

ROAD SPACE RATIONING TO REDUCE TRAFFIC CONGESTION: AN EVALUATION OF THE ODD- EVEN SCHEME IN JAKARTA, INDONESIA

OKTANIZA NAFILA

March, 2018

SUPERVISORS:

Ir. M.J.G. Brussel

Dr. A.B. Grigolon

ROAD SPACE RATIONING TO REDUCE TRAFFIC CONGESTION: AN EVALUATION OF THE ODD-EVEN SCHEME IN JAKARTA, INDONESIA

OKTANIZA NAFILA

Enschede, The Netherlands, March, 2018

Thesis submitted to the Faculty of Geo-Information Science and Earth Observation of the University of Twente in partial fulfilment of the requirements for the degree of Master of Science in Geo-information Science and Earth Observation.

Specialization: Urban Planning and Management

SUPERVISORS:

Ir. M. J. G. Brussel

Dr. A. B. Grigolon

THESIS ASSESSMENT BOARD:

Prof. Ir. Martin Van Marseveen

Dr. Shanty Rachmat – ITB Institut Teknologi Bandung, Indonesia

Ir. M. J. G. Brussel

Dr. A. B. Grigolon

DISCLAIMER

This document describes work undertaken as part of a programme of study at the Faculty of Geo-Information Science and Earth Observation of the University of Twente. All views and opinions expressed therein remain the sole responsibility of the author, and do not necessarily represent those of the Faculty.

ABSTRACT

Jakarta, a capital city of Indonesia, a developing country, suffers from severe congestion. This city implement several TDM policies to combat the congestion range from public transportation improvement to traffic restriction. One of TDM policies, the “odd-even” road rationing scheme, is implemented in two main corridors within its CBD area. An odd-even scheme is popular among developing countries due to its low cost nature and easy enforcement. The odd-even scheme in Jakarta succeed in reducing congestion in the restricted road however some still argue that this regulation could not effectively reduce congestion in wider area. Unfortunately, the evaluation was done by using limited traffic flow data thus allow to further analyse the changes in traffic condition.

In this study, the effect of the odd-even scheme in Jakarta is evaluated in term of traffic reduction based on available traffic-related data. This study reflect on the limitation of the available data, particularly in the data collection methods. Furthermore, a better methodology, which allows controlling external parameters, is proposed based on the findings and literature reviews.

According to the results, the effect of the odd-even scheme on the traffic condition could not be shown or analysed further by using the available data. Based on that limitation, a methodology to evaluate TDM measures in Jakarta is proposed. A small survey with 66 respondents is done to understand what the travellers do to adapt to the restrictions. Several interviews with local experts are also done to help to discuss the advantages and limitations of an odd-even scheme based on the result. Results from the small survey and interviews with local experts is used to support the proposed methodology.

This study provides insights to local government on the evaluations of the effect of the odd-even scheme in the particular corridors in Jakarta. The recommendation could help Government to be better at monitoring and evaluating the push measures performance in the future, particularly in implementing Electronic Road Pricing which is planned to be implemented in 2019.

ACKNOWLEDGEMENTS

I would like to acknowledge my first supervisor, Ir. M. J. G. Brussel and my second supervisor, Dr. A. B. Grigolon for the constructive remarks, discussion, and encouragement during the whole research period. I am grateful to have the opportunity to learn a lot from all of you.

I would like to thank Prof. Ir. Martin Van Marseveen as the Chairman of the thesis assessment board for the valuable suggestion and discussion. Also, I thank Mr. Willem Nieuwenhuis for the spectral extraction tool that was helpful to fasten the extraction process.

I particularly appreciate the participation of 66 respondents and support from Jakarta Transportation Agency in Jakarta, Indonesia. Furthermore, this research was made possible by the great support from the the local experts. Therefore, I would like to thank the following people from those institutions for the advice, the survey data, and the help during the fieldwork:

I would like to express my gratitude to Nuffic Neso for giving me funding and opportunity to study in ITC by Stuned Scholarship.

Finally, I gratefully thank my family and friends who always support me. Special thanks also to the rest of my classmates in the Urban Planning and Management.

TABLE OF CONTENTS

List of Figures	iv
List of Tables	v
1. Introduction.....	1
1.1. Background and Justification	1
1.2. Research Problem.....	2
1.3. Significance of the Research.....	2
1.4. Research Objectives and Questions.....	2
1.5. Hypotheses	3
1.6. Thesis Structure	3
2. Literature Review	5
2.1. Travel Demand Management.....	5
2.2. TDM Implementation Worldwide	6
2.3. Road Rationing Implementation Worldwide	7
2.4. Evaluation of TDM Measure	8
2.5. Summary	15
3. Methodology.....	17
3.1. Study Area.....	17
3.2. Research Design	23
3.3. Data Collection	24
3.4. Ethical Issues.....	26
4. The Evaluation of Effect of Odd-Even Scheme in Jakarta.....	29
4.1. Effect of odd-even scheme on traffic reduction	29
4.2. Influence of the odd-even scheme on behavioural change	38
5. Review Of Methodology to Evaluate The Effect of Future TDM Policies in Jakarta.....	45
5.1. Wide-Range Impact Analysis.....	45
5.2. Methodology of Traffic Assessment.....	46
6. Conclusions and Recommendations	51
6.1. Conclusions	51
6.2. Recommendations.....	55
List of References	57
Annexes : Fieldwork plan.....	63

LIST OF FIGURES

Figure 1 Causal map of regulation and its effect adopted from Coglianese (2012).....	9
Figure 2 Conceptual Framework of how policy measures change travel choice.....	15
Figure 3 TransJakarta Passengers	18
Figure 4 Ratio Number of Passenger over Number of Bus.....	18
Figure 5 The Number of Buses	18
Figure 6 Traffic Restriction Plan in Spatial Plan 2030	20
Figure 7 TDM implementation in the corridor.....	21
Figure 8 Odd-Even Scheme Restricted Route	22
Figure 9 Research Design Flowchart (Workflow)	23
Figure 10 Timeline of traffic counting in the restricted corridors.....	29
Figure 11 Traffic Counting Survey Point	30
Figure 12 Comparison of traffic volume in 7 AM to 10 AM in the corridor (Above) and in 4 PM to 8 PM (Below). NS and SN represent the direction. NS means North-South and SN means South-North. (Source: Jakarta Transportation Agency).....	32
Figure 13 Passenger Car Unit Changes in the evening peak (left) and morning peak (right)	33
Figure 14 Travel Speed Changes after the implementation – morning peak (left) and evening peak (right)	34
Figure 15 Travel Time change after the implementation.....	35
Figure 16 Comparison of Traffic volume in 6 AM to 8 PM in the corridors	35
Figure 17 Vehicle mode distribution change after the implementation.....	35
Figure 18 Comparison of daily average number of TransJakarta in the peak hour.....	36
Figure 19 Average bus occupancy in the corridor, in the peak period.....	36
Figure 20 The comparison of traffic volume in alternate road.....	37
Figure 21 Classification of the respondents based on occupation	38
Figure 22 Classification of the respondents based on age group	38
Figure 23 Before the implementation, did you always using car to work?.....	39
Figure 24 Their chosen modes besides cars.....	39
Figure 25 When the respondents use their cars	40
Figure 26 Respondents' adaptations.....	40
Figure 27 Willingness to change their travel modes from car to public transportation	41
Figure 28 The reasons people want to change to public transport.....	41
Figure 29 the reason why people still use private cars	42
Figure 30 Infringement of Odd-Even Scheme	43
Figure 31 Fuel Price.....	48

LIST OF TABLES

Table 1 Comparison of several journals on measuring the effect of road space rationing	9
Table 2 Factor affecting travel demand (Litman, 2013)	13
Table 3 Behavioral change due to TDM implementation adopted from Steg & Schuitema (2007)	14
Table 4 Data Acquired and Sources	24
Table 5 The research questions and data collections methods	25
Table 6 Research Matrix	27
Table 7 Summary of Traffic Volume Data.....	31
Table 8 Summary of Travel Speed and Travel time Data.....	31
Table 9 Vehicle composition changes in morning peak period for each road segment	33
Table 10 Methodology for Evaluation of Future TDM policies in Jakarta	56
Table 11 Summary on how the data required can answer each research questions	63
Table 12 Interviewee list for Non-Governmental Organization and Researcher related to TDM development and evaluation	71

1. INTRODUCTION

1.1. Background and Justification

Traffic congestion is one of the most severe problems in many cities worldwide. In developing countries, this problem is even more prominent because of the rapid population and economic growth. Population and economic growth induce urban area expansion and automobile usage, which lead to traffic congestion. Congestion cause not only environmental problems but also economic problems such as inefficient delivery as well as distribution of goods and resources (Santos et al., 2010). Steg and Tertoolen (1999) argued that changes in human behaviour are required to achieve effective solutions of traffic congestions because the arising problems of automobile use are the accumulation of individual choices and behaviours of automobile users. Furthermore, Kaffashi et al. (2016) argued that promoting modal shifts to public transport has been proven to reduce congestion effectively.

Many policy instruments have been developed and implemented to encourage people to change their travel behaviour. Travel Demand Management (TDM) is a policy strategy often used to promote change in transport mode choice. TDM aims to escalate the urban transport system's efficiency by modifying the travel demand in two possible ways (Batur & Koç, 2017; Broaddus, Litman, & Menon, 2009; Eriksson, Garvill, & Nordlund, 2006). The first strategies are promoting healthier and more efficient transportation modes usage, which are often called as soft policies or pull policies. The second strategy intends to discourage private vehicles usage, often called as hard policies or push measures.

One push measure that is popular in developing countries is the "odd-even" road space rationing. In this scheme, the vehicle is restricted to certain roads, in particular times of the day, based on its license plate number. Usually, this restriction is applied in CBD areas and only applied in the rush hours. Several cities, which already implemented this restriction, claimed that this scheme has succeeded decreasing the congestion level. For instance, in Beijing, Li and Guo (2016) found that the odd-even scheme was effective in reducing the congestion in a short-term period during the Olympic Games.

However, Wang, Xu, Zheng, and Qin (2013) argued that the extended odd-even scheme, which was implemented after the Olympic Games, was not entirely effective. In the long-term period, citizens would find another way to circumvent the regulation, such as covering the plates or borrowing cars from friends. Drivers were rarely changing to public transportation usage because of this regulation. The same evidence was found in Mexico city, with part of the population saying it was effective in reducing car usage, and others felt an increase in the number of car ownership (Eskeland & Feyzioglu, 1997). Based on the cited experiences, it seems that the effect of the odd-even scheme in reducing traffic congestion remains unclear, particularly regarding its effects on shifting behaviour to more sustainable modes of transport. Therefore, it is essential to evaluate the effect of this measure in reducing congestion.

An evaluation is needed to support better policies in the future. One measure should be evaluated to understand to what extent such efforts have reached the aims of reducing congestion (Steg & Tertoolen, 1999). Ferguson (2000) explained that evaluating the effect of a TDM measure would be tricky because it is often integrated with other measures within a broader policy. That is why the effect could not be separated from that context. Therefore, a wide range of information, before and after implementation, should be required to make a proper examination and to predict the consequences of one policy (Taylor, Bonsall, & Young, 2000).

Many studies have evaluated the effect of policy measures in changing peoples' mode choice before the implementation by using hypothetical analysis. For instance, Batur and Koç (2017) have found that workplace and school travel plans are effective policy measures, especially in the peak times. In another study, Habibian & Kermanshah (2013) found that push measures have more significant effects in reducing car usage and promoting public transport usage, compared to the effect of pull policies implementation. However, the effect of policy measures in reducing congestion is rarely monitored and evaluated after the implementation. If there is, the evaluation could not explain why the implementation could lead to such impact because of data insufficiency, especially in developing countries.

1.2. Research Problem

Jakarta has implemented an odd-even scheme for the first time from August 2016. This scheme was implemented on five major roads in the CBD area where 3 in 1 scheme was formerly implemented (3 in 1 scheme is a road space rationing scheme that allows at least three people in 1 car). The scheme was canceled because Jakarta Transportation Agency and Local Authority for Traffic Management (Dirlantas) found that there were serious social impacts despite no significant changes in congestion levels. In fact, the local government was designing an electronic road pricing (ERP) system in the same corridor. However, due to complication in the regulation and resistances from National Government, the system still could not be implemented at that time, so local government assigned odd-even scheme as a "transition" regulation in the corridor.

The odd-even scheme was implemented from 30 August 2016, after one-month trial period. The measure was only implemented in peak periods (07.00 to 10.00 in the morning peak and 16.00 to 20.00 in the evening peak). The implementation was only applied to limited corridors in CBD area, where most of government and business districts are located. After eight months of implementation, Local Authority for Traffic Management found that the implementation of the policy caused 2% decrease of travel time and 2% increase of travel speeds (Khafifah, 2017). However, based on a survey that was done by KedaiKOPI, they found that almost 72% of respondents think that odd-even traffic restrictions were not effective, and even made the congestion worse (Aryani, 2017).

In addition, the roads around the five major roads where the odd-even scheme was implemented were not yet evaluated whether they are more or less congested due to the potential increase in demand. An increased level of congestion is expected around the restricted road because of the limited area of odd-even scheme implementation. Another issue that must be addressed in the evaluation is whether the odd-even scheme, as a travel demand management, could drive a modal shift from private cars to public transportation. Therefore, there is a need to analyse the effect of the measure on traffic congestion in the corridor and further, in the citywide area.

1.3. Significance of the Research

The effect of TDM policies needs to be evaluated to reduce congestion effectively. The odd-even scheme, as one of TDM policy measures, recently has become popular in developing countries while there is evidence that this type of measure is less useful than others, such as congestion pricing (Nie, 2017). In this study, the effect of the odd-even scheme in Jakarta is evaluated in term of traffic reduction and travel behaviour changes. The discussion of the effect of TDM measures can be an input to the local government to evaluate whether this regulation is effective and what can be improved to make it more effective. Also, the recommendation could help the local government to better monitor and evaluate TDM policies in the future.

1.4. Research Objectives and Questions

The objective of this research is to analyse the effect of the odd-even scheme on traffic congestion reduction in Jakarta. Four sub-objectives are derived to achieve this objective:

Sub-Objective 1: To discuss Travel Demand Management policies implementation in reducing traffic congestion.

- 1.1. What are the TDM measures already implemented worldwide?
- 1.2. What are advantages and limitations of TDM measures in reducing congestion?
- 1.3. What are the methods that are used to assess the effectiveness of TDM measures?

Sub-Objective 2: To assess the effect of the odd-even scheme implementation in Jakarta.

- 2.1. What are the characteristics of the transportation system and transportation policies in the study area?
- 2.2. What is the effect of odd-even scheme implementation on congestion reduction, in and around the area where it was implemented?
- 2.3. What is the effect of odd-even scheme implementation on car users' travel behaviour?

Sub-Objective 3: To discuss the effect of the odd-even scheme in light of other measures aiming to reduce congestion.

- 3.1. What are the advantages and limitations of the odd-even scheme in reducing congestion in Jakarta?
- 3.2. What can be improved in the implementation of the odd-even scheme?

Sub-Objective 4: To propose a methodology to evaluate the effect of TDM policy implementation in Jakarta.

- 4.1. What are the data required for the evaluation of TDM policies in Jakarta?
- 4.2. What are the parameters that have to be controlled to successfully implement TDM policies in Jakarta?
- 4.3. What are the methods that can be used to evaluate TDM policies in Jakarta?

1.5. Hypotheses

As mentioned above, the road rationing strategies could affect the traffic condition in various ways. For example, some people said that it is effective to reduce congestion while on the other hand some people said that it increase the number of cars in the road. Those effects of odd-even scheme is assumed to be occurred during the odd-even scheme implementation in Jakarta. Therefore, the following hypotheses are formulated to help discussing the effect of the odd-even scheme in Jakarta.

Hypothesis 1: The traffic volume in both corridors decreases.

Hypothesis 2: The average travel speed in both corridors decreases.

Hypothesis 3: The traffic volume outside the corridors increases.

Hypothesis 4: The odd-even scheme changes the modal distribution of vehicles rather than decreases traffic volume in the corridor.

Hypothesis 5: Car users' average travel time from origin to destination decreases because average travel time in the corridors decreases.

Hypothesis 6: The odd-even scheme does not lead to shifting behaviour from car to public transport usage if the level of services of public transportation remain the same.

Hypothesis 7: The odd-even scheme influences the departure time of commuters.

1.6. Thesis Structure

This thesis has six chapters:

1. Chapter 1: Introduction

This chapter elaborates on the background and justification of study, states the research objective and questions and formulates some hypotheses.

2. Chapter 2: Literature Review

This chapter reviews all concepts which are related to the thesis. It begins with the concept Travel Demand Management (TDM), specifically road rationing scheme, and how it is implemented. Next, the methodology that is used will be explored and explained in this chapter.

3. Chapter 3: Methodology

This chapter explains the methodology applied in this thesis, detailing the study area, data collection methods, data analysis, research matrix and research workflow.

4. Chapter 4: Evaluation of the Effect of the Odd-even Scheme Implementation in Jakarta

This chapter presents an evaluation of the effect of the odd-even scheme implementation in Jakarta based on traffic-related data and a survey with car user's.

5. Chapter 5: Review on the Methodology that can be used for future evaluation of TDM measures

The chapter reflects on the findings of this research then proposed a methodology that can be used for future implementation and evaluation of TDM in Jakarta.

6. Chapter 6 : Conclusions and Recommendations

The chapter concludes result from this thesis and recommends some points that can be done in further research.

2. LITERATURE REVIEW

This section describes the concept of Travel Demand Management generally, then mentions several examples of TDM implementation worldwide especially road rationing implementation. Next, the methodology of evaluation that are already used are discussed.

2.1. Travel Demand Management

Three elements are considered in combating congestion, namely, supply element, demand element and land use element (Meyer, 1997). Among those elements, currently, the demand management has gain popularity because supply management alone could not reduce the congestions due to the fact that the elasticity of latent travel demand override the development of roads (Ferguson, 2000). Many studies have found that travel demand management (TDM) is a significant measure to combat congestions by reducing private vehicles trips and increasing the use of public transportation (e.g. Batur & Koç, 2017; Broaddus, Litman, & Menon, 2009). Broaddus et al. (2009) argued TDM strategies are the most cost-effective transportation strategy. It also has many potential benefits including road cost saving, parking space saving, road safety, energy conservation, emission reduction, land use efficiency, and improved public fitness and health. Researchers usually divided TDM policies into two classifications of travel demand management namely push measures and pull measures (Bamberg, Fujii, Friman, & Gärling, 2011; Batur & Koç, 2017; Broaddus et al., 2009; Habibian & Kermanshah, 2011; Moer & Bamberg, 2008).

Pull measures (also called volunteerism strategies) are more politically popular and acceptable rather than push measures (Ferguson, 2000). Moer & Bamberg (2008) explained that pull measures refer to strategies that try to influence travel choice by changing people's perceptions and motivations. It may include persuading people to change their mode by providing shuttle buses in every commuter rail and light rail station, adjusting transit planning and subsidising the public transportation fare (e.g. transit pass sales, fare discounts, pass subsidies offered by developers and employers). It may also include promoting ridesharing or alternating the travel hours. The employer often initiates the alternate travel hour programs by deploying flexible working hours or compressed working hours (Ferguson, 2000). However, Ferguson (2000) explained that pull measures rarely provides stable long-term solutions because these strategies could not reduce the attractiveness of car use (Garling & Schuitema, 2007). Furthermore, pull measures, such as improvement of alternative modes, are increasingly hard to implement because of urban sprawl and sub-urban housing trend.

In contrast, despite the unpopularity among politicians, push measures are more practically viable than pull measures in reducing congestion (Ferguson, 2000). Push measures are implemented to force people to use another mode choice instead of a car. Push measures might be implemented as a regulation mechanism, such as a driving restriction in Beijing, Mexico City or Delhi, or a market-based mechanism (also called as economic instruments) such as a congestion pricing in Singapore, Stockholm, and London. Another kind of push measure that is found sufficient to reduce the car usage in the city centre is parking restriction which is easy to control, especially if it runs by private company (Behrendt & Teytelboym, 2010)

However, Nie (2017) argued that as a policy, push measures often meets public resistance. This resistance is problematic as Steg and Tertoolen (1999) argued that public support or compliance is a crucial element in doing effective regulations and policies. Public resistance to push measures, especially economic measures, could be minimised if the government could assure public that the revenues from this measure will be used for increasing quality of transportation system (Tanaboriboon, Hokao, & Haider, 1994). Moreover, Garling and Schuitema (2007) found that push measures could achieve the goals of reducing car use if the advantages offered by other transportation modes could outweigh the advantages that car trips

could offer. This condition did not occur only for economic determinants such as fuel price, or vehicle price, but also for other determinants of car usage such as comfort, speed and flexibility (Steg & Tertoolen, 1999).

Furthermore, in reality, TDM strategies are rarely applied as a single strategy. Several studies found that TDM strategies should be combined to get more effective result (Behrendt & Teytelboym, 2010; Habibian & Kermanshah, 2011; Javid, Okamura, Nakamura, Tanaka, & Wang, 2016; Steg & Tertoolen, 1999) because combining two or more strategies may cover more individual trips (Habibian & Kermanshah, 2011). In addition, push measure alone is not effective in achieving car use reduction. Jianwei, Zhenxiang, and Zhiheng (2009) found that in Beijing, during important occasion (e.g. Olympic season), a combination of odd-even scheme and staggered morning hours are more effective and impactful, compared to implementation the odd-even scheme alone. Moreover, Cairns et al. (2004), in the final report of a research project published by the Department for Transport of UK, also found that the combination of pull and push measures can affect significantly in reducing car usage up until 15% as a national average and up 20% in local conditions.

This study focuses on the advantages and limitation of push policies implementation. However, the pull policies would still be relevant in the study because as mentioned above, integrated TDM measures are working more effective in reducing car usage than a single TDM measure.

2.2. TDM Implementation Worldwide

Push measures are already implemented worldwide particularly in the developing countries where the growth of vehicle number is faster than the road development. The number of cars multiplies rapidly while the development of roads takes times. Road pricing, road rationing, and vehicle ownership quota are the example of measures that are has been implemented in some developing countries.

As one of the push measures, road pricing has many potential benefits such as the source of transportation revenue, congestion relief, pollution reduction and traffic safety improvement (Ferguson, 2000). Road pricing can be implemented in various ways in the form of congestion pricing, cordon (area) toll, HOT lanes, road tolls, and vehicle use fees (Victoria Transport Policy Institute, 2017). However, Ferguson (2000) explained that road pricing is hardly implemented because it causes public opposition. Usually, equity becomes the most significant reason of the opposition because public thought it will benefit high-income group more than the others (Zhu, Du, & Zhang, 2013). Moreover, road pricing might failed to decrease the car attractiveness (Garling & Schuitema, 2007) because the added cost due to road pricing could not override the other factors that make private care appealing, such as comfort, flexibility and safety. Therefore, there is a need to carefully analyse the demand elasticity over the price on different socio-economic groups within the area and the surroundings to understand what are determinants that drivers accentuate in choosing travel modes. Despite those limitations, several cities, such as Stockholm and Singapore, succeed on reducing congestion by using Electronic Road Pricing (ERP).

In Stockholm, congestion pricing (which they called congestion tax) has succeeded in reducing congestion in the CBD area. The congestion tax issues are spread in 1990 when the traffic volume growth suddenly ended after continuously increased since 1970 (Eliasson, 2014). After almost 16 years of debates, due to public oppositions, in 2006, the seven-month trial was conducted to evaluate the effect of congestion charges implementation. As the result, the congestion charges were proven successfully reducing congestion in CBD area and, even, in the outskirt area (Eliasson, 2014). This fact led to the reintroduction of the regulation in 2007. The congestion tax were implemented in the form of cordon pricing with time differentiation (e.g. the price would be higher in the peak hours than in the off-peak hours). However, the decreasing traffic volume could not be only attributed to the road pricing. The government also improved public transportation quality and expanded public transportation network to give the citizen more options for commuting and travelling inside the city.

Similar impact of road pricing was found in Singapore. Singapore has applied Electronic Road Pricing (ERP) since September 1988. Before ERP implementation, they have already applied Area License Scheme (ALS) in the same area since 1975. The traffic volume evaluation has been done after ALS implementation, and the result showed that in the restricted hours the traffic volume decreased 73% from March 1975 to October 1975. The ERP system boosted the fairness of the pricing scheme. The initial monitoring of ERP implementation showed traffic volume reduction on the expressway up to 15% and an increasing speed up to 20 km/hour during the ERP hours. The different between ERP and ALS is the charging system. ALS are manually enforced and charged by the local authority while ERP uses an automatic system to charge the motorist who use the implemented roadway. Using ERP, the motorist is charged based on the traffic conditions. Higher rates were charged during the rush hours, and lower rates or no charges were levied at the other times. Moreover, ERP system is more efficient and flexible than ALS to collect the fee (Agarwal & Koo, 2016).

Alternatively, road rationing is noticed as an acceptable and equitable strategy by public compared to a road pricing strategies. However, road rationing strategies do not usually effectively affect the traffic condition in long term. Zhu, Du, and Zhang (2013) combined behavioural theory and econometric model, to evaluate rationing and pricing strategies for congestion mitigation in Beijing. As a result, they found that the equity and efficiency will decrease in the long-term implementation because people have already adapted themselves to the new system and could find the loopholes. Moreover, road rationing strategies depend on the excellent quality of enforcement as it has been proven in Brisbane where successful enforcement of High Occupancy Vehicle regulation, one of the road rationing strategies, was correlated with increasing travel time (Lyndon, Marinelli, Macintosh, & McKenzie, 2014).

Another push measure that has been applied in the world is limiting car sales in a year. This has been implemented in several cities such as Singapore, Shanghai, and Beijing. Singapore is one of the cities that succeed in limiting vehicle ownership. The strategy is called as Vehicle Quota System which was implemented since August 1990. Through this regulation, Government obliges the car users to have a certificate of entitlement for buying a new car. The quota is set based on the vehicle growth rate every year, and the purchased vehicle can be used only for ten years (Koh & Lee, 1994). After ten years, they must pay another tax to extend the certificate of entitlement. By using Vehicle Quota System, Singapore's government manage to control vehicle growth rate. Even so, Vehicle Quota System is quite complex and complicated. A meticulous plan and procedure are required to implement it successfully

Parking restrictions are also one of the TDM measures that can be used for reducing congestion. It has a direct effect while relatively easy to control. Parking restriction can be implemented in the form of parking pricing or parking area constraint. Furthermore, parking restrictions that are implemented in the workplace would potentially reduce the amount of car commuting (Batur & Koç, 2017; Redman, Friman, Garling, & Hartig, 2013). In addition information, Behrendt & Teytelboym (2010) explained that parking area restraint might be easier to control than parking charges primarily when a private company manages the car parks.

2.3. Road Rationing Implementation Worldwide

As explained in the previous part, road rationing has been already implemented worldwide. One popular rationing strategy in the developing countries is license plate rationing (Nie, 2017). It is sometimes called by alternate-day travel, driving restriction, or no-drive days in some context. This kind of regulation has been debated whether it succeeds in reducing congestion or not. Several cities have already implemented it and have gotten direct benefits such as decreasing average travel speed and air pollution. In this section, benefit and shortcoming of license plate rationing will be explored based on the experience of Delhi, Beijing and Mexico City.

Mexico City implemented license plate rationing in 1989 which was called as *Hoy No Circula*. They restricted cars with license plate number ended with zero and one on Monday, two and three on Tuesday and so on.

While some people argued that this regulation is acceptable and reasonable for car owners, others argued that this regulation is inefficient and counterproductive. That is because they found some citizens bought a new car to circumvent the regulation (Eskeland & Feyzioglu, 1997). This fact was proved by simulating gasoline consumption and modelling the vehicle household ownership with or without restrictions. As the result, the total car use in the city was increased after the implementation.

Delhi also implemented the license plate rationing from 1st January 2016 to 15th January 2016 (Kumar, Gulia, Harrison, & Khare, 2017). The rule was odd-license-plate-cars are only allowed to use the road in odd-date and vice versa. This rule was exempted for all taxis, environment-friendly cars, cars with only women passengers, and motorbikes. As the result, the average speed within those days increased while on the other hand, the flow of other vehicles such as motorbike increased. In addition, about 30% of the traffic is consist of vehicles with inappropriate plates number which is probably due to taxi's exemptions and partly due to non-compliance behaviour. Furthermore, as an environmental effect, only small amount of PM 2.5 were decreased (Chowdhury et al., 2017).

Beijing also uses a similar approach to reduce car usage. From 20 July 2008 to 20 September 2008, due to The Beijing Olympic Games, Government enforced driving restriction based on license plate number. The rule was the same with the implementation in Delhi. The Odd-Even scheme was applied in all days and all hours except midnight to 3 AM (Viard & Fu, 2015). Based on the comparative analysis of traffic flow in the expressway network before and after the event, Li and Guo (2016) concluded that the odd-even scheme might be effective to tackle the short-term-increased travel demand due to a significant event such as Olympic Games. This restriction ended on September 20, 2008.

On 11 October 2008, Beijing Government reapplied driving restrictions with a different procedure. In the new procedure, Government restricted a car to enter the road, one-day-per-week, based on the license plate. The new procedure is similar to what Mexico City did. This regulation applied only on weekdays between 6:00 a.m. and 9:00 p.m. At first, the restriction has succeeded in decreasing the traffic volume in the corridor. However, Wang et al. (2013) pointed out that the benefit of driving restriction in the inner city was lost over time. They also found, as the side effect, rule-breaking behaviour has been observed throughout the implementation.

Based on those cities' experiences, most of road rationing implementations have direct benefit such as increased travel speed and decreased traffic volume at the restricted road. However, rationing implementation can be counter-productive as it did in Mexico where the total car use was increased in a longer term due to the restrictions. It also can lead to non-compliance behaviours as it did in Beijing and New Delhi. On the other hand, road rationing is still widespread in developing country. Nie (2017) argued that there are two reasons of why policymakers tend to implement this regulation. First, license plate rationing is relatively inexpensive to implement and reinforce, compared to congestion pricing. Secondly, this regulation is more likely to be perceived fair by the public, because of all car users, rich or poor, became subject to the same restriction.

2.4. Evaluation of TDM Measure

Before evaluating the effect of a regulation, the regulation development process and the desired effect of such regulation must be understood. Coglianese (2012) stated that in general, regulation attempts to change the behaviour of the target and to pursue the desired outcomes. The causal relations between regulation and its effect can be seen in Figure 1. The figure shows that every regulations implementation must go through several steps in achieving the ultimate outcome. The enforcement influences the regulation implementation and leads to behavioural change. Then, the behavioural change would lead to several intermediate outcomes which accumulate into ultimate outcome.

However, it should be noted that how the regulation meets the desired outcomes is complex. Coglianese (2012) mentioned many things could influence behavioural change. For instance, besides regulation implementation, there might be other regulations that affects the targets' behaviour. Furthermore, the regulation might not change the behaviour as intended. So it is hard to attribute one outcome to a single regulation. Therefore, it is important for the government to take those influences and factors from inside and outside the regulation into account to evaluate the effect of one regulation.

Based on the conceptual map (Figure 1), the regulatory policies can be evaluated in three ways which are regulatory administration evaluation, behavioural evaluation and outcome performance evaluation (Coglianese, 2012). Regulatory administration evaluation focuses on how the regulation is delivered and enforced. Behavioural evaluation focuses on to what extent the regulation changes the behaviour of the policy target. Outcome performance evaluation focuses on evaluating the outcome of the policy implementation. In this study, we only focus on analysing the outcome performances of the odd-even scheme.

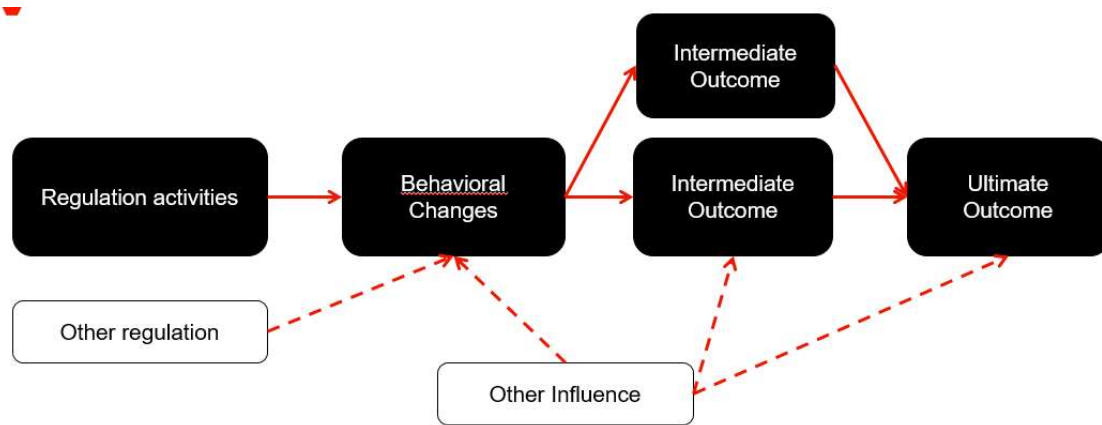


Figure 1 Causal map of regulation and its effect adopted from Coglianese (2012)

In different notes, many approaches could be used in assessing the effect of TDM measures. Some of them evaluate the effect of the TDM measures based on indicators that are directly affected by the regulation, such as travel times, travel speed and traffic flow (e.g. Li & Guo, 2016). Another researcher looked into the indicators that are indirectly affected, such as the amount of gasoline used (e.g. Eskeland & Feyzioglu, 1997), or the number of rule breakers (e.g. Wang et al., 2013). Some of them also pointed out the impact of this regulation in alternate road (Hanna, Kreindler, & Olken, 2017)

Table 1 Comparison of several journals on measuring the effect of road space rationing

No.	Journal	Indicator	Methods	Data Required
1	Eskeland and Feyzioglu (1997)	Reduction in induced demand	Modelling gasoline demand	Aggregate time series data of gasoline demand from before the regulation
			Modelling of car ownership with discrete choice modelling to see what socio-economic determinant that influence	General-purpose household expenditure survey 1989, conducted before regulation

No.	Journal	Indicator	Methods	Data Required
2	Wang et al. (2013)	Percentage of car reduction	Calculate the average number of simple tour trip of individuals in every weekday and compare it to the number of cars	OD matrix from Beijing Household Travel Survey.
		Number of rule breakers	Calculate the trip that violates the rule (for instance, the number of odd vehicles which enter the area in peak period in the even day).	OD matrix from Beijing Household Travel Survey.
3	Li and Guo (2016)	Traffic volume	Compare the total traffic volume before and after regulation in each expressway network (there are five ring expressway network in Beijing)	Data collected hourly, daily and weekly by using traffic detector.
4	Hanna et al. (2017)	Traffic Delay	Comparing the traffic condition in the restricted road and the unrestricted road, before the abolishment and after the abolishment	Travel time and speed which collected every 15 minutes using Google API
5	Eliasson (2014)	Traffic Volume	Comparing the average traffic volume across the cordon on weekdays, before the trials, on the trials, and in the implementation.	Annual average traffic volume
		Traffic Reduction,	Assessing the traffic reduction by using the model that considers inflation, economic population growth and car fleet growth.	Annual Average traffic volume Inflation, economic population growth and car fleet growth
		Travel time	Assessing the congestion reduction, comparing travel time before to after the implementation.	Average travel time, taken from all weekdays for six weeks in April-May
6	Xie & Olszewski, (2011)	Traffic volume	Modelling to forecast short-term effects of rate adjustment on peak period traffic volumes by estimating the maximum likelihood value of preferred arrival time (PAT) for each vehicle's arrivals at a particular ERP gantry under different charging conditions	Traffic data that are collected by ERP system and estimation of PAT using discrete choice modelling.

Ferguson (2000) classified effect measurement of TDM implementation into three group based on geographic exposure. He described the geographic exposure as site level, corridor level and regional level. Reflecting the study mentioned above, Eskeland and Feyzioglu (1997) evaluated the effect by modelling gasoline demand and car ownership on the regional level. Li and Guo (2016) and Hanna et al. (2017) evaluated in corridor level by using traffic data such as traffic delay and traffic volume while Wang et al. (2013) evaluated the changes in traffic reduction and rule breakers in the site level. Based on those geographic exposures, the data required and the methodological considerations for the evaluations would be different.

Ferguson (2000) explained that data sources for evaluation could be collected in different ways including direct observation, revealed preference and stated preference survey. Direct observations are done by observing change due to the implementation such as traffic volume changes or travel speed changes. Furthermore, he mentioned that revealed the preferences survey could be used to collect the additional information which cannot be collected by direct observation. Through the revealed preference survey, travellers' detailed information and their travel choices can be provided. However, he stated that the survey for revealed preference would need more time and fund compared to the direct observations.

In this study, the effects of the odd-even scheme are evaluated from two sides. First, the effect on traffic conditions is assessed by using comparative analysis between before and after the implementation of odd-even scheme both inside the corridor and outside the corridor. Second, the effect on travellers' behaviour is also identified by interviewing car users and local experts in Jakarta who understand about urban transport system and travel behaviour in Jakarta. Interview and web-questionnaire are used instead of revealed preference survey because the survey would need much time and resources. In the next subpart, data requirement and methods from other case studies are explained as an example of how other cities assessed the traffic effect and behavioural changes after they implement TDM measures.

2.4.1. Effect on Traffic Condition

Congestion relief could be occurred when the traffic evaluation could be done effectively (Zhang, Wang, Quan, & Liu, 2013). Therefore, in this section, data requirement and methodological considerations of traffic evaluation will be discussed.

2.4.1.1. Performance Indicator

Analysing the effect of traffic restriction could be done by comparing the traffic condition before and after the implementation. Some studies using different indicators to evaluate the traffic conditions. Some of them measured the congestion level (Hanna et al., 2017; Transport for London, 2003, 2006, 2007, 2008). Some others described the changes in the traffic pattern (Eliasson, 2014; Xie & Olszewski, 2011). Litman (2017) described several congestions indicators that are frequently used such as roadway level of service, multimodal LOS, travel time index (TTI), commute duration, and annual delay per capita. Moran Toledo (2011) divided the congestion indicator into two groups based on the measurement approaches, namely travel time approach and the bottleneck approach. He explained that the travel time approach use the indicator that considers the contrast between the observed and relative free flow traffic conditions such as excess delay, travel time index and relative speed reduction. Meanwhile, the bottleneck approach refers to the travel demand that exceeds the capacity in a particular point of roads such as queue indicator. Later, by using a simulations, he found that the relative speed reduction and excess delay performed better than the others in describing the congestion level in area-wide.

Hanna et al. (2017) use excess delay (i.e. an inverse of travel rate) to measure the congestion level after the abolishment of 3 in 1 policies in Jakarta. The excess delay was also used by Transport for London (2003, 2006, 2007, 2008) in monitoring the traffic condition related to the congestion charge. Transport for London (2003) argued that this indicator suit better than the average network speed in describing the congestion. The excess travel time is defined as "the time spent over and above that under 'uncongested' or 'free-flow' conditions." This indicator is derived from the network speed data. First, they calculate the average travel rate (i.e. the inverse of speed) to represent the average of the vehicles slowness. Then, they calculate the differences between the uncongested network travel rate and the network travel rate to represent the excess travel time.

Another indicator that usually used to measure congestion is average travel speed. Average travel speed is a relatively straight-forward indicator that is affected immediately after the regulation is implemented. Travel speed is defined as the distance of one vehicle travel per unit of time (Hunter-Zaworski et al., 2003). To

evaluate the traffic effect, individual travel speed must be aggregated, usually, by averaging based on time and space.

Time-mean speed is the average speed of all vehicles at one point in a particular period. This type of average speed usually calculated by a detector in a specific location. The most common instrument is the dual-induction loops (Knoop, Hoogendoorn, & Zuylen, 2009). In another study, Li & Guo (2016) used collected time-mean speed from 592 microwave and ultrasonic detectors every 2 min, as one of the measurement units. However, averaging speed based on time can overestimate the mean speed because it underestimates the influence of faster vehicles (Knoop et al., 2009). Thus it leads to underestimating the traffic volume and density. Therefore, it is better to use space-mean speed. Space mean speed usually acquired by using moving car observer (Taylor et al., 2000; Transport for London, 2003, 2006, 2007, 2008).

However, recent technologies allow an easier way to collect space mean speed data. Using floating car data from Google API, Hanna, Kreindler, & Olken (2017) used space-mean speed throughout the city in evaluating the city-wide effect on 3 in 1 discontinuation in Jakarta. An API (application programming interface) is an interface that is used by the developer to deliver some of their data or services to the public. One of Google Maps Services that can be accessed through Google API is Distance Matrix Services. This service allowed the public to access aggregate real-time travel time from one point to another point that is compiled from Android smartphones users. The space-mean travel speed can be calculated by multiplying the real-time travel time in a road segment and the distance of that particular segment.

In describing the changes of traffic pattern the most commonly used indicators are traffic volume (Eliasson, 2014; Xie & Olszewski, 2011). Traffic volume could be presented as actual number of vehicles observed that passes a given point on the highway in a given time (Hunter-Zaworski et al., 2003). The traffic volume can be observed in passenger car unit (PCU). PCU is the measurement unit that considers the impact of the difference between modes which is essential to analyse mixed traffic because one vehicle type cannot be equivalent to other vehicle types (Mardani N, Chandra, & Ghosh, 2015). The number of vehicles is converted to an equivalent number of a passenger car by multiplying mode shares to an equivalency factor.

The traffic volume can be collected manually or automatically (Smith, Melntyre, & Anderson, 2002). Manual traffic counting refers to manual procedure using tally sheets, hand tally or mechanical counters. Manual traffic counting is commonly used to collect data for determination of vehicle classification, turning movements, travel directions, pedestrian movements, or vehicle occupancies. Zheng and Mike (2012) studied the possibility of error in manual traffic counting from a video source. They pointed out that manual counting is dependent on the individual judgement from traffic counters. The error can be classified into two categories, counting error and classification error. They counted traffic from three different cameras and estimate the error by calculating the difference between those results. They also count the traffic by two approaches, which are by counting the number of unclassified vehicles and by counting the number of classified vehicles. They found that by doing manual traffic counting, the error of classified-vehicles counting is higher than the unclassified one.

On the other hand, automatic counting method is more efficient than manual counting method. Automatic counting is done by using portable counters, permanent counters, or videotape and commonly used to gather data for assessment of hourly patterns, daily or seasonal variations and growth trends, or annual traffic estimates. Several studies used the automated counter to monitor the traffic condition. This kind of data is important to understand the traffic pattern and understand the effect of regulation much further, especially if using statistical analysis. Eliasson (2014) studied the traffic effect of an ERP implementation by comparing the average traffic volume across the cordon on weekdays, before the trials, on the trials, and in the implementation. These detailed data are collected by using ANPR, which also the device for enforcing the regulation. In a different study, Li & Guo (2016) also used 528 traffic detectors to detect the traffic volume (hourly, daily and weekly) to assess the effect of the odd-even scheme in Beijing. However, providing

automated counters might be costly and sometimes could not cover the whole target area (Taylor et al., 2000).

2.4.1.2. Key issue in traffic effect evaluation

The variability of the traffic conditions before the implementation should be analysed to understand the change in traffic condition after implementing the regulation. The variability can be based on spatial and temporal variations. That spatial and temporal pattern of traffic conditions represents vehicle use, congestion and safety issues, as well as its influence on emissions (Batterman, Cook, & Justin, 2015). That variation can be modelled to test the robustness of traffic restrictions or to make public transportation timetables more responsive to the needs of travellers or commuters (Crawford, Watling, & Connors, 2017). For instance, Xie & Olszewski (2011) forecasted the short-term effect of ERP rate adjustment on peak period traffic volumes using a one-year dataset of traffic volume recorded by ERP gantries.

One critical issue in evaluating the variability of traffic conditions is data availability. Usually, the data is collected in a sloppy manner or is not adequately managed. In addition, to capture the variability of traffic condition requires a vast amount of traffic data because traffic can be dynamic depending on external factors such as weathers, events or accidents (Zhang et al., 2013). To illustrate the traffic pattern, the data used would be challenging. Crawford, Watling, and Connors (2017) explained that traffic could also vary between the time of the day, days of the weeks or months of the year and its difference could be predicted. In their study, they predicted the day-to-day systematic difference of traffic using a statistical approach. They used real-time traffic flow data for two year period. In another study, Zhang et al. (2013) also used one-year dataset collected by using inductive dual loop detectors to measure the variability of traffic conditions in the freeway in Jilin, China.

Moreover, sometimes the external factors are not even related to the traffic conditions. Those factors usually affect the travel demand directly as Litman (2013) mentioned, including demographics, commercial activity, transport options, land use, demand management and prices (see Table 2). Not all those parameters are affecting the ridership in the short times. The direct and short-term implications usually are induced by prices, transport options augmentation and demand management. Demographics, commercial activity, land use more likely affect travel demand in a long time because those factors evolve in a longer time. These parameters should be included in the analysis to understand the “real” effect of the regulation.

Table 2 Factor affecting travel demand (Litman, 2013)

Demographics	Commercial activity	Transport options	Land use	Demand management	Prices
• Number of people (residents, employees, visitors) • Employment rate • Wealth /Incomes • Age/lifecycles • Lifestyles • Preferences	• Number of jobs • Business activity • Freight transport • Tourist activity	• Walking • Cycling • Public transport • Car-sharing • Automobile • Taxi services • Telework • Delivery services	• Density • Mix • Walkability • Connectivity • Public transport services • Proximity • Roadway design	• Road use prioritisation • Pricing reforms • Parking management • User information • Promotion campaigns	• Fuel prices and taxes • Vehicle taxes • Road Tolls • Parking fees • Vehicle insurance • Public transport fares.

Understanding the spatial variation and the temporal pattern is also helpful to select the best period in implementing traffic restrictions. For instance, Yannis, Golias, & Antoniou (2006) have proven that the

effectiveness of an urban delivery restrictions policies in Athens is dependent on the selection of the time of implementation, as well as the types of business for which they applied. In the study, they used hourly traffic flows (per link), average travel speeds (per link); traffic mix (per hour and link) for five vehicle classes; and fleet composition. In another study, Eliasson (2014) evaluated the Stockholm congestion charges using annual average traffic volumes across the cordon from 2000 to 2013. Through the analysis, they could show that the annual average traffic volume increased after the implementation and was steady in specific volume after seven years of the implementation.

2.4.2. Effect on Travel Behavior

TDM implementation affects people's behaviour in various ways. An individual may change their routes, mode of travel, and time of day for making their trip in response to TDM measures. An individual may also travel less frequently and choose closer destinations. Eliasson (2014) explained that adaptations due to regulation implementation are much more multi-faceted. Those adaptation strategies depend on the city characteristics and the system design, and the travel alternatives that leaves open. Steg and Schuitema (2007) listed type of change due to transport pricing which is believed to be similar to behavioural changes that are caused by other hard measures.

Table 3 Behavioral change due to TDM implementation adopted from Steg & Schuitema (2007)

Type of Change	Specification of Behavioural Changes
Driving Behaviour	Driving style
Travel Behaviour	Trip chaining
	Route choice
	Time of Travel
	Destination choice
	Number of Trips
	Mode choice
Vehicle ownership	Type of car (e.g. fuel type, size)
	Number of cars
	Replacement of cars
Location choice	Choice of Residence
	Choice of Workplace

Several studies have investigated the adaptation of drivers after implementation of regulation, Franklin, Eliasson, & Karlstrom (2009) investigate the changes of car users' travel pattern because of the congestion charges in Stockholms and how did it happen. They also explored more detailed of who changed modes or adjusted departure time. The source of information for their analysis is a two-time panel trip surveys carried out in 2004 (before the charges) and 2006 (when the charges had been introduced). As a result, they found that 25% person trips across the cordon disappeared. They divided the trips into two categories which are work trips and discretionary trips. They found that route switching was only a minor adaptation strategy that drivers use. The advantage by separating the work trips and discretionary trips is they can think of other strategies that are used to adapt the charges which is switching to other destinations or reducing the trip frequency, possibly by trip chaining or combining trip purposes.

Wang et al. (2013) choose a different point of view in evaluating the regulation based on the travel behaviour. They investigated the rule breakers due to the driver restriction in Beijing. In their study, they used OD matrix from Beijing Household Travel Survey to calculate the number of the restricted car that passes through the area in the restricted time range. As a result, there are 47.8% violators. From the examination, most of them are relatively young, and the violation more likely did during peak hours.

Bamberg et al. (2011) presented one conceptual framework (see Figure 2) that often used to explain car user's decision making. In the framework, hard measures (also called push measures in this research) such as traffic restriction intervenes and modifies the perception of the objective environment. That modification influence individuals' purposes of travel, departure time, travel times and costs, which belong to trip-chain attributes. The changes in trip chain attributes affect the decision-making system that is already affected by socio-demographic factors and situational factors. Meanwhile, soft measures intervene the travel decision making process in several ways. It can be supporting strategies for the hard measures. It can also directly affect the individuals' perception of the environment (e.g. improving the service quality of public transport) or trip chain attributes.

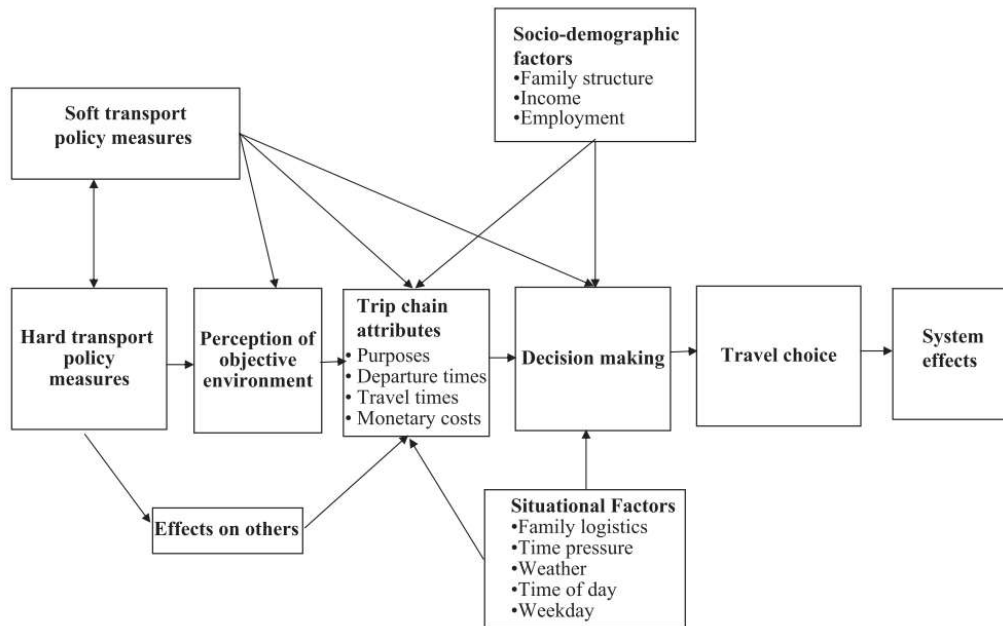


Figure 2 Conceptual Framework of how policy measures change travel choice

Ferguson (2000) mentioned that cost and time are mostly the factors that influences travel decision making. Travel cost is the cost incurred to travel from origin to destination including public transit fares, road tolls, parking fees and fuel cost. Travel time is time that is used to travel from origin to destination including waiting time, walking time, transit time, and in-vehicle time. Ferguson also said that besides quantitative attributes, there are qualitative attributes which include comfort, convenience, reliability, safety and security.

2.5. Summary

The difficulty of dealing with congestion through supply management policies is increased due to rising cost of construction and elasticity of latent travel demand. Therefore, the importance of travel demand management has arisen. It can be classified as two kind of measures, push measures and pull measures. Each kind of measure has advantages and limitations compared to one another. However, some studies found that implementing a combination of push and pull measures work effectively compared to only implementing a single measure.

The focus of this study is the influence of road space rationing as one of the push measures. Road space rationing is widespread in developing countries because it is seen as an easy to implement and low-cost strategy compared to other hard policies such as Electronic Road Pricing which is required rigorous preparations. However, from the experience of several cities, the implementation of road space rationing are rarely effective in the long-term implementation. Through this research, implementation of road space

rationing is evaluated two ways which includes the evaluation of the traffic reduction, as the outcome performance, and the evaluation of behavioural changes.

First, the outcome performance, in this case, the traffic performance, is evaluated by comparing the traffic variables before and after the implementation both inside the corridor and outside the corridor. In this study, average traffic volume, average travel speed and average travel time are used to define congestion. Because the traffic condition was not only affected by demand management regulation, but also demographics, commercial activity, transport options, land use and prices, comparing the condition before and after the regulation could lead to wrong conclusion. Therefore, those factors that influence the traffic should be controlled in analysis.

Secondly, behavioural change evaluation focuses on how the people adapt due to the regulation of implementation. The travellers' travel choice might be helpful to understand the traffic effect. In this study, this behaviour effect is seen as a complementary analysis to support the traffic effect analysis due to lack of data. It is only an indication of how people avoid the traffic restriction, and could not represent the whole population of the affected travellers.

3. METHODOLOGY

3.1. Study Area

Jakarta, as the capital city of Indonesia, has experienced rapid urbanisation and economic growth. The city is home to 10.27 million people. As the center for businesses and government activities, Jakarta attracts residents from surrounding cities Bogor, Depok, Tangerang and Bekasi. A commuter survey that was conducted by the Central Statistics Agency of Jakarta (BPS Jakarta) in 2014 has revealed that 2.43 million commuters travel within, into and out of the city daily. Out of these, 1.38 million travel from the outskirts of Jakarta into the capital (Central Statistic Agency of Jakarta, 2015). Thus, severe congestion happens especially in the rush hours on weekdays, when commuters travel to their offices in the center of Jakarta. Adiwianto (2010) explained that the economic losses (including the value of time, fuel costs, and health costs) because of traffic congestion are Rp. 12.8 trillion/year (or equal to € 813 million). In 2020, the losses were predicted increasing to Rp. 65 trillion (or equal to € 4,13 million).

Sudirman-Thamrin-Medan Merdeka Barat corridor and Gatot Subroto corridor are parts of Jakarta's main access roads to the CBD. Together with Rasuna Said corridor, these corridors form the Golden Triangle, which is the center of the business district and government offices in Jakarta. Since the activities attract workers from the city's outskirts on the weekdays, these corridors are becoming increasingly congested. That is why Jakarta Government has implemented some TDM measures to relieve congestion. One of this measures is the odd-even scheme. This regulation is only implemented in the morning and evening peak period along four major roads in Jakarta. Transportation System in Jakarta.

3.1.1. Transportation System in Jakarta

The transportation system in Jakarta still faces many problems such as insufficient road capacity and unintegrated public transport provision. Adiwianto (2010) explained that Jakarta has low capacity of public transport, only covering 53% of the travel demand. The condition is also aggravated by the decreasing number of buses because of poor maintenance. The integration between different types of public transportation is also poorly planned.

Due to limited and unintegrated public transportation systems, residents and commuters use private vehicles. According to Central Statistic Agency of Jakarta (2017), the registered vehicles in 2016 are mostly consists of motorcycle (73,92%), followed by passenger car (19,58%). From 2011-2016, car growth was 6.48% per year, and motorcycle growth was 5,30% per year. Moreover, the ratio of the number of private vehicles (i.e. registered motorcycles and passenger car) to the number of Jakarta residents in 2015¹ is 1.71, which means that generally at least the residents of Jakarta has at least one or two private vehicle. However, road infrastructure growth was only 1% per year while vehicle growth is about 11% per year (Regional Development Planning Board of Jakarta, 2013). Although there are ongoing road expansion programs until 2030 (Spatial Plan 2030), the added capacity would not catch up the vehicle growth.

In 2004, The Jakarta Capital City Government established a new BRT system called TransJakarta. Initially, TransJakarta was established in 12 primary routes with 228 transit stops. In 2017, TransJakarta established the 13th primary routes and ten additional routes. TransJakarta operates from 5 AM to 10 PM. To improve

¹ The source of the number of Jakarta's residents in 2015 is Apsari et al (2016)

the service, PT TransJakarta established Night Service Buses in 2015, which operate from 10 PM to 5 AM. Although the number of TransJakarta passengers were increased dramatically from 2007 to 2010, the number of passengers remain stable after 2010 and even decreased in 2015 (see Figure 3)



Figure 3 TransJakarta Passengers

The decreased total number passenger in 2015 might be because many buses retired from the road due to quality inspection from local government. In 2016, Government added more than 300 new buses including TransJakarta bus and feeder bus (Figure 5) therefore it led to the increasing number of passengers in 2016 (Figure 3). The Government also merged the regular buses into the BRT system. These buses were assigned as feeder buses which usually served citizen in the residential area were not served yet by TransJakarta (Central Statistic Agency of Jakarta, 2017). However, the ratio of number of passenger to number of bus declined in 2016

(Figure 4) which means that the number of bus increased significantly whereas the number of passengers increased not as significant as the increased capacity of bus fleet.

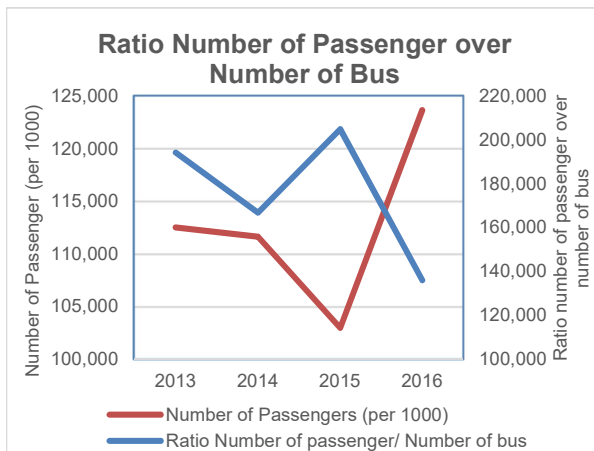


Figure 4 Ratio Number of Passenger over Number of Bus

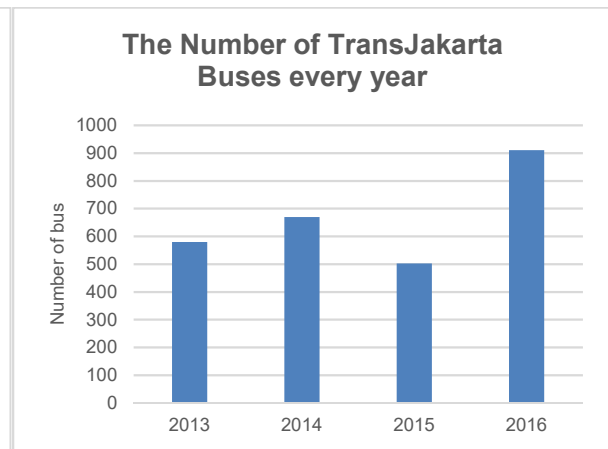


Figure 5 The Number of Buses

Besides TransJakarta, Commuter line is one of the public transportation modes which serve commuters from outskirts to the city centre. Most of the residents from surrounding cities use this mode every morning in the peak hours. Although PT. KAI, which is the transport operator of the Commuter line, improved it by adding wagons which increased the capacity from 400.000 passengers to 700.000 passengers per day in 2015. However, this capacity still needs to be improved in order to serve more commuters and travellers because the demand for this type of public transportation is increasing.

Although each of the cited public transportation systems has been improved, the Regional Development Planning Board of Jakarta (2013) explained that the lack of integration between these transportation system causes inefficiency and ineffectiveness in mobility. First mile and last mile trips, which are the movement between the origin to the transit or the transit to the final destination, are still not planned attentively. An integration of the public transportation systems is needed, but also an improved pedestrian facility to facilitate the first mile and the last mile trips. The interviewee from MTI (Indonesian Transport

Association) confirmed this by stating that *“Jakarta still do not have good pedestrian facilities. We should have a good pedestrian facility because every public transportation user is a pedestrian”*. Furthermore, an expert from University of Indonesia said that Government has to improve public transportation quality to be as good as the quality that private car can offer, so the commuters have other option besides cars. He explained that *“Hard measures ‘push’ people to neglect their car, but, push them into what? All the while, their lives goes on, they have to work, and if there are no alternative modes, they would still use their cars.”*

Currently, the first mile and the last mile transportation are filled in by online-based transportation, especially using ojek (motorcycles taxi). This kind of transportations can be ordered by using an application through smartphones such as Uber, Gojek and Grab. In Jakarta, these modes are favourite among commuters because it is easy to order, cheap, fast and also serve from door to door. However, these kinds of transportation are still not legalised by the Indonesian government and still has resistance from e.g. taxi companies, minibus cooperation because they are seen as competitors. However, this problem persists for about 7 years, since the first online-based transport emerged in the transport market in Jakarta.

3.1.2. Transportation Policy in Jakarta

Jakarta Capital City Government has already put the transportation system plan within Regional Spatial Plan 2030. It was the first step of integration of land-use and transport planning in Jakarta. In the plan, to achieve efficient and effective transportation system, The Government set the target that by 2030, 60% of all trips would be done by public transportation and the minimum average travel speed of the road network would be 35 km/h.

Before the Regional Spatial Plan 2030 has been established, Jakarta Capital City Government enacted the “Governor Regulation Number 103 Year 2007”, which contains the plan of transportation network system and its supporting regulation in Jakarta. In the regulation, Jakarta Capital City Government aims to optimise public transportation utilisation as the primary network. However, they also apply TDMs and develop road network to support it. They intend to increase accessibility and mobility in the area and surrounding, also to integrate transportation mode. Based on this regulation, the Government will integrate all of the public transport modes as they want to shift people mode choice from private vehicles to public transportation. The government is also investing in new mass rail transportation systems (MRT and LRT) since 2012, planned to be finished in 2018. In addition, the government established the plan to add more bus priority routes (BRT) in the next three years. Along with the improvement of infrastructure, TDM measures (such as odd-even scheme for traffic restriction) are also implemented in several road segments, as well as park and ride systems, and improvement of the information systems and traffic control.

Three Travel Demand Management measures are currently implemented in Jakarta. They include a restriction for motorcycle, a school travel plan and an odd-even scheme. The odd-even scheme is applied in 2 corridors while motorcycle restriction is implemented in two road segments within these corridors. Motorcycle restriction is from 6 AM to 11 PM every weekday while the odd-even scheme is implemented only during rush hours every weekday. Besides these two regulations, the school travel plan instructed an earlier start for schools in Jakarta. Although this regulation was not purely done for transportation purposes, it has successfully dispersed travellers' departure times.

In applying TDM measures, the Government established the traffic restriction plans which are to be implemented by 2030, and located in Jakarta's central business district Figure 6 Traffic Restriction Plan in Spatial Plan 2030. These plans are to be implemented in four phases within the CBD area. These area are designed as the traffic area restrictions by considering the public transportation availability. Among these

implementation phases, Sudirman-Thamrin- Medan Merdeka Barat corridor was assigned to phase one while Gatot Subroto corridor to phase 2 (Figure 6)

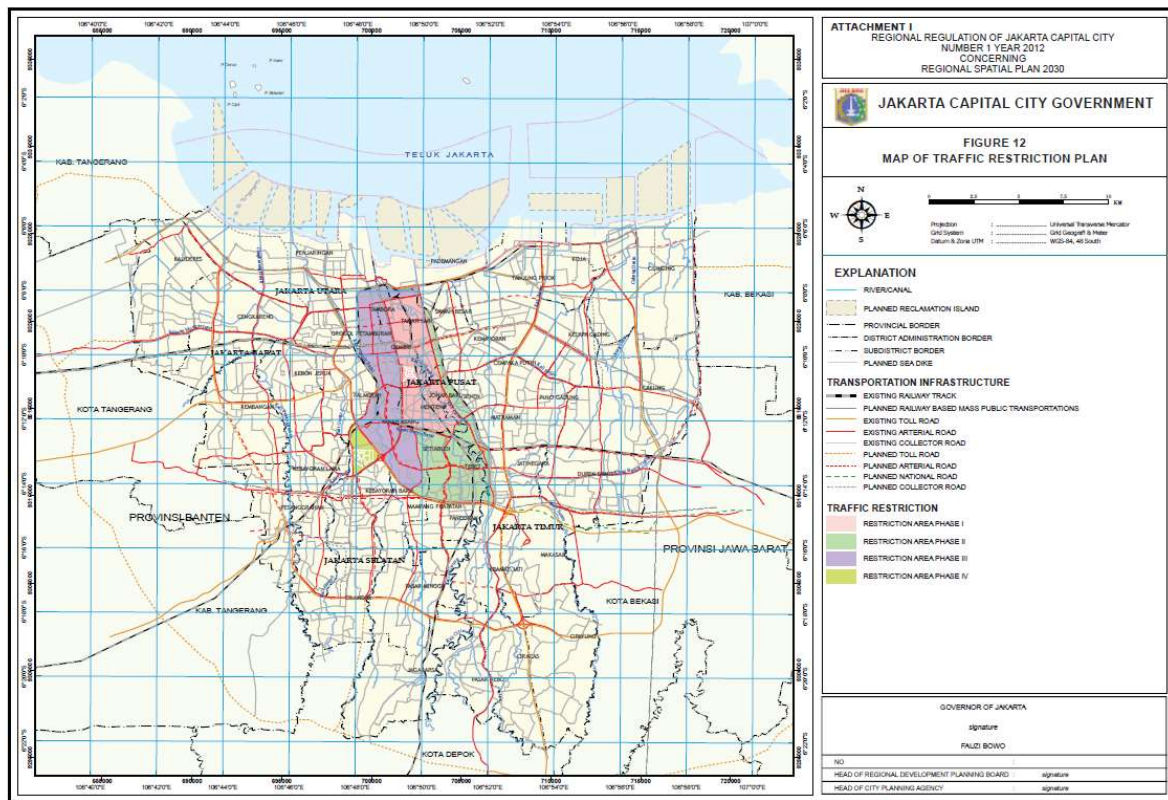


Figure 6 Traffic Restriction Plan in Spatial Plan 2030

3.1.3. TDM Measure in Two Corridors

Sudirman-Thamrin-Medan Merdeka Barat corridor and Gatot Subroto corridor are parts of Jakarta's main roads, and together with Rasuna Said corridor form the Golden Triangle, which is the centre of the business district and government offices in Jakarta. These three corridors are a part of traffic restriction area that is already included in the Spatial Plan 2030 (Figure 6). However, until now, the traffic restriction has only been implemented in the two first cited corridors. Jakarta Transportation Agency reasoned because both corridors are already served by public transportation systems, and also because the traffic restriction plan would be applied gradually to prevent public oppositions. Thus, they implemented first in these two corridors, which are already known by the public as traffic restriction area.

"We have not implemented the traffic restriction in all areas yet (based on Spatial Plan 2030) because not all of the area is covered by the public transportation system. What I mean is not only TransJakarta but also other public transportation that meets the standard (which could be regular bus, LRT and MRT) from the Ministry of Transportation." -Jakarta Transportation Agency-

The first traffic restriction scheme in Jakarta was the "3 in 1 regulation", implemented in 1992 and abolished in 2016 (Hanna et al., 2017)(Figure 7). This regulation restricted cars with under three-persons in a vehicle to enter the corridors. This regulation was first introduced to relieve congestion in the morning peak. Because of the findings that the implementation was successful to reduce traffic in the peak hours (Nanang

& Tamin, 2009), they added the length of restriction hour for the evening peak in 2003. However, the non-compliant behaviour arose and was seen as having a bad social impact. Car users were hiring “jockey”² to avoid the restrictions. Over time, “jockeys” could not be controlled, as they were not only adults but also children below 15 years old hence 3 in 1 regulation was abolished in May 2016. On the other hand, based on Hanna, Kreindler, and Olken (2017) the regulation lifting affect the traffic inside the corridors. By using data from Google Floating Car Data, comparing the traffic delay before and after policy lifting with the consideration city- wide changes in school schedules, income, and weather changes. As a result, they found that the traffic delay was getting worse after the policy lifting. The policy lifting was not only affecting the traffic inside the formerly restricted corridors but also affecting the alternative roads and time periods. By using a simple stylized model, they inferred that the observed increased traffic was due to the increase in the number of cars (e.g. people stopped using busses, or stopped carpooling).



Figure 7 TDM implementation in the corridor

After two months with no regulation attached to the corridor, the Government implement another TDM measure to substitute the implementation of 3 in 1 policy. Between 27th July 2016 and 26th August 2016, trials were held for the odd-even scheme implementation in the same corridors as the former 3 in 1 policy was applied. During the trial, they found that the odd-even scheme could lead to private car reduction and further decrease the traffic volume in both corridors. The application of this regulation started on 30th August 2016 on five road segments which are Medan Merdeka Barat road, M.H. Thamrin road, Jenderal Sudirman road, part of Sisingamangaraja road and part of Gatot Subroto road (Figure 8). Motorcycles, emergency vehicles, mass transit vehicles, and public service vehicles were exempted from these restrictions.

The regulation is enforced by the Local Authority on Traffic Management. Earlier in the implementation, 200 personnel of Jakarta Transportation Agency and Local Authority were deployed to observe the implementation and enforce the regulation. There are nine monitoring points which include the entry point and exit point along the corridors (Bundaran Patung Kuda, Bank Indonesia, Sarinah, Hotel Indonesia, Imam Bonjol, Senayan, CSW, Gatot Subroto, dan Mampang). Violation of this regulation falls under violation of license plate installation rule and will be charged Rp. 500.000 (approximately € 33) or 2

² Jockeys are persons that provide an additional passenger to the car user who did not have 3 passenger in one car when entering the 3 in 1 area (Hanna et al., 2017)

months prison. The implementation is monitored manually by observing the plate number in nine locations along the corridor.

The local experts agreed that the odd-even scheme has a less social impact than the 3 in 1 policies. The “jockeys” disappeared due to the abolishment of 3 in 1 policies. However, the odd-even scheme enforced manually, similar to 3 in 1 enforcement procedure. This kind of enforcement is unpractical and needs considerable number of human resources. Moreover, at first, the odd-even scheme might seem easy to use, but along the way, it will be ineffective, since the monitoring quality will depend on the individuals responsible for monitoring.

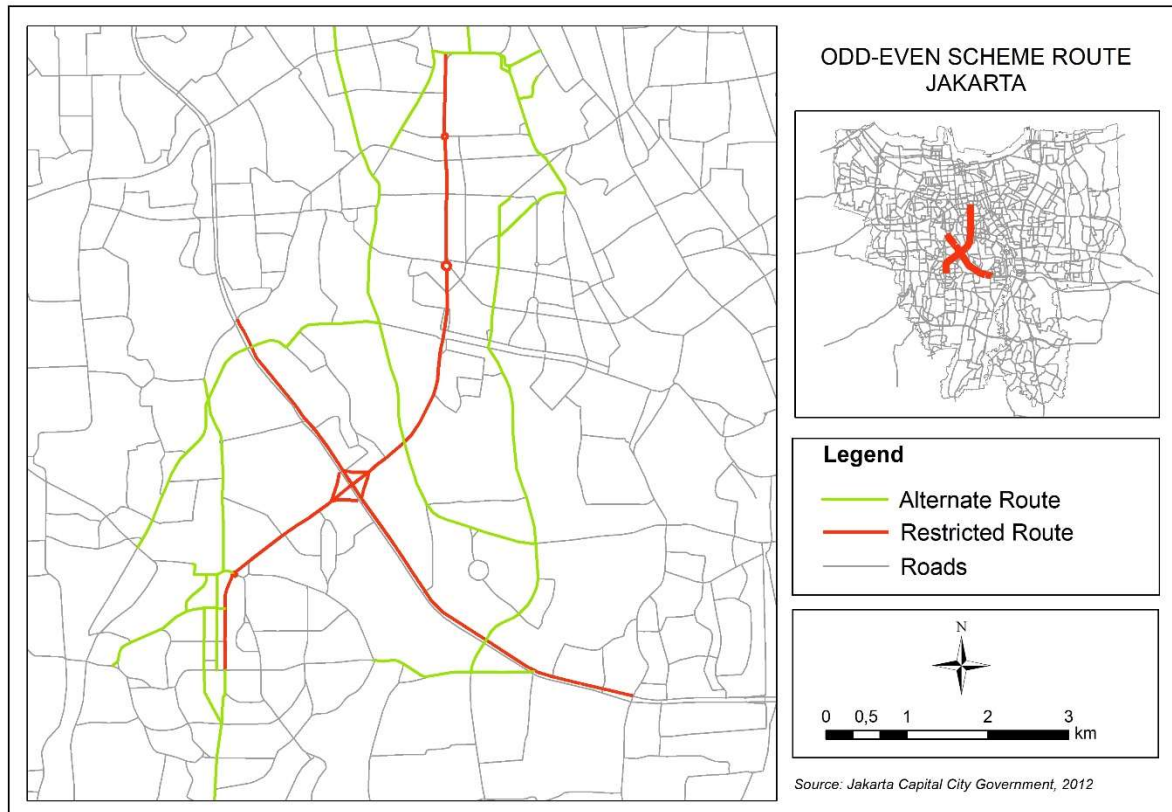


Figure 8 Odd-Even Scheme Restricted Route

Initially, the Government has planned to substitute the 3 in 1 regulation with electronic road pricing (ERP) implementation. However, because ERP implementation is complex due to its system, it could not be executed in the corridor at the time of 3 in 1 abolishment. The ERP system was instigated in 2006 and had been hot debates since then. The implementation is planned to be implemented in the Golden Triangle Corridors. They already held trials in two corridors in 2014, but its implementation is planned for 2019. ERP could be more effective compared to 3 in 1 policy and odd-even scheme because the system can be adjusted based on the traffic condition itself when the traffic volume is higher, the price could be set higher than usual. Experts from MTI and ITDP confirm that, by using the ERP system, the Government could easily monitor the traffic condition, thus making it easier to evaluate its effectiveness.

On the other hand, they still have to plan the system accurately including determine where they should charge people, how is the charge collection system, how much driver should pay, how is the price determined, as well as how large the restriction coverage. The implementation is also constrained by a

national law, which still does not include ERP as regional income. Thus, there are still many things that should be prepared for implementing the ERP system.

3.2. Research Design

Figure 9 Research Design Flowchart (Workflow) shows the research design of this study.

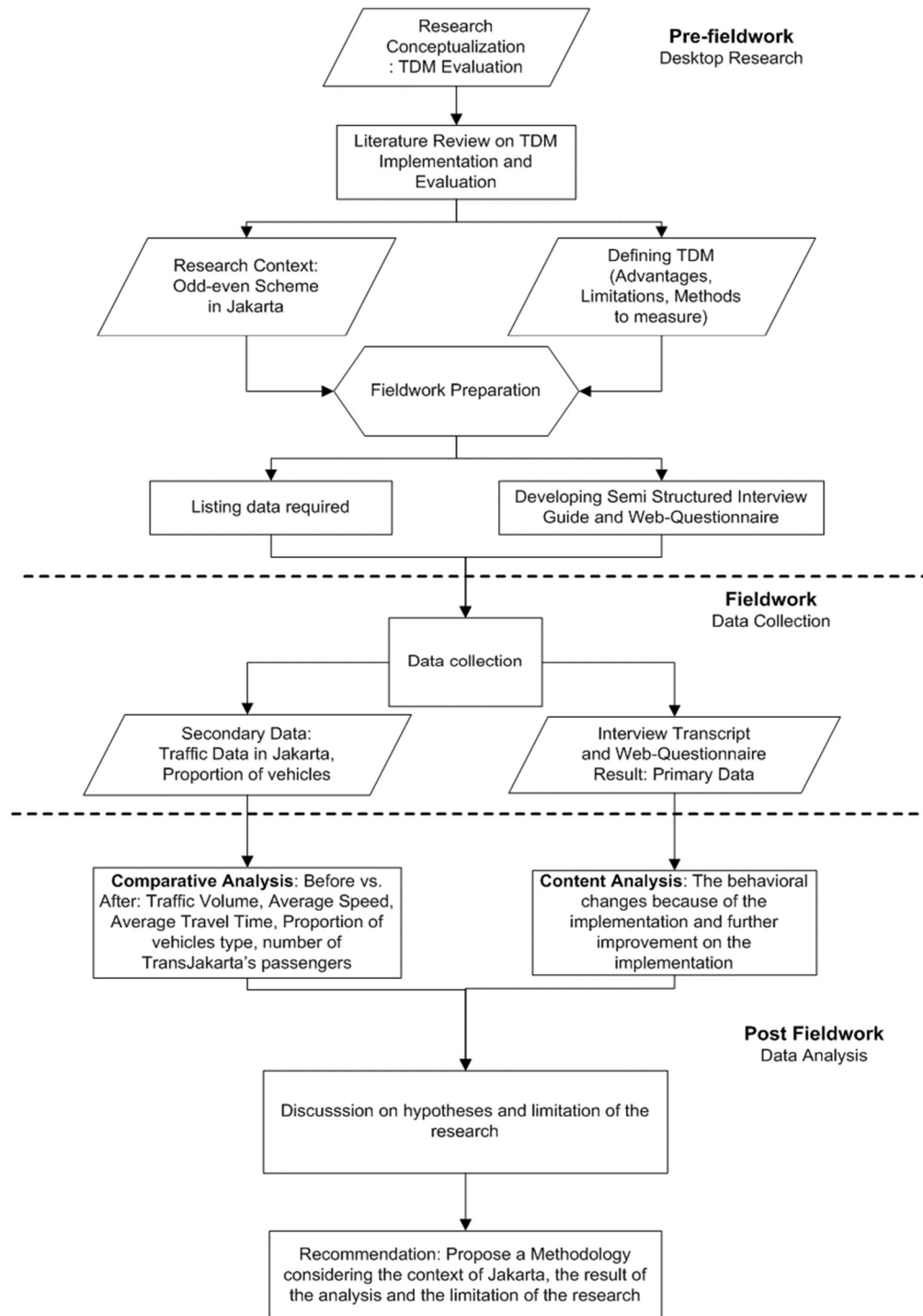


Figure 9 Research Design Flowchart (Workflow)

In pre-fieldwork phase, a literature review is done to understand why TDM policies is implemented, what are the objectives of the policies, what are the type of TDM, as well as, what are the advantages and the limitations of using such policies. After understanding TDM policies and their advantages-disadvantages, the odd-even scheme in Jakarta is investigated as one case study. To assess the effect of the odd-even restriction, we do the literature review for identifying the indicator and for understanding the context of case study (in term of the odd-even rules, the location of the restricted road, the characteristic of the land-use and transport plan in the location). In the fieldwork phase, the secondary data is collected from Jakarta Transportation Agency and also by doing interviews with a local expert to answer the third sub-objective. A comparative study is done by using available data. Based on the result, the effect of the odd-even scheme in Jakarta is concluded and the limitation of the study is discussed. According to the study limitation, a methodological approach is proposed for future TDM implementation in Jakarta.

3.3. Data Collection

This study uses secondary and primary data. The secondary data is provided by Jakarta Transportation Agency, and the primary data is collected by spreading web-questionnaire and interviewing local experts.

3.3.1. Secondary Data

To assess the effects of the odd-even scheme in and around the restricted corridors, traffic-related data was acquired from the Jakarta Transportation Agency, which is described in Table 4. Several consultants that are collected and analysed the data are also contacted to get more information on what methods they use and to gather more detailed data. However, not all of the consultants can be contacted except one consultant, PT. Danureksa Sarana Cipta.

Table 4 Data Acquired and Sources

Data	Temporal Unit	Spatial Unit	Source
Average Speed	Average speed in the peak hour (morning (6 AM-10 AM) and evening (4 PM – 8 PM))	per corridor	Jakarta Transportation Agency
Average Travel Time	Average travel time in the peak hour (morning (6 AM-10 AM) and evening (4 PM – 8 PM))	per corridor	Jakarta Transportation Agency
Average Traffic Volume in the restricted road	14 hours in 3 days before, 6 days in trial period, and after 7 month implementation.	4 monitoring point	Jakarta Transportation Agency or the consultancies
Average Traffic Volume in the unrestricted road	In peak period in 3 days before and 3 days in trial period	7 monitoring point	Jakarta Transportation Agency
Number of TransJakarta users per transit	Daily average number of passenger in the peak periods for the months of July, August and September 2016.	per transit	Transjakarta via Jakarta Transportation Agency

3.3.2. Semi Structured Interview

Semi Structured Interview will be done to answer third sub-objective, which is to discuss the effect of odd-even traffic restriction. Semi-structured is a combination of specific questions which to bring the already-known information (e.g. from literature review) but also add some open-ended questions to explore more

about the phenomenon (Hove & Anda, 2005). This interview transcript will be analysed to understand the advantages and the shortcomings of odd-even traffic restriction based on local expert and also how they think traffic conditions in Jakarta can be improved to combat congestion in Jakarta.

The respondents are chosen using purposive sampling methods which include government institutions that established and monitored the implementation of the odd-even scheme, expert from University, practitioner and NGO that engaged in the transportation field, specifically in Indonesia (See Table 5). Their response is vital to analyse the effect of policy implementation based on context because one policy implementation will have a different result in different context.

Table 5 The research questions and data collections methods

Research question	Data Collection	Data Required	Respondent/Source
Research Sub-Objective 2			
What are the characteristics of the transportation system and transportation policies in the study area?	Semi-structured interview	Interview Transcript	Jakarta Transportation Agency
			Local Authority on Traffic Management
What is the effect of odd-even scheme implementation on car users' travel behaviour?	Semi-Structured Interview	Interview Transcript	Local Authority on Traffic Management
Research Sub-Objective 3			
What are the advantages and limitations of the odd-even traffic scheme in reducing congestion in Jakarta?	Semi-structured interview	Interview Transcript	Jakarta Transportation Agency
			Expert
What can be improved in the implementation of the odd-even scheme?	Semi-structured interview	Interview Transcript	Expert
Research Sub-Objective 4			
What are the data required for the evaluation of TDM implementation in Jakarta?	Semi-structured interview	Interview Transcript	Jakarta Transportation Agency
			Expert
What are the methods that can be used in evaluating TDM measures in Jakarta?	Semi-structured interview	Interview Transcript	Expert
What are the parameters that have to be controlled to implement the TDM measures in Jakarta effectively?	Semi-structured interview	Interview Transcript	Jakarta Transportation Agency
			Expert

3.3.3. Questionnaire

The questionnaire's purpose is to understand what car users do to adapt the odd-even scheme and to explore about what can be improved in implementation through understanding public perception of this regulation. The data collected from this questionnaire can be classified into three groups which are the trip pattern of respondents, the adaptation methods due to odd-even scheme implementation and their socio-

economic status. The trip pattern contains the data of how they usually travel before the odd-even scheme implementation while the effect of odd-even scheme gathers information about respondents' driving habits and the effect of the odd-even scheme on their travel habits. The socio-economic status includes their gender, occupation and age.

Online survey methods were used to get wider-responses. The link of the web-questionnaire were spread through social media and direct email. The target respondents are the car-users who work at offices along and around the restricted corridors and always use the restricted corridors to go their offices. Face-to-face interview with the same questionnaire is done to get more understanding of the environment and the conditions, Later, the result of the face-to-face interview is entered into the web-questionnaire manually.

3.4. Ethical Issues

In this research, the ethical issues are mostly related to the data collection phase. The respondents might not want to be interviewed. Before the interview, the respondent is given a brief explanation about the contents of the interview, together with a consent letter. Their answers will be treated with anonymity and solely used for research purposes

Table 6 Research Matrix

Research Question	Methodology		Required Data And Software	Data Availability	Anticipated Result
	Data Collection	Data Analysis			
What are the TDM measures already implemented worldwide	Online search, Library	Literature Review	Literature on transport policy, TDM and its implementation	Available	Review of TDM policy concept sand TDM measures that are already implemented.
What are the advantages and limitations of TDM measures in reducing congestion?	Online search, Library	Literature Review	Literature on transport policy, TDM and its implementation	Available	Review on advantages and limitations on TDM measures that are already used in the world.
What are the methods that are used to assess the effectiveness of TDM measures	Online search, Library	Literature Review	The literature on transport policy evaluation, and TDM effectiveness evaluation.	Available	Review of evaluation methods to measures traffic effect of TDM policies.
What are the characteristics of the transportation system and transportation policies in the study area?	Online search	Literature Review	Jakarta Transportation Masterplan, Spatial Plan 2030, Governor Regulations	Available	Explanation about the characteristic of Jakarta and the restricted road, in term of transportation system, land use, mode share and TDM policies in the area
What is the effect of odd-even scheme implementation on congestion reduction, in and around the area where it was implemented?	Secondary Data	Comparative study	Average traffic volume, average speed, average travel time,	Fieldwork	Comparison between before and after implementation in term of traffic volume, average speed and average travel time, in the restricted road and also alternate road surrounding the area.
	Questionnaire	Content analysis	Questionnaire result	Fieldwork	

Research Question	Methodology		Required Data And Software	Data Availability	Anticipated Result
	Data Collection	Data Analysis			
What is the effect of odd-even scheme implementation on car users' travel behaviour?	Questionnaire	Content analysis	Questionnaire result	Fieldwork	The influence of odd-even scheme on the behavioural change
	Secondary data	Comparative analysis	Daily average number of TransJakarta passengers	Fieldwork	
What are advantages and limitations of the odd-even scheme in reducing congestion in Jakarta?	Literature, Semi-structured interview	Content analysis	Literature, Interview Transcript	Available, Fieldwork	Reflection on influence of odd-even scheme to reduce congestion problems in Jakarta
What can be improved in the implementation of the odd-even scheme?	Literature, Semi-structured interview	Content analysis	Literature, Interview Transcript	Available, Fieldwork	Recommendation to the policymaker to improve the policy measures, especially odd-even scheme
What are the data required for the evaluation of TDM policies in Jakarta?	Literature, Result from the discussion	Content analysis	Literature and discussion of the effect of odd-even scheme in Jakarta	Available	List of data required for the traffic impact assessment of TDM implementation policy in Jakarta.
What are the parameters that have to be controlled to successfully implement TDM policies in Jakarta?	Literature, Result from the discussion	Content analysis	Literature and discussion of the effect of odd-even scheme in Jakarta	Available	List of a parameter that have to be considered in analysing the traffic effect of TDM policy
What are the methods that can be used to evaluate TDM policies in Jakarta?	Literature, Result from the discussion	Content analysis	Literature and discussion of the effect of odd-even scheme in Jakarta	Available	Methods to assess the effect of TDM policies in Jakarta.

4. THE EVALUATION OF EFFECT OF ODD-EVEN SCHEME IN JAKARTA

The odd-even scheme was implemented in Jakarta on 30 August 2016 and enforced by Local Authority since then. This scheme affected drivers' behaviour which then contributed to changing traffic conditions inside and outside the corridors. In this section, the effect of the odd-even scheme in Jakarta will be analysed using available data that was collected by the local government before, during and after the implementation of the scheme. This will allow an assessment of the effect of the odd-even scheme in Jakarta.

4.1. Effect of odd-even scheme on traffic reduction

4.1.1. Characteristic of traffic data

The data provided by the Jakarta Transportation Agency (JTA) includes average travel speed, average travel time and average traffic volume in and outside the corridors. According to Jakarta Transportation Agency (2016, 2017), the traffic data before the trial and during the trial period was used to determine whether the regulation would be implemented or not. In the trial period (27 July– 26 August 2016), the Local Authority and JTA implemented the regulation but were not yet charging fines to violators of the scheme. The fines for violation of the odd-even scheme were only collected from 30 August 2016.

For assessing changes in traffic volume, JTA hired several consultants, which were responsible for collecting, analysing and presenting the results back to JTA. The changes in traffic volume were evaluated by comparing the conditions before implementation, in the trial period, and after seven months of the implementation. However, the measurement unit which was used after seven-month implementation is different than the trial period, which compromises the comparison between the periods. Traffic volume after seven-months implementation was represented by the number of vehicles while traffic volume before the implementation was represented by passenger car unit (PCU³). During the fieldwork for the present MSc research, done in October 2017, we tried to get in contact with the consultants for further clarification, but only two were contacted and provided more information about the data collection methods.

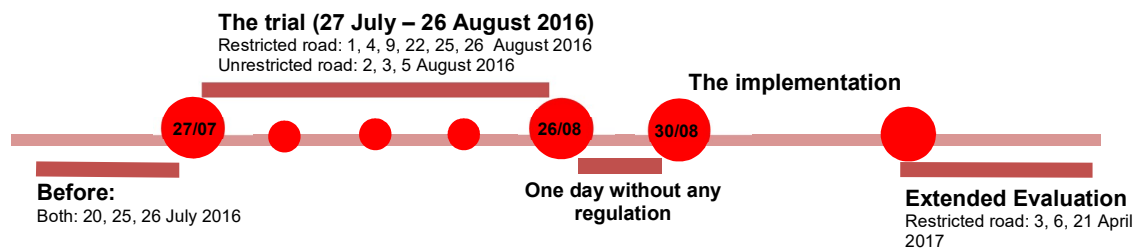


Figure 10 Timeline of traffic counting in the restricted corridors

As informed by JTA, the consultancies performed manual traffic counting on the corridors and also on the alternative roads. In the restricted corridor, the traffic was counted in three phases. Figure 10 shows the timeline of the traffic counting. An extended evaluation was done after seven-month implementation, in 3, 6 and 21 April 2017 but only traffic volume data in each restricted road segment was provided. Different

³ Passenger car unit is one of traffic volume measurement units that consider that every vehicle types have different volume and did not equal to each other. Mardani N et al. (2015) explained that the passenger car unit could represent the dynamic characteristics of mixed traffic (which contains different categories of vehicles).

consultants did the traffic counting in the restricted corridor and the unrestricted corridor. Meanwhile, outside those corridors, the traffic was counted only in two phases and done by two different consultants (a different consultant at each phase).

The counting was held on four locations during 14 hours (from 6 AM to 8 PM) along the corridor and also on seven locations along the alternative road (Figure 11 **Error! Reference source not found.**). The traffic was counted in a 15 minutes count period by using hand tally (PT. Danureksa Sarana Cipta, 2014). Furthermore, they calculated the number of vehicles in two approaches; during working hours (6 AM to 8 PM) and at peak periods - morning peak periods (7 AM to 10 AM) and evening peak periods (4 PM to 8 PM) (PT. Danureksa Sarana Cipta, 2016). During the counting, the directions of the roads are differentiated (e.g. North direction, South direction, etc.). However, in the data provided for the unrestricted corridors, the directions were not differentiated.

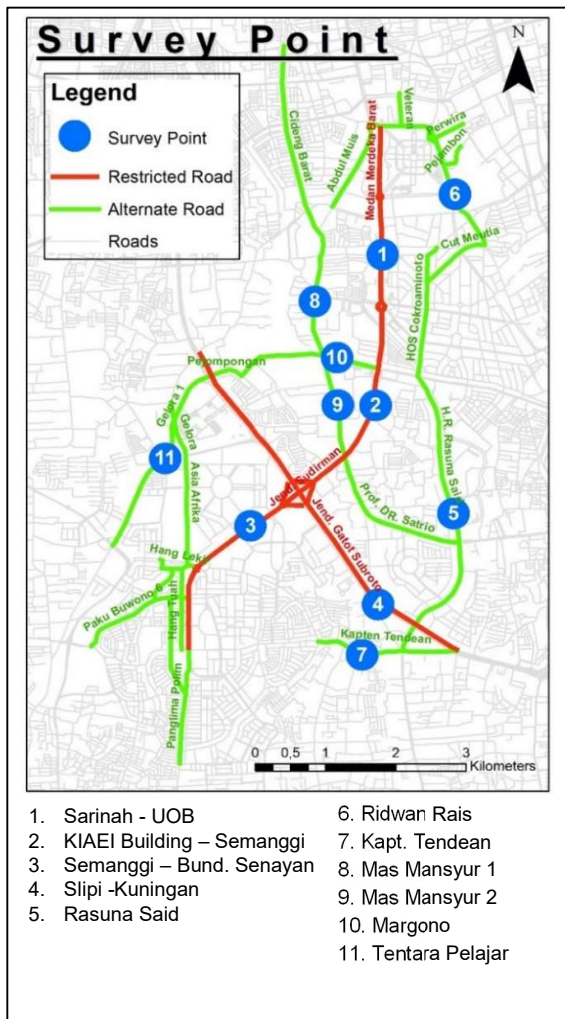


Figure 11 Traffic Counting Survey Point

5148 Year 1999, Jakarta Capital City Government restricted operational hour for heavy vehicles in the corridor from 6 AM to 8 PM since 1999.

To convert the number of vehicles to PCU for each segment, the consultant multiplied each vehicle type in each road segment with an equivalency factor, which for motorcycles is 0.25, while car, taxi and minibus is 1, and for regular bus and TransJakarta bus is 1.2. The limitation of the vehicles composition that was given

The data management was better performed in the restricted road than the unrestricted corridors. In the restricted corridors, the data contains the daily average of vehicles' mode shares and the average traffic volume (presented as the number of vehicles and passenger car unit). Meanwhile, because the traffic counting in the unrestricted roads was done by two different consultants, the data was not well-managed. One of them provided the raw traffic data for the trial period, which was taken on 2, 3 and 5 August 2016. Based on the data, the proportion and the number of vehicle trips could be calculated. However, the other consultant who counted the traffic before the implementation could not be contacted. Thus the traffic volume in the unrestricted road can only be compared by using the PCU/hour (i.e. using data provided by JTA).

PT. Danureksa Sarana Cipta (2014, 2016), the consultant responsible for the counting at restricted corridors, classified the vehicles during the manual traffic counting. The consultant divided vehicles into four groups namely motorcycles, light vehicles (cars, taxis, and minibuses), TransJakarta bus, and Regular Bus (Kopaja and Metromini). TransJakarta bus is differentiated from the regular bus because JTA wants to know the effect of the odd-even scheme to the TransJakarta operationalisation. Heavy vehicles (such as trucks) were not counted because based on Governor Decree Number

by the consultant is that the composition between car, taxi and minibus is already combined. Therefore, changes in private cars volumes alone could not be indicated.

Table 7 Summary of Traffic Volume Data

Location	Unit	Time Period	Date of Data Collection		
			Before	Trials	After
Inside the corridor	The number of vehicles	One day	20, 25 and 26 July 2016	1, 4, 9, 22, 25, 26 August 2016	3, 6 and 21 April 2017
		Morning peak period	20, 25 and 26 July 2016	1, 4, 9, 22, 25, 26 August 2016	3, 6 and 21 April 2017
		Evening peak period	20, 25 and 26 July 2016	1, 4, 9, 22, 25, 26 August 2016	3, 6 and 21 April 2017
	PCU	One day	20, 25 and 26 July 2016	1, 4, 9, 22, 25, 26 August 2016	None
		Morning peak period	20, 25 and 26 July 2016	1, 4, 9, 22, 25, 26 August 2016	None
		Evening peak period	20, 25 and 26 July 2016	1, 4, 9, 22, 25, 26 August 2016	None
	PCU/hour	One day	20, 25 and 26 July 2016	1, 4, 9, 22, 25, 26 August 2016	None
	PCU/hour	Morning peak period	22,25 and 26 July (only average)	2,3, and 5 August 2016	None
		Evening peak period	22,25 and 26 July (only in average)	2,3, and 5 August 2016	None

Another consultant collected the average travel time and average travel speed for both restricted corridors. The data collection was done by using Waze application and also Google maps API. At first, travel time was derived for each corridor by using Distance Matrix Services from Google API. The corridor was divided into two, Sudirman-Thamrin corridor and Gatot Subroto corridor. Then, average travel speed was calculated for each segment by dividing the length of each corridor to the travel time of each segment.

The data collection of travel speed and travel time for the period before implementation was done on 22, 25 and 26 July 2016 (Table 9). For the trial period, the data collection was done from 27 July to 23 August 2016. In the implementation period, one week after the first-day implementation (30 August), the data collection was done from 07 to 21 September 2016. The data was collected in the peak period, morning at 6 AM to 10 AM and evening at 4 PM to 8 PM. Table 8 shows the summary of traffic data that was provided by JTA.

Table 8 Summary of Travel Speed and Travel time Data

No	Data	Inside/ outside	Data Collection Methods	Date collected			
				Before	Trials	After	Unit of analysis
1	Travel time	Inside the corridor	Collected on Waze app and Google Maps	22, 25 and 26 July 2016, only in the peak period	Within 27 July until 23 August 2016,	07 – 21 September 2016	minutes
2	Travel Speed	Inside the corridor	Collected on Waze app and Google Maps	22, 25 and 26 July 2016,	Within 27 July until 23 August 2016,	07 – 21 September 2016,	km/hour

Source: Jakarta Transportation Agency, 2017

In addition, the average number of Transjakarta's passengers in the peak period for the months July, August and September 2016 was also acquired. The data was collected by PT. TransJakarta in three corridors that

relatively most affected by the odd-even scheme according to JTA, which are Corridor 1, Corridor 6 and Corridor 9. TransJakarta Corridor 1 served the passenger along Sudirman-Thamrin- Medan Merdeka Barat Corridor (or road segment 1, 2 and 3 both direction in Figure 11 **Error! Reference source not found.**) while TransJakarta Corridor 9 served the passengers along Gatot Subroto Corridor (road segment 4 both direction in Figure 11). The data provided is the average number of passenger in daily peak periods within a month, morning at 6 AM to 10 AM and evening at 4 PM to 8 PM.

4.1.2. Effect on Traffic Conditions

When the odd-even scheme was introduced in the trial period, the traffic condition was immediately affected. In the morning peak period, the number of vehicles reduced by 5% in the whole corridor. However, the traffic volume in each road segment remained stable after seven-months implementation. The same trend happened in evening peak period (Figure 12) when the number of vehicles decreased by 30% in the trial period in the whole restricted corridors. The number of vehicles after seven-months were only slightly risen compared to the number of vehicles in the trial period.

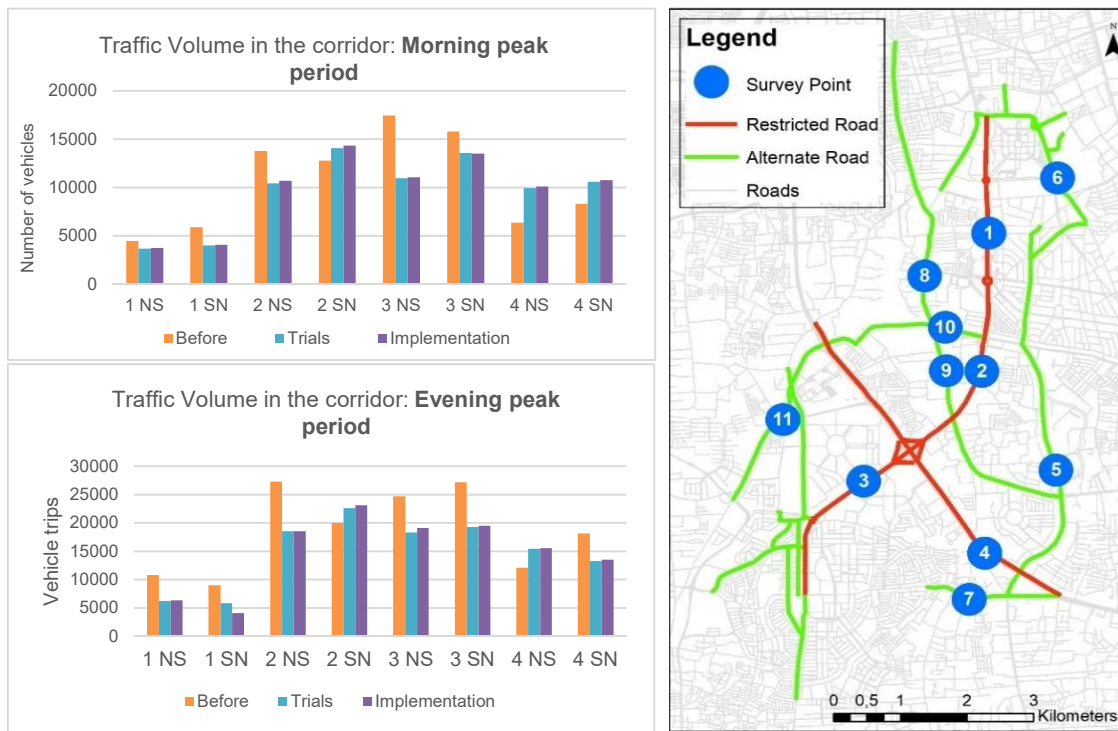


Figure 12 Comparison of traffic volume in 7 AM to 10 AM in the corridor (Above) and in 4 PM to 8 PM (Below). NS and SN represent the direction. NS means North-South and SN means South-North. (Source: Jakarta Transportation Agency)

Although in the morning peak period the number of vehicles decreased in several road segments, unexpectedly, the number of vehicles increased in Gatot Subroto corridor (4NS and 4SN) during the trial period and implementation period (see Figure 12). A similar trend also happened in the evening peak period. Instead of decreasing in numbers, vehicles increased in two road segments, namely road segment 2SN and road segment 4NS. Therefore Hypothesis 1 cannot be proven right entirely because the odd-even scheme did not cause a decrease in traffic volumes in all corridors, but rather distribute the congested area thus increase the traffic volume in several road segments.

The increasing number of vehicles in several road segments might also indicate that although the number of cars decreased, the number of other vehicle types increased. The phenomenon is seen in the changes in

passenger car unit of each corridor. Figure 13 illustrates that in most road segments, the passenger car unit decreased during the trial period, except for the road segment 4NS, at the morning peak. The changes in the passenger car unit have a different pattern with the changes in the number of vehicles. For example, the number of vehicles in road segment 2SN increased 10% while the passenger car unit in the same road segment decreased 13%. This information leads to confirm that the Hypothesis 4 is true that the odd-even scheme affects mode distributions of vehicles and not decrease the number of vehicles.

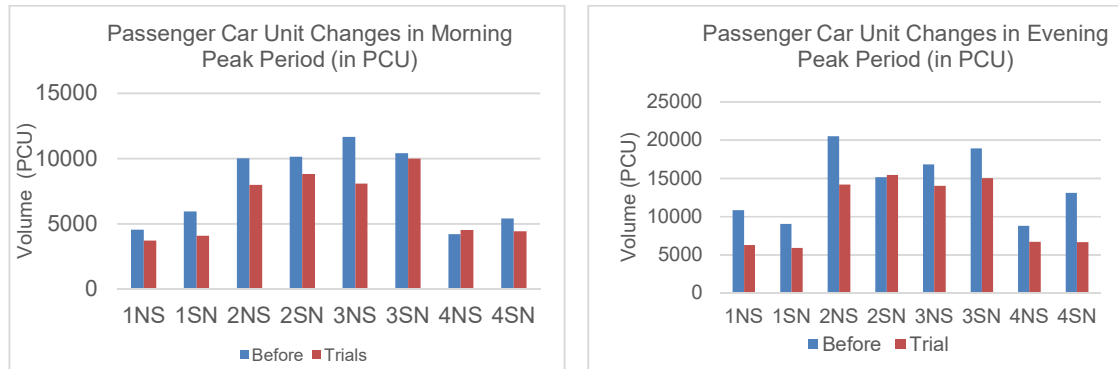


Figure 13 Passenger Car Unit Changes in the evening peak (left) and morning peak (right)

Looking further to the changes of mode distributions in the morning peak period (Table 9), as expected, cars, taxi and minibus decrease significantly except for road segment 3 SN. In road segment 3SN, although the overall number of vehicles decreased, the number of cars, taxis and minibuses increase. It might be because, while the number of private cars decreased, the number of taxi and minibus increase. However, because the data provided combine the number of cars, taxis and minibuses in one class, this argument cannot be analysed further.

Table 9 Vehicle composition changes in morning peak period for each road segment

Road Segment	Motorcycle	Cars, taxi and minibus	Regular Bus	TransJakarta	Total Changes in Vehicle trips
1 NS	0	-934	4	98	-832
1 SN	0	-2019	-30	157	-1892
2 NS	-1716	-1746	-12	134	-3340
2 SN	3552	-2349	70	51	1324
3 NS	-3911	-2431	-197	59	-6480
3 SN	-2398	284	-121	32	-2203
4 NS	4466	-1313	270	167	3590
4 SN	4402	-2265	91	63	2291

Source: Analysis Result, 2018

Table 9 also shows that while the number of cars, taxis and minibuses decreased, the number of motorcycles increased significantly. Even in some road segments, the number of motorcycles rose higher than the decreased number of car, taxi and minibus which then led to an increased total number of vehicle trips. For example, in road segment 4NS and 4SN, the motorcycles numbers increased substantially, compensating the decrease in the number of cars, taxi and minibus, thus, leading to an increase in total number of vehicles. The same trend of mode distribution changes also happened for the evening peak period. This might be occurred because the motorcycles was exempted from the odd-even scheme whereas the majority of residents of Jakarta have motorcycles (73,92%). Many travellers might have both vehicle types, so when their car is restricted, they use motorcycles to avoid the restrictions. The motorcycle restriction are implemented in the Medan Merdeka Barat – Thamrin (1NS and 1 SN) corridor thus the number of motorcycles in that corridors is zero.

The decreasing peak-period traffic volume in some road segments contributes to increasing average travel speed in the peak periods.

Figure 14 shows that comparing the before period with the trial period, the average travel speed, in each road segment, increased for both peak periods thus Hypothesis 2 can be confirmed. The highest increase in the morning peak and the evening peak between the before and trial periods was on “1+2+3 NS” corridor of 6.7 km/h and 6.4 km/h respectively. Furthermore, in the implementation period, the average speed increased was not significant, less than 1 km/hour compared to the trial period. Although the changes in the morning peak and evening peak are more likely the same (increase between 4 km/h to 6 km/h), the increased pattern between the morning peak and evening peak is different.

Figure 14 illustrates that average travel speed in morning peak was significantly higher than in the evening peak. For instance, the average travel speed in corridor “1+2+3 NS” increased from 29,8 km/h to 36,5 km/h while in the evening peak it increased from 17 km/h to 23 km/h. It might be because the individual departure time in morning peak is more dispersed than in the evening peak. Workers might depart earlier from home in the morning but usually, they choose to go home right after the work hour end. It leads to increased congestion level in the evening peak thus the average travel speed decreased. Moreover, average travel speed in “1+2+3 SN” remain relatively the same in the evening peak and the morning peak, while the other road segment has significant difference between morning peak and evening peak. This could mean that “1+2+3 SN” road segment in the morning peak and evening peak might have the same traffic volume hence the same level of congestion. This phenomenon also can be seen later in the travel time change pattern (Figure 15).

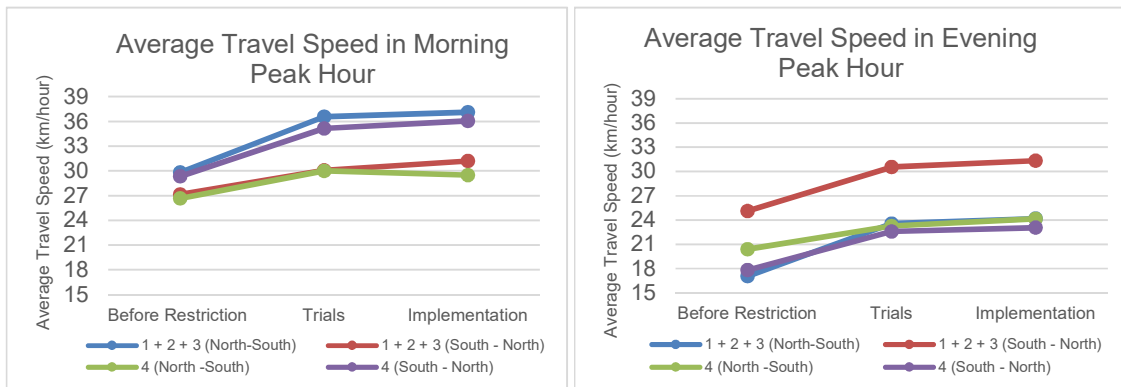


Figure 14 Travel Speed Changes after the implementation – morning peak (left) and evening peak (right)
Source: Jakarta Transportation Agency, 2017

Figure 15 shows that average travel time has also improved. The most significant decrease happened in “1+2+3 NS” corridor, with a decrease of 9 minutes in travel time in the evening peak when comparing the before and trial periods. Furthermore, the decreasing average travel time is relatively more significant in the evening peak period than in the morning peak period. For instance, in the evening peak period, the average travel time in the trial period, in road segment 4SN decreased 3.44 minutes (from 14 to 11 minutes) compared to before trial, while in the morning, the average travel time in the same road segment only decreased 1.8 minutes (from 11 to 10). That means that the average travel time much more improved in the evening period than in the morning.

Furthermore, looking further on Figure 15, the direction of road segment might influence the average travel time. For example, North-South direction might be more congested in the evening peak than in the morning

peak especially for “1+2+3” road segment. It might be because the south-part of Jakarta (including South Jakarta, Depok, Tangerang Selatan and Bogor) has more residential area than the north-part of Jakarta, thus in the evening peak, the traffic flows from North to South direction.

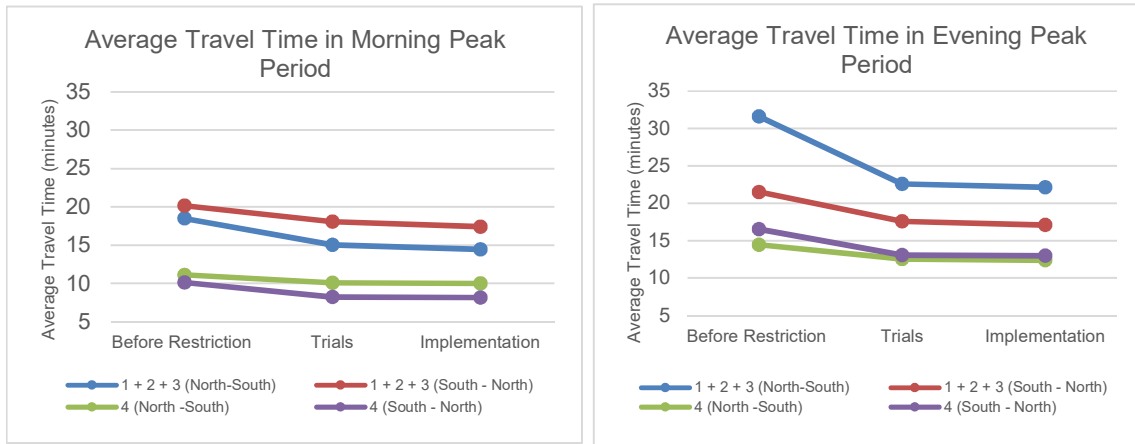


Figure 15 Travel Time change after the implementation
Source: Jakarta Transportation Agency, 2017

The analysed data suggests that the odd-even scheme contributed to an overall decrease in the average travel time along the corridors. However, based on a small survey that was developed during fieldwork, our sample of 66 respondents suggested the opposite. Among respondents whose offices are along the corridor and use cars before the implementation, only 35% of respondents perceived that the travel time from home to office became shorter than before the odd-even scheme implementation. There are still 25% of the respondents who perceived no change in average travel time while 40% of the respondents think that the traffic congestion got worse than before implementation. This information indicates that the Hypothesis 5 cannot be confirmed because although the travel time in the corridors decrease, the car user's overall door-to-door travel time might not change as is indicated in the questionnaire result. However, this phenomenon requires further analysis. On a different note, the perception of time should be noted with caution due to our limited sample, but also because several infrastructure developments are happening in Jakarta, which could have caused increased congestion.

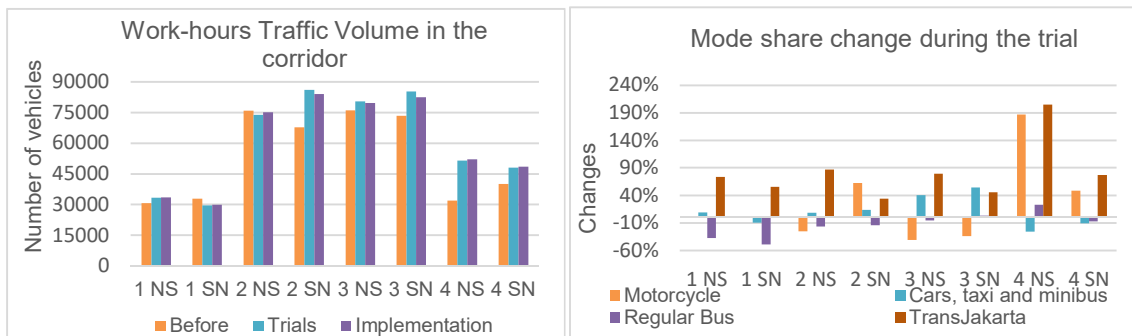


Figure 16 Comparison of Traffic volume in 6 AM to 8 PM in the corridors
Source: PT. Danureksa Sarana Cipta (2014)

Figure 17 Vehicle mode distribution change after the implementation

Moreover, although the traffic volume during peak periods decreases, looking through work-hours traffic volume (Figure 16), in most of the road segments, traffic volume increases when comparing the before and

trial period, and then remained stable after seven-months implementation. The increasing work-hours traffic volume might indicate that the drivers were not changing their travel modes in commuting but were changing their departure time, as Hypothesis 7 postulates. That indication also can be seen in the changes of vehicles proportion. Figure 17 shows that the number of cars, minibusses and taxis increased, especially in Sudirman road segment (3 NS and 3 SN) 40% and 60%, respectively. The indication was confirmed by one respondent who said that in the early morning, the roads near her house were more congested than before the implementation. “(...) However, I feel that the road surrounding my house is more congested than before the odd-even scheme implementation”.

On a different note, a positive change during the trial is the increasing usage of the TransJakarta. From the mode share changes (Figure 17), the number of TransJakarta buses that passes by the corridor in the work-hours increased from 30% (corridor 2SN) up to 200% (corridor 4NS) when comparing the before and trial periods. It could be due to the combination of two factors: (1) the odd-even scheme affects the clearance of TransJakarta lanes thus increasing their reliability and, (2) the growing TransJakarta fleet which Government did to anticipate the odd-even scheme effect.

The odd-even scheme affects the clearance of TransJakarta’s exclusive lanes due to the decreasing number of private cars. Before the restrictions, although TransJakarta has an exclusive lane, many drivers violated the rules to avoid the congestion in the regular lane. Over time, the exclusive lane became congested too so TransJakarta busses were also stuck in traffic. The highest increase of TransJakarta distributions happened in Gatot Subroto road segment while the number of cars, taxis and minibuses decreased significantly. It might indicate that the decreasing number of cars could influence the clearance of TransJakarta exclusive lanes. Moreover, the increasing enforcement due to the odd-even scheme implementation might affect the clearance of exclusive lanes. The driver would have to think twice before entering the exclusive lanes.

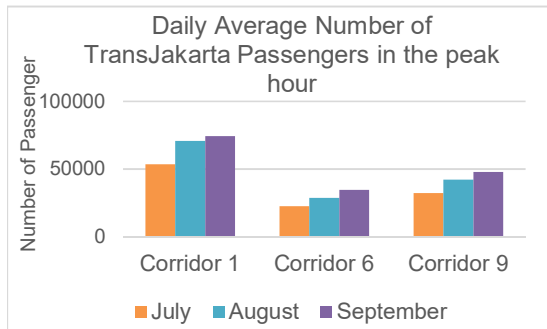


Figure 18 Comparison of daily average number of TransJakarta in the peak hour

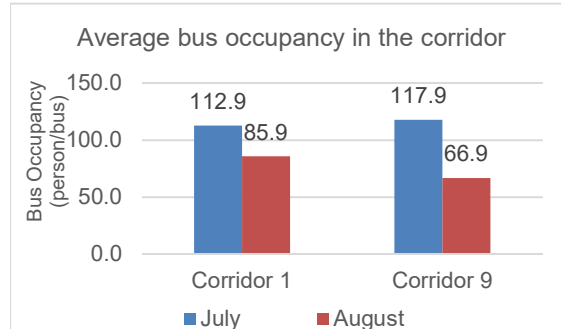


Figure 19 Average bus occupancy in the corridor, in the peak period

Along with the increasing distribution of TransJakarta buses in the peak period, the peak periods’ average number of passenger in Corridor 1 (the “1+2+3” road segment) increased up to 39% in the early implementation period (Figure 18). The same condition also happened in Corridor 9 (the “4” road segment), with an increase up to 48% in the average number of TransJakarta passengers in the peak hours. As the additional evaluation, they also calculate the changes of TransJakarta passengers in the unrestricted corridor which is Corridor 6, and as a result, the number increased 53% after the implementation.

Furthermore, by comparing TransJakarta’s bus distribution during peak periods and the average number of passengers, the average bus occupancy during peak hours can be calculated. From the result, the bus occupancy shows a reduction trend for both corridors (Figure 19). This could means TransJakarta’s comfort increase after the implementation. On the other hand, it might also means the number of TransJakarta

passenger was not increase as much as expected by PT. TransJakarta at the time when they planned the addition of TransJakarta fleet in those corridors.

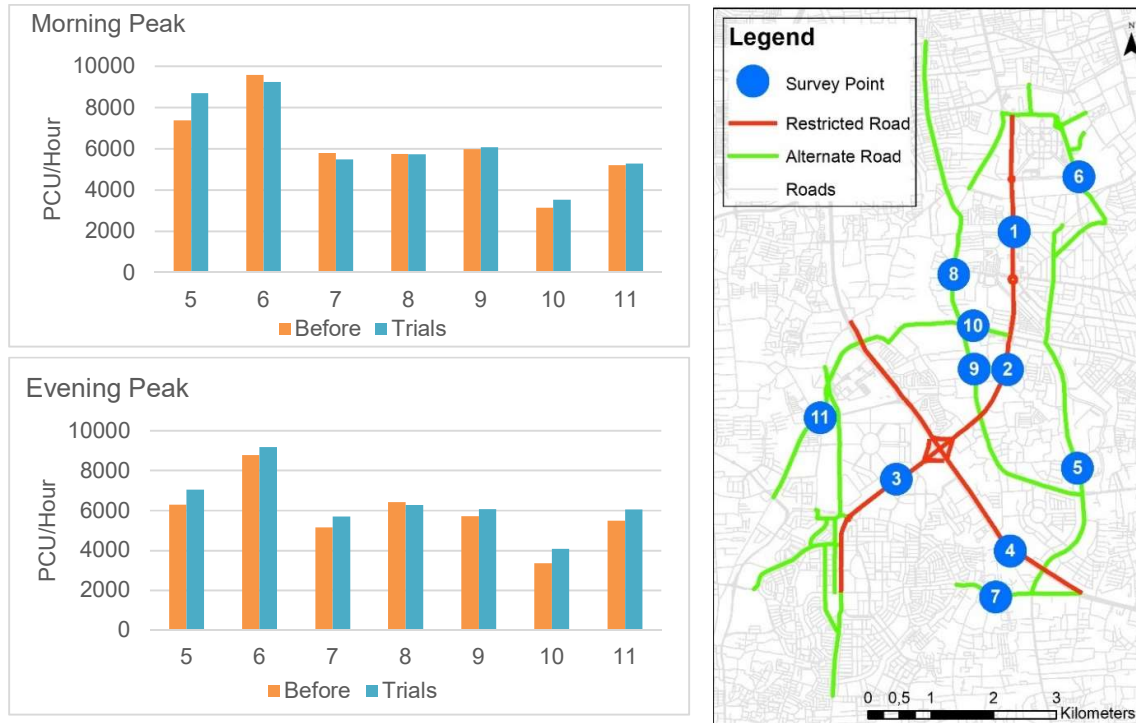


Figure 20 The comparison of traffic volume in alternate road
Source: Jakarta Transportation Agency, 2017

When looking only at the influence of the odd-even scheme on the alternate roads, as expected, the traffic volume outside the corridor increased (Figure 20), which confirms Hypothesis 3. The higher increase in the morning peak period happened in Rasuna Said (5) and Margono (10). Rasuna Said might be chosen by commuters because this road segment does not have many intersections. Therefore, it is relatively less congested than another road segment. However, in Ridwan Rais (6) and Tendea (7), the traffic volume slightly decreased (3% and 5%, respectively) when comparing the traffic volume before implementation and during the trial period. The decreasing traffic volume in Tendea might be because a flyover was being constructed in this road segment. This development slowed down the vehicles speeds, which made the congestion worse. This led drivers to choose another road to avoid the restricted road. However, due to lack of data, the impact of the odd-even scheme on the traffic outside the corridor could not be further analysed.

In summary, the odd-even scheme affected the traffic condition immediately after its implementation. Based on the results, it has direct advantages which are the increasing average travel speed and the decreasing average travel time. The number of TransJakarta bus that passes by the corridor in the work-hours also increase. However, based on the changes in traffic volume, the odd-even scheme still could not reach Jakarta Transportation Agency objective, which is decreasing half of the traffic in the corridor. Moreover, the odd-even scheme might not cause a decrease in traffic volumes (especially in the number of vehicles) in all corridors, but rather distribute the congested area thus increase the traffic volume in several road segments. The mode distribution indicates that although the number of cars decreased, the number of other vehicle types increased especially motorcycles. Furthermore, the traffic volume changes in the unrestricted roads indicate that the odd-even scheme implementation has an impact on the outside corridors. although the

travel time in the corridors decrease, the car user's overall door-to-door travel time did not change due to spill-over congestion. However, one of positive effect of the odd-even scheme,

However, it should be noted that those analysis is done by using limited data provided by JTA and measured by consultants. The data are not adequate to examine the effect of the odd-even scheme in Jakarta for several reasons. First, JTA hired several consultants to measure traffic volumes and speeds. Consequently, the result of the traffic counting might be not comparable because the accuracy and methods of data collection between one consultant and the other consultant might be different. In addition, data was only collected manually, which increases the possibility of human error. Second, the traffic volume outside the corridor was only counted as additional analysis and was not evaluated after the implementation, as it was done for the corridor. This fact could indicate that the impact analysis to the unrestricted area was not adequate to understand the effect of this regulation in the broader area. Third, by using the data given, the effect could not be appropriately explained because the three-days average traffic volume before the implementation could not represent the traffic pattern before the implementation. Fourth, the mode share of private cars, taxi and minibus are presented as one class thus the effect on the mode share changes could not be assessed further.

4.2. Influence of the odd-even scheme on behavioural change

A questionnaire was undertaken to understand how a sample of commuters reacted to the odd-even scheme. The data collection was held from 16 October to 27 October 2017 with a web-questionnaire and several direct interviews. In total 66 respondents answered the questionnaire, which consist of 27 female respondents and 39 male respondents. The respondents' occupations are government officials, entrepreneurs or employees at a private company (Figure 21). Entrepreneurs are respondents whose offices might not be located in the corridor but often meet their clients within the restricted corridors. Employees work for private companies located along the corridor and usually have fixed working times. The respondents are from 15 to 64 years of age (Figure 22).

Only respondents working somewhere inside the studies corridors, or those who always use these corridors to reach their offices were considered. 77% of respondents' offices are located along the restricted corridors which are Sudirman street, Thamrin street, Gatot Subroto street, and Medan Merdeka Barat Street. The remaining respondents choose these corridors because they are the most convenient route to their offices, which are located somewhere at the unrestricted roads around the restricted roads.

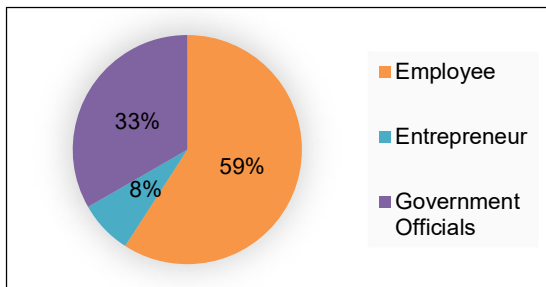


Figure 21 Classification of the respondents based on occupation
Source: Questionnaire, 2017

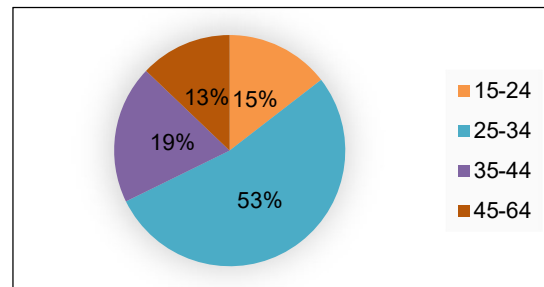


Figure 22 Classification of the respondents based on age group
Source: Questionnaire, 2017

Furthermore, respondent reside in South Jakarta (30%), East Jakarta(11%), Bekasi (15%) and Tangerang (13%), while less cited locations included Tangerang Selatan and Ciawi. Respondents' travel times before implementation varied between 60 minutes to 3 hours depending on their residence place. Usually, the respondents from South Jakarta and Central Jakarta commute in less than 60 minutes. The respondents

from the outskirt area such as Bekasi, Tangerang, and Depok would spend more than 1.5 hours to 2 hours to the CBD area.

To ensure that respondents could differentiate the travel time between before and after implementation, they had to indicate having started working somewhere at and around the restricted corridors before the implementation of the scheme, and also must be car users. As a result, 71% of the respondents indicated being working in/around the corridors before July 2016, and 74% of the respondents were car users before the implementation of the scheme. Nevertheless, the information from the respondents who started working there or started using the car after the implementation is useful for understanding how did they reacted to the scheme when their car was restricted. 53% of respondents indicated always using car to commute (Figure 23) while the remaining are not using cars which indicates that they used alternative modes such as private motorcycles, taxi, buses, and other public transportation, before the implementation. This fact might affect their way of adaptation after the implementation.

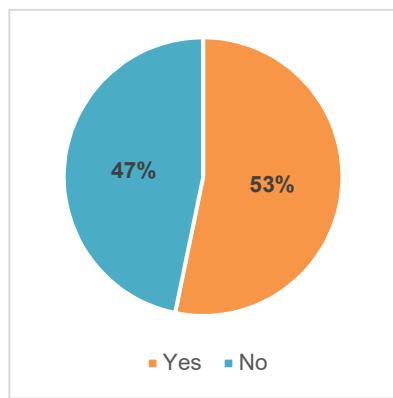


Figure 23 Before the implementation, did you always using car to work?
Source: Questionnaire, 2017

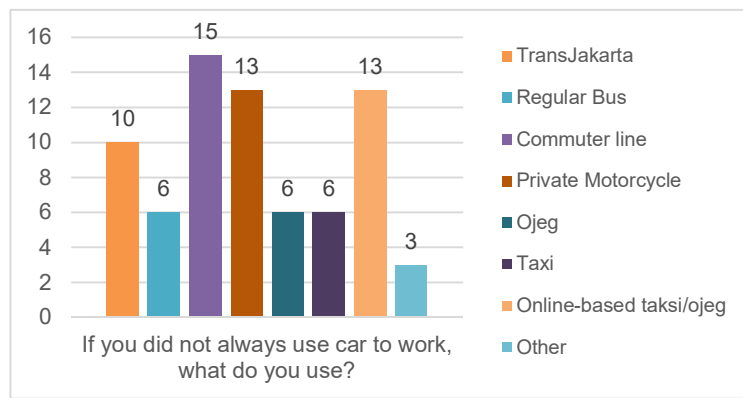


Figure 24 Their chosen modes besides cars

Then the respondents are asked about their mode choice when they do not use private cars. 15 people of 66 respondents use the commuter line as an option besides their cars to commute (Figure 24). Motorbikes and online-based taxis follow the commuter line as the second and the third most chosen options. On the other hand, about 20% respondents used TransJakarta and nearly 15% used Regular Busses as an alternative mode of transport to work. A respondent also mentioned using a shuttle bus provided by the employer. Usually, the employer, especially government officials, provide buses for the commuters. The buses are only operated to pick up the employees in the particular areas in the morning and to take them back to those same areas in the evening. The operating hours are usually decided together with the employee, considering the working hours. The provision of a commuting bus is basically a strategy that employers (usually government institution) use to make sure their employees arrive at the offices on time. On the other hand, this strategy could help relieving congestion by providing a relatively cheap and comfortable mode of transport.

Based on the questionnaire, 60% of the respondents are still driving on both days (Figure 25). That means that most respondents are using other routes or changing their departure time to avoid the restrictions. Figure 26 shows that 53% respondents are using other routes to avoid the restriction roads. The routes that are used are varied based on their working locations and residence locations. 29% of the respondents indicated having changed their departure time. They choose to go early in the morning so they can enter the corridor before 7 AM when the restriction starts. Changing departure time might also be attributed to another TDM type of measure, which is the early-school-time regulation. This regulation mandated that all of the schools in Jakarta start at 6.30 AM and affecting the travel behaviour of commuters. One of the respondents said, “I always go early in the morning, first, escort my child to the school, then go to my office straight away.”

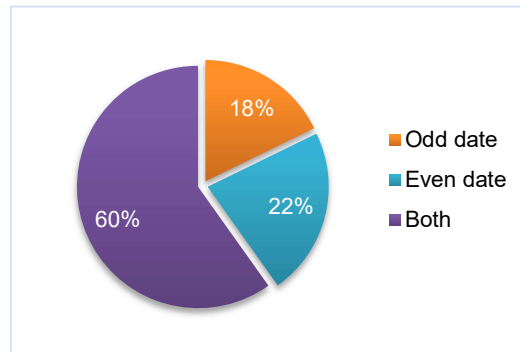


Figure 25 When the respondents use their cars
Source: Questionnaire, 2017

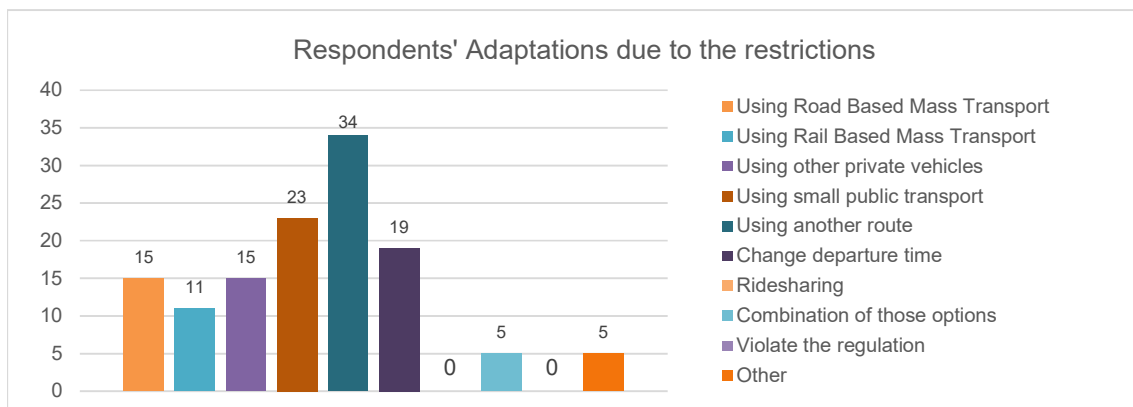


Figure 26 Respondents' adaptations
Source: Questionnaire, 2017

The most chosen alternative modes to the car indicated by respondents were small public transport (23%) (Figure 26) which consist of taxis, ojeg (i.e. motorcycle taxis), accessed or not via online-based applications. Although this kind of public transport is more expensive than mass public transports (such as TransJakarta and Commuter line), they offer flexible trips and a door-to-door service. Online-based transportation becomes popular among travellers due to its convenience. The traveller does not have to wait too long on the side of the road for their taxi or motorcycle taxi. It is also supported by an informative interface to detect the taxi or motorcycles locations.

Although most of respondents still use cars to commute, among 66 respondents, 26 respondents informed using road or rail-based transportation when their cars are restricted (Figure 26). The mass transportation mentioned here includes TransJakarta, Commuter line and Regular Bus. The reasons for using public transportation vary for each respondent. Some of them think that travel cost spent on public transportation is cheaper than travel cost spent while using cars. Another reason is that they think that the travel time using public transportation (especially using commuter line) can be predicted compared to using cars. Despite that, some other respondents still think that public transportation in Jakarta is not reliable because respondents have to use too many transits interchanges, which requires more time to arrive at the

destinations. These different opinions might be because some residential areas are not well-served by public transportation (i.e. commuter line or TransJakarta).

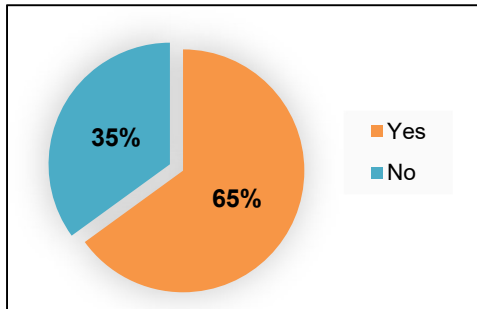


Figure 27 Willingness to change their travel modes from car to public transportation

Source: Questionnaire, 2017

In the questionnaire, respondents were also asked about their willingness to change their transport modes in the future. 65% respondents are willing to change their travel modes (Figure 27). However, in the practice, among 32 respondents who have never used mass public transportation before implementation, only two respondents indicated to have chosen mass transportation when their cars were restricted from the corridor. The rest of them chose to use other private vehicles such as motorcycles and cars with opposite plate number. Figure 28 shows that six respondents mentioned that the public transportation are more comfortable and reliable. In this

case, reliable means that the travel time is more predictable than using private cars. Few respondents indicated being willing to switch into public transportation because they feel exhausted to drive especially in a congested condition. The majority of respondents (20) indicated that the most attractive factor of public transportation in Jakarta is that the public transportation is cheaper than using other modes.

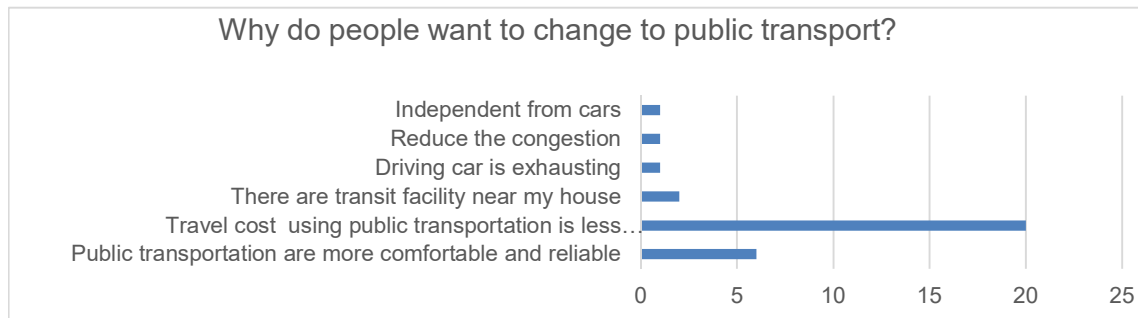


Figure 28 The reasons people want to change to public transport

Source: Questionnaire, 2017

When asked why respondents still prefer using the private car, Figure 29 shows the responses. The most cited reason is because the travel time spent while using public transportation is longer time than using private cars. Most of the respondents believe that they have to spare more time if they use public transportation, especially when they have to take many transits to their destination. One of the respondents said *“Using private cars are more comfortable than using public transport. If you use public transport, you need to transfer in different modes and spend too much time, up to 2.5 times longer than using cars.”*

Another reason is because public transportation provided are not comfortable enough from the travellers. It might be because the public transportation such as TransJakarta and Commuterline are crowded especially in the peak hour. For example, TransJakarta, as mentioned before, sometimes still stuck in the traffic, hence many passengers should stand for hours in the bus. The same occurrence is happened in the commuter line in the rush hours, sometimes even worse.

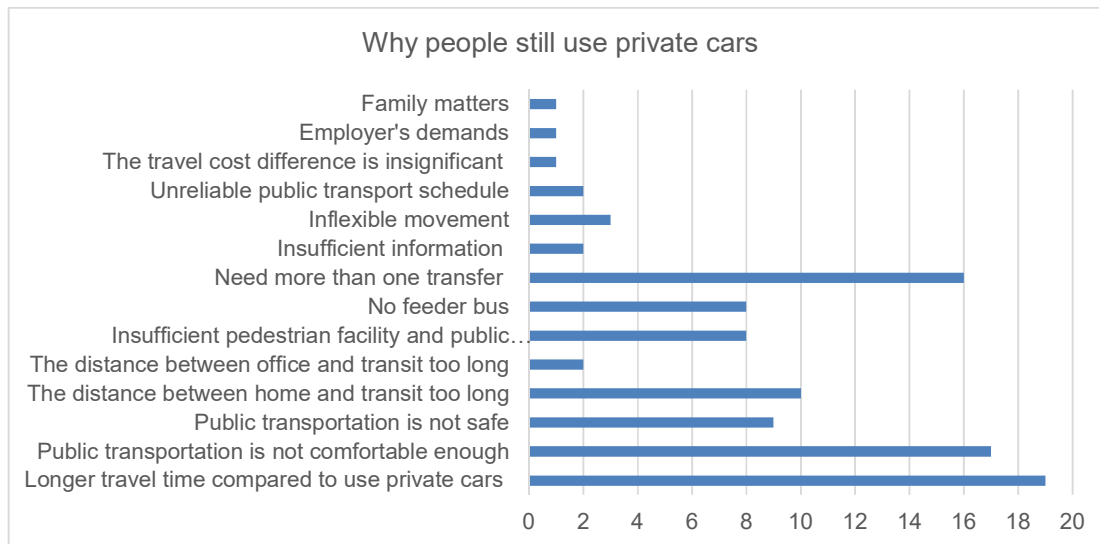


Figure 29 the reason why people still use private cars
Source: Questionnaire, 2017

Furthermore, comfort also related to accessibility to transit such as the absence of feeder bus, inadequate pedestrian facilities, unreliable schedule, or even too much transit needed. The expert from Indonesian Transport Association (MTI) said that the first mile and last mile transportation in Jakarta was still not adequately managed and integrated with the mass transportation like TransJakarta or Commuter line. Furthermore, he explained that improvement in public transportation is not only about adding more route or adding more buses but also about integration with another kind of public transportation and pedestrian facilities. *"Jakarta still did not have good pedestrian facilities. We should have a good pedestrian facility because every public transportation users is a pedestrian"*. This statement also expressed by the expert from Indonesian Planner Association that the mass public transportation in Jakarta is still concentrated in the center of activities and still poorly served the residential area.

Some of them (3) also mentioned about flexibility in movement as their reason why they choose the private cars (Figure 29). Flexible mobility is the condition when travellers can move quickly without thinking what modes should they take or what time should they go. Cars offer this factor of flexibility where people can always change their plan anytime and anywhere which will lead to convenience. This issue is essential especially for those who must attend more than one occasions in a day, such as an entrepreneur. One of the respondents argued that although the travel cost using public transport less expensive than using the car, the difference of their cost are not significant particularly if they consider comfort, reliability and flexibility into account.

As mentioned in the literature review, push measures could achieve the goals of reducing car use if other modes outweigh the car trips (Garling & Schuitema, 2007). Comfort, reliability and safety are the factors that private car could offer while public transportation could not provide. This fact is also mentioned by the expert from University of Indonesia who said that Government has to improve public transportation quality to be as good as the quality that private car can offer, so the commuters have other options besides cars. He explained that *"Hard measure 'push' people to neglect their car, but, push them into what? All the while, their life goes on, they have to work, and if there is no alternative modes, they would still use their cars."*

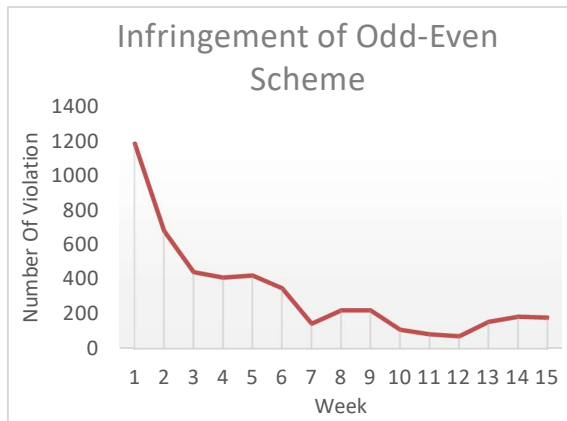


Figure 30 Infringement of Odd-Even Scheme
Source: Jakarta Transportation Agency, 2017.

Moreover, although none of the respondents chooses the option of violating the regulations as the response due to the regulation (Figure 26), based on the observation, there are still people who violate the regulations. Local Authority evaluation on the enforcement shows that there are regulation violations although the number of violation are decreasing through time (Figure 30). Based on the data from Local Authority on Traffic Management, there are several excuses that car users used when they were caught by the police such as forgetting about the date or the restricted hour, as well as think that police would not see them. Nevertheless, this decreasing trend of violation could be because of the decreasing quantity of enforcement. Based on an

interview with Jakarta Transportation Agency, initially, they assisted Local Authority to enforce the regulation, though JTA cannot put a fine on the violator. However, after a month, they handed all the enforcement task to Local Authority. This could mean that the intensity of the enforcement was decreasing.

Using the questionnaire results, the Hypothesis 6 could not be confirmed. However, based on the result discussed above there is an indication that an odd-even scheme does not lead to a switch in car users' mode choice as long as public transportation remain the same. These indications are seen in the way the respondents adapt the regulations. They mostly choose to use another route, or change their departure time or using online based transportation. The respondents also indicate that the public transportation is not reliable and comfortable on the reason of why they still use cars. However, this indication should be confirmed by more detailed analysis.

5. REVIEW OF METHODOLOGY TO EVALUATE THE EFFECT OF FUTURE TDM POLICIES IN JAKARTA

Jakarta has planned to implement Electronic Road Pricing (ERP) by 2019 in the corridors where currently the odd-even scheme is applied. Furthermore, by 2030, the local government would applied the ERP system within an area that has been established in Spatial Plan 2030. This chapter will discuss the methodology in evaluating the effect of future TDM measures in Jakarta, reflecting the limitation of available data used for this study.

5.1. Wide-Range Impact Analysis

Implementation of TDM policy might affect other aspects besides traffic thus the impact assessment should not be done limited to traffic impact assessment only. The impact assessment might include the impact on travel behaviour, public transportation operation and socio-economic aspect. A wide-range impact assessment has been done by London and Stockholm in implementing and monitoring the congestion charge. Transport for London (2003, 2006, 2007, 2008) evaluated the congestion charge by 5-years monitoring impact assessment on the congestion charges. The impact assessment includes the effect on congestion level, the traffic patterns in and around the area, public transport operational, travel behaviour and traffic accidents/collision, business and economy, social, and environment. The same act was done by Stockholm (Eliasson, 2014). To evaluate the effect of the congestion tax, the city government, through several researchers, measure the changes in several aspects including traffic effect, travel times, environment, retail/business, public transport operation, travel behaviour adaptation.

The impact on the travel behaviour and attitude is essential to be analysed because reflecting Bamberg et al. (2011) and Coglianese (2012), a TDM policy modifies travel behaviour. In this study, the questionnaire result indicate changes in traveller's behaviour by asking them about what they do to adapt the regulation and their perception about the travel time changes. However, it should be noted that the implementation of the odd-even scheme was already implemented for one year before the survey was conducted. The result might not be representative because the respondents might already have forgotten about what happened one year before. Furthermore, the small survey on the travel behaviour changes could not represent the whole population that is affected by the odd-even scheme.

Therefore, for future implementation of ERP, the survey should be done in at least two phase, before and after implementation, to capture what they do to adapt the measure. Based on the experiences of other cities, usually travel survey in the form of a travel diary would be conducted (Karlström & Franklin, 2009; Transport for London, 2003; Wang et al., 2013). The travel diary might consume considerably extensive resources and time, but it could provide insight about travel demand pattern (such as origin and destination) and the characteristic of traffic (such as journey time and mode preference) (Weijermars, 2007).

Furthermore, although the effect of public transportation operation was already done in this study by using an average number of passenger in the peak hour, it might also be extended to more detailed data such as bus occupancy and bus reliability. For example, in monitoring the congestion charge, Transport for London (2003, 2006, 2007, 2008) evaluated the bus operational improvement by using bus passenger counts, bus occupancy counts, bus journey times and speeds and bus reliability. Moreover, the increased average number of TransJakarta in the trial and implementation period could not be attributed to the odd-even scheme alone. The "real effect" of the odd-even scheme on mode shift could also be further studied if the detailed data of bus utilisation could be acquired. Agarwal & Koo (2016) analysed the impact of rate adjustment on modal choice in Singapore by using statistical model. Although the statistical model might not be the same, the

data must be required as detailed as they require. They can acquire the information of bus card use in nine weeks within the restricted area. In Jakarta's case, Jakarta Transportation Agency may cooperate with PT. TransJakarta to acquire those data. The impact assessment on public transportation is essential to be included in the evaluation because Jakarta has targeted mode share of public transportation increase up to 60% by 2030.

The evaluation of TDM policies should also evaluate any issues that could be affected by this regulation (e.g. social aspect or economic aspect). Social impact assessment is especially important in evaluating the ERP system that would replace the odd-even scheme in the future because the implementation of an ERP system would affect socio-economic aspect of the traveller, household or even, the city economy. However, evaluating the social and economic changes would require more time than evaluating traffic changes because the socio-economic factor changes slowly.

5.2. Methodology of Traffic Assessment

Commonly, a traffic assessment would use the average daily traffic data such as AADT (Annual Average Daily Traffic: AADT), or AAWT (Annual Average Weekday Traffic Data)(Weijermars, 2007). Many research analyse the changes before and after a regulation implementation by comparing the average daily traffic data to see whether the traffic condition is getting worse or better (R. Li & Guo, 2016; Transport for London, 2003, 2006, 2007, 2008). Coglianese (2012) called it as a non-attributional research, which could not explained the reason of why the condition is getting worse or better. Moreover, by using non-attributional research design, we don't know whether the TDM policies is actually reduce the congestion or not because there are many external factors that could affect the traffic condition. Thus, understanding the external factors could help identifying needs for a better future implementation.

The traffic condition is influenced by many external factors including the socio-economic factors (e.g. social activities, income, employment) and the situational factor (e.g. time pressure, weather) (Chen et al., 2015; Taylor et al., 2000; Crawford et al., 2017; Xie & Olszewski, 2011). Weijermars (2007) explained that traffic could also vary between time and space depending on external factors that influenced the traffic system. The traffic would vary within hours and between hours due to weather or human activities. This variation should be analysed and considered while estimating the short-term effect of the TDM measures. Meanwhile, the variation between month and year should be considered to estimate the long-term effect of the TDM measures. Therefore, an attributional research should be done to to better understand what factors that influence the traffic condition.

To be able to control external factors that might influence the traffic condition, quasi-experimental research design (or some called it observational studies) should be used (Coglianese, 2012; Taylor et al., 2000). This research design rely on statistical techniques to compare the reality with what might have been if the regulation is not implemented (Coglianese, 2012; Taylor et al., 2000). In the next sub-section, data requirement, the control parameter, and data collection methods would be proposed considering the ERP implementation and area-based traffic restriction.

5.2.1. Data Requirement

One of the limitations in the evaluation of the odd-even scheme in Jakarta is temporally limited data. The data provided can only capture the immediate effect of odd-even scheme implementation whereas it did not illustrate the variability of traffic condition. Monitoring scheme should be applied to gather a proper longitudinal data. These data could be used to analyse the traffic flow profile, daily, weekly, monthly and annually. The traffic flow profile, further, could provide the information of how traffic changes between times and predict what are the factors that influence the changes. Understanding the flow pattern is especially important in evaluating the congestion reduction strategies, because congestion happens in cyclic and seasonal basis which could be recognised by using traffic flow pattern.

A traffic flow profile is a pattern of traffic volume at a given site that varies according to the time of day, the day of the week and the season of the year (Taylor et al., 2000; Weijermars, 2007). These patterns are prompted by the changes in external factors over time. A short-term variation is commonly caused by travel demand and capacity of the transport system while a long term pattern primarily caused by demographic, economic and infrastructural development (Weijermars, 2007).

A short-term variation could be represented by using the traffic volume data that is collected per hour or minute. The time-of-day flow profile (can be called daily pattern) could be helpful to select the best period in implementing traffic restrictions (Yannis et al., 2006). This is especially important in designing an ERP system in Jakarta. This traffic flow pattern would be an essential information to adjust the pricing. One of the local experts from Indonesia Transportation Association explained that the price of ERP must be adjustable based on the traffic condition to be perceived fair by public. *“If the V/C ratio of the road increase, the price also has to be increased based on the demand elasticities”*.

A long-term traffic pattern (i.e. between months and between years traffic pattern) should be analysed to understand whether another factor outside the regulation might influence this effect. This kind of pattern could be represented by using the traffic data that aggregated in monthly or annual term and collected over the years. For example, Borjesson et al. (2012) used the one-year flow profile of the monthly traffic volume before the implementation those analyse the traffic pattern before the congestion charged implementation in Stockholm. Due to the understanding of traffic pattern, the local expert could understand and explain why traffic volume increased right after the implementation (Borjesson et al., 2012).

However, it is still arguable that 1-year-dataset of traffic flow could adequately represent the long-term flow profile. In some cases, there are possibilities that the one-year of flow profile would not be enough to express the long-term trend of the traffic condition. For example, the year of 2002 in London, which is one year before congestion charge implementation, in London was characterised by “an unusual disruption” by the Transport for London (2003). Thus, it is stated in their report that the measurement taken during 2002 might not be a good representative for the traffic condition before the implementation. Thus to accurately describe the yearly flow profile, external factors such as traffic disruptions should be considered or another regulation that could influence the traffic pattern. Furthermore, 1-year traffic data would not represent the changes due to the demographic aspect or economic aspect because these factors change gradually.

The data provided also could not represent the characteristic of traffic condition spatially because the data provided for the unrestricted roads are not adequate for illustrating the traffic condition around the restricted road. Considering the Government’s plan of area-based traffic restrictions, the evaluation must include the impact assessment on the area basis. However, the data requirement would be challenging, and the data collection would consume a considerable amount of resources. Unlike the corridor based implementation that only has several entry points and two corridors to be monitored, the area-based implementation has many more entry points and cover all of the roads inside the area. For example, Transport for London (2003, 2006, 2008) was collecting the traffic data within the congestion charge area including traffic circulating within the charging zone and traffic entering and leaving the charging zone across the charging zone boundary. Traffic around the implementation area was also counted, including the traffic entering the centre of London; traffic on the Inner Ring Road, and even broader traffic trends in London.

Collecting data in all restricted and unrestricted road would need too many resources and time. Therefore, sample roads must be selected to represent the road population. The most suitable sampling methods for this case is stratified sampling (Taylor et al., 2000). The sampling can be based on road types (i.e. road width) like Transport for London (2003, 2006, 2008) did. This type sampling ensures that every road type has a representative within the analysis (Transport for London, 2003).

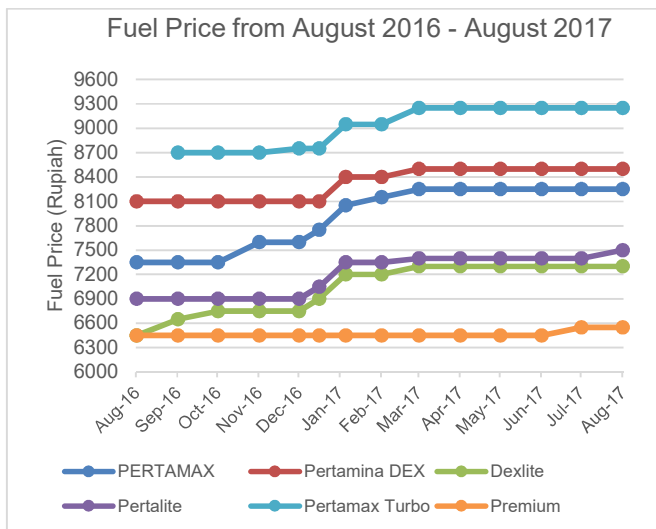
Moreover, since a TDM measure was aimed at reducing congestion, indicators such as excess delay, travel time index or relative speed reduction could represent congestion level more accurate than traffic volume and travel speed. Moreover, the excess delay, travel time index and relative speed reduction can represent the contrast between the observed condition to the free flow traffic conditions (Hanna et al., 2017; Moran, 2011; Transport for London, 2003). These kinds of measurement is relatively an easy-to-understand indicator for the public and also for the decision maker to understand the level of congestion and how much the improvement was made by using this TDM policies.

In measuring the effect of the odd-even scheme in Jakarta, local government use the average travel speed data. Although it is not directly measuring the congestion level, the changes in average travel speed could illustrate the changes in road performance. However, similar to traffic volume, the average travel speed and travel time should also be improved. In this study, the average travel speed and travel time were collected in limited temporal and spatial coverage. The travel speed was only collected in several days in between each phase, only in the peak periods and only within the restricted road. To be able to see the pattern, the average travel speed should be collected continuously (see Cai & Xie, 2010; Li & Guo, 2016).

5.2.2. Control Parameter

As mentioned before, a simple comparison between before and after implementation could not represent the “real” effect of the TDM policy implementation. By including the control parameters into consideration, the analysis could distinguish the effects of a policy instrument from those influences. For example, Borjesson, Eliasson, Hugosson, & Brundell-Freij (2012) used several factors that might influence the traffic including fuel price, total employment in Stockholm County, relative car ownership. In that study, time series model is used to estimate the traffic reduction if the external factors remained constant by using traffic flow across the cordon from 1973 to 2005. However, the external factors vary in time. Therefore, the time-scale of the control parameter data should be synchronised with the traffic data.

Reflected the factor affecting travel demand from Litman (2013), the direct and short-term implications usually are induced by prices, transport options augmentation and demand management. In the case of Jakarta, fuel price might affect the traffic pattern in Jakarta in a short term. Fuel price is one of the factors that could affect the travel demand directly. It also relatively dynamic because it depends on the fuel price



around the world. However, subsidised fuel price should be taken into account. In Indonesia, there is one kind of fuel price that has a relatively stable price, which is called as Premium. This kind of fuel has targeted the low-income class motorist/car user, such as minibus driver or motorcyclist. Therefore, it should be understood first, which kind of fuel that usually used by most car users. Figure 31 shows that although the non-subsidised fuel such as Pertamina, Peralite, Pertamina Dex, Pertamina Turbo and Dexlite, increase significantly across the year, the Premium (as the subsidised fuel) has insignificant increase.

Figure 31 Fuel Price

Unlike fuel price, changes of parking fees, as one of the TDM strategies, might not change as much as fuel price in the monthly cycle, except if there is a new-radical policy that changes the parking fee. Parking fee

in the CBD area is stable at Rp. 4000 (or equal to 30 euro cent) per hour since 2015. As for the road tolls, the pricing scheme will be evaluated every two years. Therefore there are no possible changes within two years. These external factor might be included in the long term effect analysis. Other short-term factors that might be included in the analysis are weather, accidents and infrastructural development (Weijermars, 2007).

In analysing the long-term effect, the factors such as the population growth, the growth of vehicle ownership, and the employment rate should be also considered. Those factors more likely affect travel demand in a long-term because those factors evolve in a longer time. In Jakarta, those factors are essential to be considered in the analysis because Jakarta has a fast population growth and economic growth. Furthermore, if the ERP is implemented the inflation rate also should be considered because the inflation would influence the real value of the price.

However, external factor data usually is spatially aggregated. For instance, in Indonesia, usually, the data of employment rate or the number of employment or employment rate are available on province level or at least city level. On the other hand, the traffic restriction would only cover a part of the city, thus adjustment should be made.

5.2.3. Methods of Data Collection

Collecting adequate data for analysing traffic effect would need huge efforts in term of resources, both human and financial resources. Not only does the data need to be collected continuously, but also it should cover a vast area, primarily, in the case of Jakarta, which has many local roads. The methods of collection also varies depending how detailed data required. For example, to illustrate the seasonal profile of traffic flows, the traffic flow within a day, week, month and year, should be counted continuously across the year. Automated traffic counting methods that usually the most suitable for collecting this kind of data. The type of automatic traffic detector varies according to the purpose of the survey. Some detectors are suitable for the temporary survey (pneumatic tube detectors, switch tapes, electric cable) while the others are stationary (e.g. induction loop)(Taylor et al., 2000).

Jakarta still uses the output of manual traffic counting for calculating the average traffic volume before and after the implementation of the odd-even scheme. Although using the manual traffic counting methods is not entirely wrong, for analysing the traffic trend changes, using manual traffic counting methods could be too ineffective and too costly. Moreover, the manual traffic counting also increases the possibility of human error and has low cost-effectiveness (Smith, McIntyre, & Anderson, 2002; Taylor et al., 2000).

However, the provision of automated or stationary devices (i.e. to collect traffic data) could be costly and sometimes could not cover the whole target area (Taylor et al., 2000). If the ERP system is implemented in the traffic area, the data collection, especially for traffic flow data collection, would be easier. The gantries do not only have the capacity to enforce the restriction, but also the capacity to collect the data such as traffic volume, as well as average time-based speed in the cordon area. Based on Wijaya (2016), Jakarta has planned to use the DSRC (Dedicated Short-range Radio Communication) which detects each vehicle that passes through a gantry through an onboard unit (can be called in-car transponder). This system would continuously collect the traffic data, especially traffic flow.

On the other hand, not all automated traffic counters could distinguish the vehicle types. Even so, the automated counter could only distinguish vehicle types up to six class based on their length, their physical bulk and their configuration(Taylor et al., 2000). This classification is especially important to analyse the mode share changes due to the regulation. For example, in Jakarta's case, the odd-even scheme only restrict private cars and exempt taxis and minibus. However, taxi and private car have some length, physical bulk and configuration. Thus this two kind of vehicles could not be differentiated by the automated traffic counters. That is why the manual traffic counting is still needed for the evaluation. Therefore, the combination of manual and automated counts is needed to complete each other. Transport for London (2003, 2006, 2007, 2008) used the manual classification to distinguish 15 different vehicle types, based on

visual identification as well as the automated counts to provide the seasonal and cyclic trend of traffic condition before and after the implementation of the congestion charge.

Another method in traffic data collection that increasingly used is Floating Car Data (FCD). FCD is a method that use the location of GPS or mobile phones in the road network to gather the traffic information such as speed or travel time (Briante et al., 2014). Data such as car location, speed and direction of travel are sent anonymously to a central processing centre. This kind of methods is claimed to be a more cost-effective data collection methods compared to traditional measurement techniques (e.g. point detector). Furthermore, through FCD, the traffic data from the entire network could be provided (Rahmani, Jenelius, & Koutsopoulos, 2014).

One of FCD that are often used recently is Google FCD. The most incredible advantages for Google FCD is it can be extracted freely by the public through Google Application Programming Interface. This floating car data is accumulated from the location of Android phones all over the network. By querying the data with Google API, the real-time travel speed and travel time, which is captured by the Android phone users, could be collected. Beside real-time traffic data, predicted traffic data which initially is used for real-time navigation, could also be retrieved using Google API. The prediction was estimated by Google using historical traffic data that capture typical travel time in certain time of day. Hanna et al. (2017) used the both predicted and real-time travel time to analyse the effect of 3 in 1 policies lifting in Jakarta.

Van den Haak and Emde (2016) validated the use of Google Floating Data Car output for traffic management purpose. The study case was done in the Netherlands where inductive loops have been used to monitor the traffic. In the study, Van den Haak and Emde compare the traffic statistic from the inductive loops and Google statistic. As the results, they found that Google floating car data can be used for assessing scenarios for traffic management or for informing road users about traffic condition. However, it was not sufficient to be used for operational traffic management such as for controlling traffic lights (van den Haak & Emde, 2016). Moreover, they also found that the coverage of Google floating car data is acceptable as long as the traffic intensity is higher than one vehicle per 2 minutes.

This method has been already used by the consultant that is hired by JTA to evaluate the effect of the odd-even scheme. The average travel speed before implementation, in the trial period and after implementation in Jakarta is extracted by using Distance Matrix Service in Google API. The data is collected in three phase (3 days of July, six days in August and two weeks in September). The consultant collected the real-time travel time every 30 minutes, only in the peak hours. Based on those real-time travel time, the travel speed is calculated. Then based on those travel speed data, the consultants presented the average travel speed in the peak hour for each phase.

Furthermore, because of the low-cost nature and the easiness of this methods, Jakarta Transportation Agency use this interface to monitor the travel speed, as their key performance index, every month since January 2017. The real-time data is collected in 8 days within one month, every 30 minutes, only in the peak hours (7 AM – 10 AM morning peak hour and 5 PM - 8 PM evening peak hour). Every month, they calculate the average travel speed in the peak hour as their monitoring program. In fact, this method could be used to collect the data for further analysis such as representing the daily average speed pattern and profile. Although this method is efficient, it should be noted that this method requires high skilled human resources.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

Travel demand management (TDM) is one of the strategies that are implemented to reduce car usage and to promote public transportation usage which is expected to relieve congestions. TDM can be divided into two categories, push and pull measures. Push policies are focused on reducing car use via traffic restriction or road pricing, while pull policies are focused on improving public transportation. This study focused on evaluating push policies, especially road rationing scheme which has been implemented worldwide. This scheme, which was usually applied as a license-plate rationing, was already implemented in several cities, mainly in developing countries (Eskeland & Feyzioglu, 1997; Jianwei et al., 2009; Kumar et al., 2017; X. Li, Liu, Gao, & Liu, 2016b). This scheme is known for easy implementation and low-cost nature as opposed to its decreasing advantages in a long-term period.

Jakarta, as one of capital cities in developing countries, has implemented several types of TDM measure range from 3 in 1 policies to odd-even scheme as well as improving public transportation system. An odd-even scheme was implemented since August 2016 after 3 in 1 policies was abolished abruptly in May 2016. It was also claimed to be a transition regulation before ERP implementation in 2019. The scheme was implemented only in the peak period (morning 6 AM -10 AM and evening peak 4 PM to 8 PM) and only in a limited area (i.e. two corridors within CBD area). Local government found that in the trial period, the odd-even scheme reduce the traffic volume effectively and increase the travel speed in the restricted road. However, this result is analysed by only comparing the traffic condition before and trial periods without considering other factors that might influence the traffic condition.

This study evaluated the odd-even scheme in Jakarta by comparing the traffic condition before trial, during trial, and after 7-month implementation in the restricted corridors and in seven unrestricted corridors. The data is provided Jakarta Transportation Agency which is represented by average traffic volume, average travel speed and average travel time. Moreover, the average number of TransJakarta passengers in the peak period in July (before trial), August (trial period) and September (implementation period) was also compared. Furthermore, a small survey was conducted to understand what workers did to adapt the odd-even scheme. Several interviews were also conducted to understand more about the context of Jakarta. Based on the study, the following conclusions were drawn:

- Improvement in traffic condition indeed happened immediately after the odd-even scheme implementation. The average travel speed and average travel time within the restricted corridors increased during the trial and after seven months implementation. However, based on the changes in traffic volume, the odd-even scheme still could not reach Jakarta Transportation Agency objective, which is decreasing half of the traffic in the corridor. Moreover, the traffic volume did not decrease in all road segments but rather increased in several road segments within the restricted corridors.
- The result of the questionnaire, where 15 out of 66 respondents chose other private vehicles such as motorcycles or cars with opposite number. This finding was confirmed by the changes in modal share in both corridors. Although the number of cars decreased, the number of other vehicle types increased especially motorcycles. This might be happened because the motorcycle was not restricted from the road whereas most residents of Jakarta have motorcycles. This phenomenon was also happened in Delhi where the average speed within 15-restricted days decreased while on the other hand, the flow of other vehicles such as motorbike increased (Chowdhury et al., 2017)

- Moreover, the odd-even scheme might not be effective in reducing city-wide congestion. According to the result of the questionnaire, most of the respondents chose to change their route choices instead of changing mode choices thus the traffic might shift to the adjacent road. The evidence was illustrated in the increasing traffic volume in several primary roads outside the restricted road. It is also indicated in the questionnaire result that the car user's overall door-to-door travel time might not change although based on Google FCD, the travel time within both corridors decreased.
- Furthermore, the respondents also changed their departure times of travel instead of changing mode choices. Hence the traffic might distribute to another time period. It is also indicated in the changes of mode share. While the peak-periods' number of car, taxi and minibus decreased, the 14-hours number of car, taxi and minibus increased in several road segments.
- The cited traffic impacts might be resulted from the limited period and limited area of implementation. This scheme was only implemented in the peak periods while in different cities (such as Beijing and Delhi, the schemes was implemented in the working-hours (from 6 AM to 9 PM and 6 AM to 8 PM respectively (Goel, Tiwari, & Mohan, n.d.; Wang et al., 2013)). Moreover, it also implemented in limited area, only within two corridors while in Beijing, this scheme is implemented within city administrative area. This is also stated by one of the expert from ITDP who said that the odd-even scheme was too easy to avoid by car user. He, then, suggested to use this restrictions into an area basis restriction. Actually, the local government has already planned the traffic restriction which implemented by 2030 but was constrained by lack of availability of public transportation in the planned area.
- The odd-even scheme might not lead to shifting behaviour from car to public transport usage if the level of services of public transportation remain the same. Based on the questionnaire, although most respondents were willing to change their transport modes in the future, in reality, only a few substituted their cars for public transportation. Moreover, the respondents still perceived the public transportation as unreliable, inflexible, and uncomfortable. They also said that the pedestrian infrastructure is still insufficient and no feeder bus is provided between their residence and the transit. The problems mostly came from the accessibility of the public transportation itself. Most respondents said that they have to transfer more than one time to reach their destination. As a consequence, they needed longer travel time than if they were using private cars.
- On a different note, as a positive effect of the odd-even scheme, the number of TransJakarta buses that passed by the corridor in the work-hours also increased. This phenomenon reflected a similar finding which was experienced in Stockholm. After the implementation of the ERP system, congestion level was reduced in and around the inner city which was leading to increased speeds and punctuality for bus services (Eliasson, 2014). In Jakarta case, the traffic volume decrease might affect the clearance of affects the clearance of TransJakarta lanes thus increasing their reliability.
- Although the number of TransJakarta passengers also increased in the trial period and further in the implementation period, the bus occupancy decreased in the trial period. These findings could be interpreted such that TransJakarta's comfort increased after the implementation. However, on the other hand, the decreasing bus occupancy could also be interpreted as the increased number of passenger was not as high as expected (i.e. government add more bus fleet expecting high increase on the number of passenger due to odd-even scheme).
- Most experts agreed that the public transportation system in Jakarta should also be improved to reduce car usage significantly. One of the experts from University of Indonesia said that the first step to reduce car usage significantly is to push people to use public transportation by improving the public transportation to the state that it has similar quality (comfort, safety and flexibility) to private cars' quality. However, another experts said that push policies is also important to implement an effective

push policies because most of Jakarta's resident already had at least one private vehicle which means that it would be harder to push people to use public transportation.

- Based on local expert interview, ERP could be more effective compared to 3 in 1 policies and odd-even scheme. One of experts, from MTI, said that although ERP are more complex in the preparation phase, but it would be fairer than odd-even scheme in the implementation. The system can be adjusted based on the traffic condition itself, when the traffic volume is higher, the price could set higher than usual. Another experts from ITDP said that, by using the ERP system, the Government can easily monitor the traffic condition thus it is also easy to evaluate. However, the preparation of ERP system could spend some times due to its complex nature. Moreover, the pricing has to be analysed carefully considering the demand elasticities over the price to get an acceptable price.

This study attempted to evaluate the effect of odd-even scheme implementation in Jakarta by reflecting the Coglianesi (2012) framework of the regulation and its effect. This study only focused on the traffic effect as the outcome performance. However, this study could not reflect another impact that could be happened due to the odd-even scheme such as social impact which are done in Beijing and Delhi (Goel et al., n.d.; Viard & Fu, 2015; Wang et al., 2013). As Coglianesi explained, the implementation of regulation changes the behaviour of its target and modifies their habit to achieve the ultimate goals. The changes in the target's behaviour might lead to an unexpected and undesired impact. Sometimes those changes affect another thing that is not even related to the objectives. Therefore, the impact assessment should not be done limited to traffic impact assessment.

Travel behaviour changes is one of impact assessments that should be analysed. As explained by Steg & Schuitema (2007), individual adapt to the pricing in various ways, thus influence the traffic condition. In this study, a small survey was conducted to indicate travellers' adaptation due to the scheme implementation and their perceived travel time before and after implementation. The small survey could not represent the workers that are affected by this regulation because the respondents might already forget about what happened one year before. Therefore, a more reliable and accurate survey should be done. For instance, Transport for London (2003) compared a panel of 36 people from mixed-sectors before and after the congestion charge implementation. Those respondents completed questionnaires and filled four-phase seven-day-travel diaries, one before the implementation, and three after the start of the implementation. In Stockholm, Karlström & Franklin (2009) also using two-wave surveys in the form of a travel diary. Although this kind of assessment need demanding resources, but the result of questionnaire would be helpful to make a better transport policy instrument.

Furthermore, the traffic effect analysis was only done by comparing the traffic condition (average traffic flow, average travel time and average travel speed) before and after the implementation. By using that method, the effect of the odd-even scheme could not be isolated from another influence that could affect the traffic since the traffic is influenced by many factors. In the short term, the influence could come from people's daily activity pattern or even weather. To consider those short-term external factors, comparing the traffic flow profile might be more appropriate to see the changes after the implementation. For example, Li and Guo (2016) evaluate the odd-even scheme in Beijing by comparing the hourly temporal pattern between the same days (Monday before implementation to Monday after implementation, Tuesday "before" to Tuesday "after" and so on). As a result, the changes in hourly traffic pattern can be seen. Moreover, the effect of an odd-even scheme usually decreases in the long term (Eskeland & Feyzioglu, 1997; Jianwei et al., 2009; Zhu et al., 2013) thus the evaluation of long-term temporal pattern should be done. For instance, Borjesson et al. (2012) studied the traffic effect in Stockholm after the congestion charge implementation by using monthly average traffic data. The traffic flow could illustrate the seasonal pattern across the years, thus could prove that the congestion charge affect positively the city's traffic condition.

However, those studies mentioned above were not considering the external factors that influence the traffic. As explained by (Litman, 2013) sometimes the external factors are not even related to the traffic conditions, such as demographics, commercial activity, transport options, land use, demand management and prices. These external factor more likely change in a longer time period (monthly or annually). However, the data available is not adequate to conduct more appropriate methods that allow the analyst to control those non-traffic parameters. Reflected to the evaluation of congestion charge effect in Stockholm, (Borjesson et al., 2012) use annual average daily traffic flow traffic flow across the city cordon from 1973 to 2005 and consider the fuel price, total employment in Stockholm County, relative car ownership and inflation as external factor. They need the time series data from 1973 – 2005 because the external factor they consider was changing slowly, therefore to be able to estimate the traffic. Moreover, Hanna et al. (2017) also took external factor such as city- wide changes in school schedules, income, and weather into consideration in evaluating the traffic delay changes after 3 in 1 abolished by using a detailed traffic data per 10 minutes period that are collected by using Google API.

To conduct that kind of methods, the data available were not temporally adequate. The available data was only an average traffic volume before, during the trial and after seven-month implementation. The average traffic volume was calculated only by using 14 hours traffic count in three days before the implementation, in six days during the trial and in three days after seven-month implementation. These data was not collected continuously thus could represent the variability of the data. Similarly, the average travel speed and time were collected in limited temporal coverage. The travel speed was only collected in several days in between each phase, only in the peak periods. Further, the traffic pattern could not be analysed to get more information about what are the problems and what can be improved in the future implementation. Moreover, statistical analysis that allows controlling the non-traffic related parameters could not also be conducted by only using these limited data.

Further, Taylor, Bonsall, & Young (2000) explained that an interruption in one node or one link would affect a wider area. Therefore, evaluating a traffic restriction, like an odd-even scheme, the traffic condition should be considered in a broader spatial coverage, not only in the restricted road segment. However, the traffic volume data was only counted in seven unrestricted roads (which is called as alternative roads) whereas there are many unrestricted roads which connect directly to the restricted corridors. Furthermore, similar to the traffic volume data in the restricted road, the data provided for the alternative road was limited in temporal coverage. The latter was only counted in three days, in two-phase (before and during the trial). Similarly the average travel speed and time were also collected only in the restricted corridors. These data would be not adequate to understand about traffic impact in the broader area.

Furthermore, the available data was not appropriate to evaluate the changes in the mode share. The mode share of private cars, taxi and minibus are presented as one class. However, the restriction was only applied to private cars, not for the taxi and the minibus. With those data, the effect of the odd-even scheme to the changes in private cars' mode share could not be assessed further. For future implementation and evaluation, it should be noted, the classification of travel mode should reflect to the regulation itself. If the regulation are only applied to private cars, the analyst should be differentiate private cars from other light vehicles such as taxi and minibus.

In addition, there were also limitations on data management and collection program. First, the traffic counting in the unrestricted road is done by two different consultants in each phase. Consequently, the result of the traffic counting might not be comparable. It is because the accuracy and methods of data collection between one consultant and the other consultant might be different. Moreover, Jakarta Transportation Agency only had the analysis result and did not have the data from the survey. Hence, during the fieldwork, the consultants were contacted. However, because each consultant has different standard, they also has different way on managing and visualising data.

In summary, by using the available data, it can be concluded that the odd-even scheme might have a short-term effect on the traffic conditions. However, this indication should be analysed further because some phenomenon could not be explained by only using limited data as provided. Therefore, in the next section, some recommendation would be proposed to improve the evaluation process based on the limitation that already mentioned before. This recommendation is made with considerations of area-based traffic restriction plan and ERP implementation in mind.

6.2. Recommendations

Based on the findings and limitations, several recommendations are proposed as followed.

1. The impact assessment should include not only traffic impact assessment but also travel behaviour assessment, social impact assessment and economic assessment. This assessment should consider the implementation of ERP in area basis.
2. An behavioural and attitudinal study on mode choice is essential to better understand individual willingness to change their travel mode into public transportation and in what condition do they change, especially in implementing road pricing.
3. An optimal pricing should be analysed carefully considering the demand elasticities over the price. Followed by social and economic impact to understand what are the impact of pricing to the residents' daily life.
4. Based on the limitation on data management, it is recommended that Jakarta Transportation Agency should apply more strict procedure and qualification for the data collection procedure, including collection methods and data reporting.
5. A methodology for future TDM evaluation is proposed includes the traffic data requirement, the external factors as control parameter in the analysis and the methods of collection. The analysis methods should allow to control the external factors thus the effect could be isolated from the external factors. Data required for the analysis should represent variation temporally and spatially. Furthermore, the data should be statistically significant to perform an experimental study. Collecting those data could be demanding and expensive. However, due to the implementation of ERP in Jakarta, the traffic volume in every gantry could be achieved. Moreover, by using Floating Car Data from Google, the real-time space-mean speed could be acquired easily and relatively cheap. The proposed methodology on measuring effect of TDM measure are summarized in Table 10.

Table 10 Methodology for Evaluation of Future TDM policies in Jakarta

Assessment	Methods	Indicator	Temporal Coverage	Spatial Coverage	Methods of Collection
Traffic Impact	Attributional study	Traffic Volume	Short-term analysis: at least 1-year historical data before the implementation	Restricted road and unrestricted road	At the cordon: Automated traffic counting by using ERP gantries Within the restriction area: Temporary automated traffic counting in several sample roads on several sample days. Adjacent road outside the area: Temporary automated traffic counting in several sample roads on several sample days.
			Long-term analysis: more than 3-years historical data (usually used monthly)		
		Speed and Travel Time	At least 1 year data before implementation	Restricted road and unrestricted road	Google Floating Car Data, collected at least every 30 minutes
		Control Parameter			
		Fuel Price	Monthly fuel price, at least 1 year before the implementation	DKI Jakarta	
		Parking Fee	Annually	DKI Jakarta	
		Inflation	Annually	DKI Jakarta	
		Population growth	Annually	DKI Jakarta	
		Employment growth	Annually	DKI Jakarta	
		Weather	Daily	DKI Jakarta	
	Non-attributional study	Mode share	At least 7 days every months counting to capture modal variation between days within the week	Restricted road and Unrestricted road.	14 hour manual traffic counting. Stratified sampling would be used to select the road that would be counted.
		Journey Time (door-to-door trip)	At least collected in two phase	Jabodetabek	Individual travel diary
Public transportation operation		Bus passenger counts	At least 1 year data	Within the restriction area	Data from automatic ticket in every transit b

LIST OF REFERENCES

- Agarwal, S., & Koo, K. M. (2016). Impact of electronic road pricing (ERP) changes on transport modal choice. *Regional Science and Urban Economics*, 60, 1–11.
<https://doi.org/10.1016/j.regsciurbeco.2016.05.003>
- Apsari, R., Gunawan, W., Lestari, T., Prasetyo, F., Sumarna, A., Djuhartina, N., ... Sabani, U. (2016). *Jakarta in Figures 2016*. Jakarta.
- Aryani, S. (2017). KedaiKOPI - KedaiKOPI: Ini Respon Publik Jakarta Tentang Ganjil Genap dan Rencana ERP. Retrieved August 14, 2017, from
<http://www.kedaikopi.co/web/index.php/survei/37-kedaikopi-ini-respon-publik-jakarta-tentang-ganjil-genap-dan-rencana-erp>
- Bamberg, S., Fujii, S., Friman, M., & Gärling, T. (2011). Behaviour theory and soft transport policy measures. *Transport Policy*, 18(1), 228–235. <https://doi.org/10.1016/j.tranpol.2010.08.006>
- Batterman, S., Cook, R., & Justin, T. (2015). Temporal variation of traffic on highways and the development of accurate temporal allocation factors for air pollution analyses.
<https://doi.org/10.1016/j.atmosenv.2015.02.047>
- Batur, İ., & Koç, M. (2017). Travel Demand Management (TDM) case study for social behavioral change towards sustainable urban transportation in Istanbul. *Cities*.
<https://doi.org/10.1016/j.cities.2017.05.017>
- Behrendt, H., & Teytelboym, A. (2010). Part II: Policy instruments for sustainable road transport. *Research in Transportation Economics*, 28(1), 46–91. <https://doi.org/10.1016/j.retrec.2010.03.002>
- Borjesson, M., Eliasson, J., Hugosson, M. B., & Brundell-Freij, K. (2012). The Stockholm congestion charges—5 years on. Effects, acceptability and lessons learnt. *Transport Policy*, 20, 1–12.
<https://doi.org/10.1016/j.tranpol.2011.11.001>
- Briante, O., Campolo, C., Iera, A., Molinaro, A., Paratore, S. Y., & Ruggeri, G. (2014). Supporting augmented floating car data through smartphone-based crowd-sensing. *Vehicular Communications*, 1(4), 181–196. <https://doi.org/10.1016/j.vehcom.2014.08.002>
- Broadbuss, A. ., Litman, T., & Menon, G. (2009). *Transportation Demand Management*. Eschborn.
- Cai, H., & Xie, S. D. (2010). A modelling study of air quality impact of odd-even day traffic restriction scheme before, during and after the 2008 Beijing Olympic Games. *ACPD Atmos. Chem. Phys. Discuss*, 10(10), 5135–5184. Retrieved from www.atmos-chem-phys-discuss.net/10/5135/2010/
- Cairns, S., Sloman, L., Newson, C., Anable, J., Kirkbride, A., & Goodwin, P. (2004). *Smarter Choices – Changing the Way We Travel Disclaimer and copyright Accompanying report*. Retrieved from <http://discovery.ucl.ac.uk/1224/1/1224.pdf>
- Central Statistic Agency of Jakarta. (2015). *Commuter of Jakarta Capital City*. Jakarta. Retrieved from https://jakarta.bps.go.id/backend/brs_ind/brsInd-20150220094832.pdf
- Central Statistic Agency of Jakarta. (2017). *Transportation Statistics of DKI Jakarta 2016*. Jakarta: Central Statistic Agency of Jakarta.
- Chen, X., Li, L., & Shi, Q. (2015). *Stochastic evolutions of dynamic traffic flow : modeling and applications*.
<https://doi.org/10.1007/978-3-662-44572-3>
- Chowdhury, S., Dey, S., Tripathi, S. N., Beig, G., Mishra, A. K., & Sharma, S. (2017). “Traffic intervention” policy fails to mitigate air pollution in megacity Delhi. *Environmental Science and Policy*, 74, 8–13. <https://doi.org/10.1016/j.envsci.2017.04.018>
- Coglianesi, C. (2012). *Measuring Regulatory Performance: Evaluating the Impact of Regulation and Regulatory Policy*. Retrieved from https://www.oecd.org/gov/regulatory-policy/1_coglianesi_web.pdf

- Crawford, F., Watling, D. P., & Connors, R. D. (2017). A statistical method for estimating predictable differences between daily traffic flow profiles. *Transportation Research Part B: Methodological*, 95, 196–213. <https://doi.org/10.1016/j.trb.2016.11.004>
- Eliasson, J. (2014). *The stockholm congestion charges: an Overview*. Centre for Transport Studies Working Paper (Vol. 7). Retrieved from <http://www.transportportal.se/swopec/CTS2014-7.pdf>
- Eskeland, G. S., & Feyzioglu, T. (1997). *Rationing Can Backfire: The “Day without a Car” in Mexico City*. The International Bank for Reconstruction and Development.
- Ferguson, E. (2000). *Travel Demand Management and Public Policy*. Hants: Ashgate Publishing Ltd.
- Franklin, J. P., Eliasson, J., & Karlstrom, A. (2009). Traveller Responses to the Stockholm Congestion Pricing Trial: Who Changed, Where Did They Go, and What Did It Cost Them? In W. Saleh & G. Sammer (Eds.), *Demand Management and Road User Pricing: Success, Failure and Feasibility* (pp. 215–238). Ashgate Publishing, Ltd., 2009.
- Garling, T., & Schuitema, G. (2007). Travel Demand Management Targeting Reduced Private Car Use : Effectiveness, Public Acceptability and Political Feasibility, 63(1).
- Goel, R., Tiwari, G., & Mohan, D. (n.d.). *Evaluation of the Effects of the 15--day Odd--Even Scheme in Delhi: A Preliminary Report*. Delhi. Retrieved from http://tripp.iitd.ernet.in/IITodd_even_prelim_rpt_Apr16.pdf
- Habibian, M., & Kermanshah, M. (2011). Exploring the role of transportation demand management policies’ interactions. *Scientia Iranica*, 18(5), 1037–1044. <https://doi.org/10.1016/j.scient.2011.09.005>
- Habibian, M., & Kermanshah, M. (2013). Coping with congestion: Understanding the role of simultaneous transportation demand management policies on commuters. *Transport Policy*, 30, 229–237. <https://doi.org/10.1016/j.tranpol.2013.09.009>
- Hanna, R., Kreindler, G., & Olken, B. A. (2017). Citywide Effects of High-Occupancy Vehicle Restrictions: Evidence from the Elimination of “3-in-1” in Jakarta. *National Bureau of Economic Research Working Paper Series*, No. 23295(July), 89–93. <https://doi.org/10.3386/w23295>
- Hove, S. E., & Anda, B. (2005). Experiences from conducting semi-structured interviews in empirical software engineering research. *International Software Metrics Symposium*, (Metrics), 203–212. <https://doi.org/10.1109/METRICS.2005.24>
- Hunter-Zaworski, K., Fowler, J., Lall, K., Bardwell, T., Bird, P., Dahl, S., ... Nelson, J. (2003). Transportation Engineering Lab Manual. Retrieved November 28, 2017, from http://www.webpages.uidaho.edu/niatt_labmanual/index.htm
- Jakarta Transportation Agency. (2016). Extended Evaluation of The Odd-even scheme. Jakarta.
- Jakarta Transportation Agency. (2017). Evaluation of the Odd-even scheme.
- Javid, M. A., Okamura, T., Nakamura, F., Tanaka, S., & Wang, R. (2016). People’s behavioral intentions towards public transport in Lahore: Role of situational constraints, mobility restrictions and incentives. *KSCE Journal of Civil Engineering*, 20(1), 401–410. <https://doi.org/10.1007/s12205-015-1123-4>
- Jianwei, H., Zhenxiang, Z., & Zhiheng, L. (2009). An Analysis on Effectiveness of Transportation Demand Management in Beijing. *Journal of Transportation Systems Engineering and Information Technology*, 9(96), 114–119. [https://doi.org/10.1016/S1570-6672\(08\)60091-4](https://doi.org/10.1016/S1570-6672(08)60091-4)
- Kaffashi, S., Shamsudin, M. N., Clark, M. S., Sidique, S. F., Bazrbachi, A., Radam, A., ... Rahim, K. A. (2016). Are Malaysians eager to use their cars less? Forecasting mode choice behaviors under new policies. *Land Use Policy*, 56, 274–290. <https://doi.org/10.1016/j.landusepol.2016.05.005>
- Karlström, A., & Franklin, J. P. (2009). Behavioral adjustments and equity effects of congestion pricing: Analysis of morning commutes during the Stockholm Trial. *Transportation Research Part A: Policy and Practice*, 43(3), 283–296. <https://doi.org/10.1016/j.tra.2008.09.008>
- Khafifah, N. (2017). Penerapan Ganjil-Genap Belum Efektif (Odd-Even Scheme Implementation Has Not Effective Yet). Retrieved August 4, 2017, from <https://kumparan.com/nur->

- Knoop, V., Hoogendoorn, S. P., & Zuylen, H. Van. (2009). Empirical Differences Between Time Mean Speed and Space Mean Speed. In C. Appert-Rolland, F. Chevoir, P. G. Schreckenberg, S. Lassarre, J.-P. Lebacque, & M. Schreckenberg (Eds.), *Traffic and Granular Flow '07* (pp. 351–356). Springer, Berlin, Heidelberg. https://doi.org/https://doi.org/10.1007/978-3-540-77074-9_36
- Koh, W. T. H., & Lee, D. K. C. (1994). The Vehicle Quota System in Singapore: An Assessment, 28(1), 1–47. Retrieved from https://ac.els-cdn.com/096585649490040X/1-s2.0-096585649490040X-main.pdf?_tid=9d785c22-c47f-11e7-98bc-00000aabb0f27&acdnt=1510143984_ea31b9d9e951689ebb065898404ac9dc
- Kumar, P., Gulia, S., Harrison, R. M., & Khare, M. (2017). The Influence of odd-even car trial on fine and coarse particles in Delhi. *Environmental Pollution*, 225, 20–30. Retrieved from http://ac.els-cdn.com/S0269749116313124/1-s2.0-S0269749116313124-main.pdf?_tid=dc07a4ee-7f25-11e7-8c2c-00000aabb0f27&acdnt=1502518805_f294a50c5c3cde6aad8147feb1c002d9
- Li, R., & Guo, M. (2016). Effects of oddeeven traffic restriction on travel speed and traffic volume: Evidence from Beijing Olympic Games. *Traffic and Transportation Engineering*, 3, 71–81. <https://doi.org/10.1016/j.jtte.2016.01.002>
- Litman, T. (2013). Transport Elasticities : Impacts on Travel Behaviour. *Deutsche Gesellschaft Für Internationale Zusammenarbeit (GIZ) GmbH, Sector Project “Transport Policy Advisory Services”, Division 44 - Water, Energy, Transport*.
- Litman, T. (2017). *Smart Congestion Relief: Comprehensive Evaluation of Traffic Congestion Costs and Congestion Reduction Strategies*. Retrieved from http://www.vtpi.org/cong_relief.pdf
- Lyndon, S., Marinelli, P., Macintosh, K., & McKenzie, S. (2014). High occupancy vehicle lane enforcement: A successful trial in Brisbane by adding a splash of magenta. *ATRF 2011 - 34th Australasian Transport Research Forum*, (September). Retrieved from <http://www.scopus.com/inward/record.url?eid=2-s2.0-84916910492&partnerID=tZOTx3y1>
- Mardani N, M., Chandra, S., & Ghosh, I. (2015). Passenger Car Unit of Vehicles on Undivided Intercity Roads in India. *Procedia - Procedia Computer Science*, 52, 926–931. <https://doi.org/10.1016/j.procs.2015.05.167>
- Meyer, M. D. (1997). Traffic Congestion : An Overview. In *A Toolbox for alleviating traffic congestion*. Washington DC: Institute of Transportation Engineers. Retrieved from <http://trid.trb.org/view.aspx?id=344812>
- Moer, G., & Bamberg, S. (2008). The effectiveness of soft transport policy measures: A critical assessment and meta-analysis of empirical evidence. *Journal of Environmental Psychology*, 28, 10–26. <https://doi.org/10.1016/j.jenvp.2007.09.001>
- Moran, C. A. (2011). Congestion Indicators and Congestion Impacts: A Study on the Relevance of Area-Wide Indicators. *Procedia Social and Behavioural Science*, 16, 781–791. <https://doi.org/doi:10.1016/j.sbspro.2011.04.497>
- Nanang, M., & Tamin, O. Z. (2009). Mode Shift Travel Demand Management Evaluation From Jakarta’s Experience. *Proceedings of the Eastern Asia Society for Transportation Studies*, 7. Retrieved from https://www.jstage.jst.go.jp/article/eastpro/2009/0/2009_0_15/_pdf
- Nie, Y. (2017). On the potential remedies for license plate rationing. *Economics of Transportation*, 9, 37–50. <https://doi.org/10.1016/j.ecotra.2017.01.001>
- PT. Danureksa Sarana Cipta. (2014). Manual Traffic Counting Methodology of PT. Danureksa Sarana Cipta. Jakarta.
- PT. Danureksa Sarana Cipta. (2016). Odd-even scheme evaluation: Traffic Flow Volume Analysis in The Restricted Road.
- Rahmani, M., Jenelius, E., & Koutsopoulos, H. N. (2014). Floating Car and Camera Data Fusion for Non-Parametric Route Travel Time Estimation. *Procedia - Procedia Computer Science*, 37, 390–395. <https://doi.org/10.1016/j.procs.2014.08.058>

- Redman, L., Friman, M., Garling, T., & Hartig, T. (2013). Quality attributes of public transport that attract car users: A research review. *Transport Policy*, 25, 119–127. <https://doi.org/10.1016/j.tranpol.2012.11.005>
- Regional Development Planning Board of Jakarta. Rencana Pembangunan Jangka Menengah Daerah Provinsi Daerah Khusus Ibukota Jakarta Tahun 2013-2017 (2013).
- Santos, G., Behrendt, H., Maconi, L., Shirvani, T., Teytelboym, A., & Santos, G. (2010). Part I: Externalities and economic policies in road transport. *Research in Transportation Economics*, 28, 2–45. <https://doi.org/10.1016/j.retrec.2009.11.002>
- Smith, D., McIntyre, J., & Anderson, M. (2002). Traffic Volume Counts. *Handbook of Simplified Practice for Traffic Studies*. <https://doi.org/10.4135/9781849208802>
- Steg, L., & Schuitema, G. (2007). Behavioural Responses to Transport Pricing: A Theoretical Analysis. *Threats from Car Traffic to the Quality of Urban Life*, 347–366.
- Steg, L., & Tertoolen, G. (1999). Sustainable Transport Policy: The Contribution from Behavioural Scientists. *Public Money and Management*, 19(1), 63–69. <https://doi.org/10.1111/1467-9302.00154>
- Tanaboriboon, Y., Hokao, K., & Haider, S. W. (1994). Evaluation of TDM measures toward public acceptance in the Asian metropolises... Bangkok case study. *Proceedings - Conference of the Australian Road Research Board*, 17(6), 237–252. Retrieved from <http://www.scopus.com/inward/record.url?eid=2-s2.0-0028727671&partnerID=tZOTx3y1>
- Taylor, M. A. P., Bonsall, P. W., & Young, W. (2000). *Understanding Traffic Systems: Data, Analysis and Presentation* (Second Ed). Vermont: Ashgate Publishing Ltd.
- Transport for London. (2003). *Impacts Monitoring - First Annual Report*. London.
- Transport for London. (2006). *Impacts monitoring - Fourth Annual Report*. London.
- Transport for London. (2007). *Impacts monitoring - Fifth Annual Report*. *Transport for London* (Vol. 3). London.
- Transport for London. (2008). *Impacts monitoring - Sixth Annual Report*. *Transport for London* (Vol. 3). London.
- van den Haak, W. ., & Emde, M. F. (2016). *Validation of Google floating car data for applications in traffic management*. Den Haag. Retrieved from <https://repository.tudelft.nl/view/tno/uuid:b720bcdd-1cc9-4fb1-b874-3ae5860736b8/>
- Viard, V. B., & Fu, S. (2015). The effect of Beijing's driving restrictions on pollution and economic activity. *Journal of Public Economics*, 125, 98–115. <https://doi.org/10.1016/j.jpubeco.2015.02.003>
- Victoria Transport Policy Institute. (2017). TDM Encyclopedia. Retrieved September 26, 2017, from <http://www.vtpi.org/tdm/tdm35.htm>
- Wang, L., Xu, J., Zheng, X., & Qin, P. (2013). *Will a Driving Restriction Policy Reduce Car Trips ?* Beijing.
- Weijermars, W. A. M. (2007). *Analysis of Urban Traffic Pattern Using Clustering*. University of Twente.
- Wijaya, C. A. (2016). Ahok to announce winner of ERP tender this year - City - The Jakarta Post. Retrieved January 25, 2018, from <http://www.thejakartapost.com/news/2016/01/04/ahok-announce-winner-erp-tender-year.html>
- Xie, L., & Olszewski, P. (2011). Modelling the effects of road pricing on traffic using ERP traffic data. <https://doi.org/10.1016/j.tra.2011.03.006>
- Yannis, G., Golias, J., & Antoniou, C. (2006). Effects of Urban Delivery Restrictions on Traffic Movements. *Transportation Planning and Technology*, 294, 295–311. <https://doi.org/10.1080/03081060600905566>
- Zhang, S., Wang, H., Quan, W., & Liu, X. (2013). Measuring Variability in Freeway Traffic States using Real-time Loop Data in Jilin. *Procedia - Social and Behavioral Science*, 96(Cictp), 2676–2683. <https://doi.org/10.1016/j.sbspro.2013.08.300>
- Zheng, P., & Mike, M. (2012). An Investigation on the Manual Traffic Count Accuracy. *Procedia - Social and Behavioral Sciences*, 43, 226–231. <https://doi.org/10.1016/J.SBSPRO.2012.04.095>

Zhu, S., Du, L., & Zhang, L. (2013). Rationing and Pricing Strategies for Congestion Mitigation: Behavioral Theory, Econometric Model, and Application in Beijing. *Procedia -Social and Behavioral Sciences*, 80(80), 455–472. <https://doi.org/10.1016/j.sbspro.2013.05.025>

ANNEXES : FIELDWORK PLAN

1. Fieldwork Objective

The Fieldwork in Jakarta is used to collect the data for achieving the objectives of MSc Thesis about the evaluation of odd-even scheme implementation in Jakarta. The purposes of this field work are described as followed:

- (1) to collect the traffic data from Jakarta Transportation Agency and another institution that already has researched the odd-even scheme (if there is), and
- (2) to carry out interviews local governments and experts about the odd-even scheme implementation and its effect in light of other measures in Jakarta.

2. Data Collection Methods

Therefore, data will be collected in two manners, primary data collection and secondary data collection. Table 11 summaries of how the data collected are used in answering research questions.

Table 11 Summary on how the data required can answer each research questions

Research question	Data Collection	Data Required	Respondent/Source
Research Sub-Objective 2			
What are the characteristics of transportation system and transportation policies in the study area?	Semi-structured interview	Interview Transcript	Jakarta Transportation Agency
			Local Authority on Traffic Management
What is the effect of odd-even scheme implementation on traffic reduction, in and around the area where it was implemented?	Secondary Data	Traffic volume and average speed	Jakarta Transportation Agency
			Another institution that already has research on odd-even scheme or the same area
What is the effect of odd-even scheme implementation on car users' travel behaviour?	Structured Interview	Interview Transcript	Car users
			Local Authority on Traffic Management
	Secondary Data	Number of passenger for every transit	Jakarta Transportation Agency/TransJakarta
Research Sub-Objective 3			
What are the advantages and limitations of the odd-even traffic scheme in reducing congestion in Jakarta?	Semi-structured interview	Interview Transcript	Jakarta Transportation Agency
			Expert
What can be improved in the implementation of the odd-even scheme?	Semi-structured interview	Interview Transcript	Expert
			Car users

Research question	Data Collection	Data Required	Respondent/Source
Research Sub-Objective 4			
What are the data required for the evaluation of TDM implementation in Jakarta?	Semi-structured interview	Interview Transcript	Jakarta Transportation Agency
			Expert
What are the methods that can be used in evaluating TDM measures in Jakarta?	Semi structured interview	Interview Transcript	Expert
What are the parameters that have to be controlled in order to implement the TDM measures in Jakarta effectively?	Semi structured interview	Interview Transcript	Jakarta Transportation Agency
			Expert

1.1. Primary data collection

Primary data will be collected through interview. The respondent is car users, Jakarta Transportation Agency, Local Authority on Traffic Management, expert from University and NGO.

A. Interview Guides for Jakarta Transportation Agency

Interviewing Traffic Division of Jakarta Transportation Agency will help in achieving sub-objective 2, 3 and 4. First, I will ask about how they develop the regulation and evaluate the odd-even scheme implementation to help in discussing the first question (the characteristic of study area) and third questions (what can be improved in the implementation). It also helps to discuss sub-objective four about data requirements and methods that can be used for TDM evaluation and parameters that have to be controlled in order to implement the TDM measures in Jakarta effectively.

In the second part, I will ask about other regulations to understand more about the context where the regulation is implemented. This part will help me not only in answering questions in sub-objective two but also in discussing the limitations and advantages in implementation phase as well as what can be improved in the future.

Interview guide

S2 - Characteristic of Study Area: Development and Evaluation Methods

- a. Is there any pre-implementation analysis (certain types of planning and analysis to be conducted before deciding to implement the odd-even scheme, such as regulatory impact analysis, cost-benefit analysis, or another analysis)? How is the result?
- b. What are the objectives of the regulation (target or goals of the regulation)?
- c. What is the evaluation procedure of odd-even scheme performance?
 - i. How is performance defined?
 - ii. What are data required for evaluation?
 - iii. How they collect those data?
 - iv. What are the methods they use in evaluations?
 - v. Are there any guidelines for monitoring?

S2 - Characteristic of Study Area: Other regulations that are implemented to reduce congestion

- d. In the Jakarta Transportation Masterplan, Public transportation optimisation is mentioned of the core or transport system in Jakarta and TDM will be applied as the support system. What are the TDM policies that are already implemented in Jakarta?
- e. How is the integration of congestion management strategies with land use policies?
 - vi. Is there any relation between transportation master plan and the spatial master plan?

S3 – Advantages and Limitations

- f. What are limitations of odd-even scheme implementation if compared to 3 in 1 regulation or other TDM measures that already used in Jakarta?
- g. What are advantages of odd-even scheme implementation if compared to 3 in 1 regulation or other TDM measures that already used in Jakarta.

B. Interview Local Authority on Traffic Management

The purpose of interviewing Local Authority on Traffic Management is to understand about the implementation and enforcement of odd-even scheme to help in answering the sub-objective 2 about characteristic of study area (especially how they implement and enforce the regulation) and the behaviour changes because of odd-even scheme implementation. This information will further help in discussing the limitations and advantages of the odd-even scheme as well as what can be improved to enforce the regulation better.

Interview guide

S2 - Characteristic of study area: Implementation and enforcement

- a. What are the roles of Local Authority on Traffic Management in the implementation of odd-even scheme?
- b. How is the monitoring procedure?
 - vii. What kind of instruments that are used to monitor the implementation?
 - viii. How many personnel that are deployed to monitor the implementation?
 - ix. What kind of charge for the people who violate the regulation?
- c. What are the hindrances in the implementation and enforcement of this regulation?
- d. What are limitations of odd-even scheme implementation if compared to 3 in 1 regulation?
- e. What are advantages of odd-even scheme implementation if compared to 3 in 1 regulation?

S2 - Behavioural changes

- f. What are the violations that happened during the implementation?

C. Interview Car Users

The purpose of car users interview is to help in understanding the behavioural changes because of the implementation (Sub-objective 2) and also to explore about what can be improved in implementation through understanding public perception of this regulation (Sub-objective 3). The interview will be focused on how the odd-even scheme affects the trip chain attribute and further help individuals in deciding the travel choice. About 20 car users will be interviewed, and they will be varied in terms of employment and gender.

Questionnaire no.:



Survey:
Effect of Odd-even scheme on Travel Behaviour in Jakarta

I am a full-time student at the Faculty Geo-information Science and Earth Observation (ITC), University of Twente. I am pursuing a master degree, with Urban Planning and Management as my specialization. My research topic is Road Space Rationing : An Evaluation of Odd-Even Scheme in Jakarta.

Odd-even traffic restriction was adapted from 23 August 2016 onwards. The measure is only implemented in peak periods (07.00 to 10.00 in the morning peak and 16.00 to 20.00 in the evening peak) and is only applied to 4 major roads in Jakarta (Sudirman, Gatot-Subroto, Thamrin and Medan Merdeka). The purpose of car users interview is to help in understanding the travel behavioural changes because of the implementation of odd-even scheme.

Therefore, I would like to kindly ask your participation as a respondent to fill in this questionnaire. The sampling method used is purposive sampling, in which the respondents chosen are commuters using a private vehicle (car) along the odd-even scheme corridor (Sudirman-Thamrin Street-Medan Merdeka Barat and part of Gatot Subroto Street).

Your answers will be treated with anonymity and are solely used for research purposes. If you are curious to know the results of this study, feel free to write your email address here:

Oktaniza Nafila

o.nafila@student.utwente.nl

Part A: Trip pattern

This part will gather information about your trip pattern. *Please tick the right one or fill in the blank for each question)*

1. Where is your working location in Jakarta?

- ☐ Jalan Sudirman

- ☐ Jalan Thamrin
 - ☐ Jalan Gatot-Subroto
 - ☐ Jalan Medan Merdeka Barat
 - ☐ Others
2. How long have you been working here?
- ☐ Before July 2016
 - ☐ After July 2016
3. Where are you coming from?
- ☐ Jakarta
 - ☐ Tangerang
 - ☐ Bekasi
 - ☐ Bogor
 - ☐ Depok
 - ☐ Others.....
4. How long have you been using cars to work?
- ☐ Before July 2016
 - ☐ After July 2016
5. Before the implementation of the odd-even scheme, did you always use the car to work?
(*Strike the wrong one*)
- Yes/No
6. If No, what mode did you use?
- ☐ Using TransJakarta
 - ☐ Using Regular Bus
 - ☐ Using Commuter line
 - ☐ Using Private Motorcycle
 - ☐ Using Ojeg
 - ☐ Using Online-based transportation mode
7. How long does it takes from your home to office by using car?
- a. Before the odd-even scheme : _____(minutes)

b. After the odd-even scheme : _____(minutes)

Part B: Effect of Odd-even scheme in travel behaviour

This part will gather information about your driving habits and the effect of the odd-even scheme on your travel habits. You need to choose the most applicable for you or fill in the blank to explain the reason why you choose the options.

8. Do you use your car on odd days, or on even days? *Please tick the right one*

- ☐ Odd
- ☐ Even
- ☐ Both

9. What do you do at the day your car is restricted?

- ☐ Using TransJakarta
- ☐ Using Regular Bus
- ☐ Using Commuter line
- ☐ Using Private Motorcycle
- ☐ Using Ojeg
- ☐ Using Online-based transportation mode
- ☐ Take another route
- ☐ Change departure time
- ☐ Ridesharing with friends
- ☐ Using your other car because you have more than one car
- ☐ Using a combination of the options above
- ☐ Don't care about the regulation, just use your car, and police wouldn't know.
- ☐ Other

10. Related to *Question 9*, if you use a combination of the options, which are your combined options?

.....

11. Related to *Question 9 and Question 10 (if applicable)*, how long does it take from your home to your office by using that option?

.....minutes

12. Related to *Question 9 and Question 10 (if applicable)*, why do you choose to do that option instead of other options?

.....
.....

13. If in *Question 9*, your answer is taking another route, which route do you use? (*show in the map*).....
...

14. Do you ever think to change your habit of using car to using public transit? (*Strikethrough the wrong one*)
Yes/No
Why?.....
.....

Part C: Socio-economic data

Gender :

Age :

Occupation :

- ☐ Government Officer
- ☐ Private Company Officer
- ☐ Entrepreneur
- ☐ Other: _____

D. Interview Non-Governmental Organization and Researcher related to TDM development and evaluation

The purpose of this interview is to understand the situation of Jakarta Transportation and also the advantages as well as limitations of TDM implementation, especially odd-even scheme in Jakarta. This information will help in achieving the third objective. Another purpose is to help in developing a methodology for evaluation of TDM measures in Jakarta as fourth sub-objective of this study. The respondent will be non-governmental organisation and/or researchers that have done study related to TDM development and evaluation in Jakarta. Table 2 is the temporary list of expert that will be interviewed.

Table 12 Interviewee list for Non-Governmental Organization and Researcher related to TDM development and evaluation

No	Name	Descriptions
1	Indonesia Transport Society/Masyarakat Transportasi Indonesia (MTI)	MTI is an organisation that focuses on transportation development in Indonesia. It has one division which focuses on research in transportation field
2	Institute for Transportation and Development Policy (ITDP)	ITDP focuses on improving TransJakarta service as well as travel demand management, increasing pedestrian and bike facilities, and parking policies also focus on improving non-motorized transport throughout the city.
3	Shanty Yulianti Rachmat (from ITB)	A lecturer in ITB and has done several studies about TDM and Road Pricing
4	Achmad Izzul Waro	Involve in research, policy advocacies and campaigns with national and international NGOs regarding the transportation and traffic management, road safety and climate change issues as well as several cooperation projects with some institutions of Government of Indonesia.
5	Reza Firdaus from IAP (Indonesia's Planner Association)	Chief of transportation division in the association
6	Fransiskus Trisbiantara from University of Trisakti	Lecturer from Civil Engineering Faculty, University of Trisakti Jakarta that has specialization on Traffic Management

Interview guide

S3 – Opinion about odd-even scheme implementation

- a. What is your opinion about odd-even scheme implementation in Jakarta? Do you think it help reducing congestion in Jakarta?
- b. What TDM policies/regulations/strategies do you think are more suitable to be implemented in Jakarta?
 - Other hard policies (e.g. road pricing, congestion charge, High Occupancy Vehicles (HOV), parking restrictions, motorcycle restriction in certain road)
 - Soft policies that implemented by government (e.g. provision of Park and Ride site, Increased quality of public transport or Subsidies on public transport)

- Other regulation/strategies
- c. If government plans to implement this regulation for a long time, what policies/regulations/strategies do you think can complement the odd-even scheme in Jakarta?
 - Other hard policies (e.g. parking restrictions, increasing fuel price, etc.)
 - Soft policies (e.g. Park and Ride, Increased quality of public transport or Subsidies on public transport)
 - Other strategies (flexible working hours, ridesharing among employee, etc)
- d. What are the factors that influencing traffic growth and congestion reduction program especially in Jakarta?

S4 - Methodology

- e. Has this organisation studied TDM implementation in Jakarta? If yes, what is it all about?
- f. What are data required and methods that are used in those study?
- g. Have you done any research that was held in Jalan Sudirman-Thamrin-Gatot Subroto where odd-even scheme is implemented? If yes, what is it?
- h. What are data required and methods that are used in those study?
- i. What are your final remarks and advice to implement odd-even scheme in Jakarta?

