the first session of the experiment, some of them are curious in trying to use the VRP route, but there is one driver which show fully rational behaviour in his decision by constantly chose “Alternative route” throughout the first session. In the second session, it can be seen that there are learning process occurred in terms of minimizing cost from all the drivers, but there are still only a few of them were fully rational and only one of them was fully succeeded in minimizing the travel cost by choosing the “After-Peak” departure time consistently. These conditions can be linked to the participants’ responses on the post-experiment survey where some of them indicated that their decision-making behaviours in the experiment were still affected by their real life past experience as drivers or road users and their background as people who lived in Bandung, instead of Jakarta which is more congested.

Based on the experiment’s results, it can be seen that drivers’ behaviour patterns are vary in response to the implementation of VRP. The drivers’ decision choosing the VRP route although the “Alternative” route is significantly cheaper can be seen as an indicator that drivers’ decision responses towards VRP implementation are not affected solely by the price of the VRP.

Further experiment with different scenarios on road pricing scheme and the use of other drivers’ subjective values analogies are needed in order to further understand how Indonesian drivers’ responses towards the implementation of VRP’s pricing scheme. The limited numbers of participants involved in the experiment restrict further statistical analysis of the result to give a more in-depth understanding of the experiment results. Remembering that this research is the first step of a continuous process of understanding VRP’s design issues, specifically in Indonesia, more participants from different backgrounds or regions should be included in future experiments and researches regarding the implementation of VRP.
References


Waze (2016) Driver Satisfaction Index 2016. Available at: https://www.waze.com/driverindex