DISSERTATION

THE WELFARE ANALYSIS OF CONGESTION TAX:
CASE STUDY OF JAKARTA, INDONESIA

Submitted by
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In partial fulfillment of the requirements
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ABSTRACT OF DISSERTATION

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Traffic congestion is a common phenomenon in many big cities including Jakarta, Indonesia. Economists have long advocated to reduce the congestion by using tax or price mechanism. The imposition of congestion tax will improve the efficiency of resource allocation. However, congestion tax also has negative impact on equity, in the meantime equity in transportation is very important. This dissertation evaluates the impact of hypothetical congestion tax scenarios in the Central Business District (CBD) of Jakarta, Indonesia. The study shows that even though the tax has desirable effects on efficiency to travelers as a whole, it has negative impact on equity. The decomposition of welfare by income groups shows that the middle income travelers receive the highest benefits from the efficiency improvement, while the low income travelers benefit the least. Based on modal split auto drivers experience welfare improvement, while bus and motorcycle riders experience losses. By implementing cost-benefit criterion and assigning certain weights, we are not only able to make the impact of the tax to be progressive but also to increase the total utility or welfare received by travelers.

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Dedication:

To my mother, Suparti and my late father, Katri Atmaji

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Chapter 1

INTRODUCTION

Most people living in urban areas are faced with a complex set of transportation problems. Urban transport problems range from lack of transport infrastructure, to transport safety, to poor public transport services and traffic management. Among others, traffic congestion has become common phenomenon in many urban areas. Some factors, such as increasing population and urbanization, increasing car ownership, and increasing numbers of trips contribute to traffic congestion. Increasing population and urbanization, which usually take place in developing countries rather than developed countries, have resulted in more people living in urban areas. These people need housing - which makes the city denser, and mobility, which increases demand for public and private transport as well. As people's income increases, car ownership and number of trips will also increase, and both will create more demand for urban transport infrastructure or road spaces. These factors together contribute to increased traffic congestion.

Traffic congestion has been widely perceived by many people to be one of the most critical problems of urban life. According to Quinet (1994), congestion is responsible for billions of dollars of loss in time per year in many of the world's largest metropolitan areas. For example, in the US according to Lindley's (1989) estimation traffic congestion costs at $16 billion annually. This figure has increased considerably as shown by Schrank and Lomax (1999) who studied roadway congestion in the ten most congested US cities in 1997. They concluded that traffic congestion wasted approximately 2.6 billion hours of drivers' time, or equivalent to $39.3 billion. In Los Angeles alone, the corresponding figures were 739 million hours or equivalent to $10.8 billion of loss. In most Asian big cities the annual cost of time delay due to traffic congestion is also quite high. For example, in Singapore the cost is estimated as $305 million, in Hong Kong it is $293 million, and in Jakarta it is $68 million (Foster, 1994).

From microeconomic perspective traffic congestion is considered as negative externalities which cause inefficiency in resource allocation. Congested traffic creates delays for travelers, and delays are costly not only in terms of traveler's loss of time but also in terms of vehicle expenses due to greater wear of engine and the gas consumption. Delays also contribute to the increase of transaction costs, especially in terms of logistic (distribution of goods and services). Different travelers value their time differently, depending, for example, on their purpose of the trips, their economic status, etc. As a consequence, different groups of individuals will bear different amount of losses caused by traffic congestion.

Common response from the policy makers to traffic congestion problem in many countries have been to increase the capacity of infrastructure by building new roads or expanding the existing ones. This is basically a supply side approach. However, it is becoming more prohibitive to build enough road capacity to satisfy urban peak traffic demand. It is not only too costly to build new highways and roads due to the very limited resources available (e.g. land, capital), but also prohibitive from the environmental point of view.

In contrast, economists have long advocated using price mechanism in the form of congestion pricing or congestion tax[1] to manage traffic congestion more rationally. This demand side approach at the same time can also be used to achieve a better system of financing road infrastructure, so that it reflects the most efficient way to allocate limited resources. Many economists argue that urban traffic congestion is virtually unsolvable without some sort of congestion pricing.

In market economies prices serve two purposes: first, they ration available supplies among consumers; and secondly, they give signal to producers whether supplies need to be increased or decreased to meet changing demands. High prices discourage demand and stimulate supply, while low prices encourage demand but discourage supply. By imposing price to the use of congested roads, the government - as the main (in many cases the only) supplier of roads - will be able to allocate limited resources more efficiently.

There are many advantages of congestion pricing policies. Pricing measures are believed to significantly discourage trips of all types, while permitting flexible travel patterns. They encourage people to use ride-sharing or mass transit when possible, but allow them to switch to the car at other times. Congestion pricing scheme also generates revenue for the government, and also provides greater total benefits than if we let congestion delay rations road space. The success of congestion pricing is measured in

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[1] As a matter of terminology, since roads are not really market goods, instead they are part of services provided by the government or the public sector to the society, it is more common to use the terms of 'fees', 'taxes' or 'charges' instead of 'prices'. However, in many cases people use all of these terms interchangeably as what we do in this study.

terms of reduced congestion delay, avoided extra roadway costs, and other transport demand management (TDM) objectives such as increase in the number carpooling, better parking management, etc. Congestion pricing also encourages the development of alternative transport modes other than private cars, such as improvements in public transit service along the same corridor.

Congestion pricing is basically a demand management strategy intended to give motorists more incentives to shift travel time, route or mode, in order to reduce traffic on congested roadways. It can be implemented on existing roadways to avoid the need to add capacity. Congestion tolls can be set to be higher during peak periods and lower or absent when roads are not congested. Tolls can be based on a fixed rate or they can be dynamic, meaning that rates change depending on the level of congestion that exist at a particular time.[2]

From efficiency point of view, congestion pricing increases efficiency by rationing road capacity with less waste of resources due to traffic congestion. The important goal in efficiency of road pricing is to determine the optimal allocation of traffic flow by setting price equal to marginal social cost of using roads. Following British economist Arthur Pigou (1920) the implication of this goal is that a tax which is now known as the Pigovian tax, should be imposed on each unit of output (in this case the output is traffic flow) equal to the marginal cost of using road at the optimal level of output (traffic flow), which is achieved when marginal benefits equal to marginal social costs.

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[2] The technology is now available to charge the toll without creating traffic delay. It is also possible to adjust the toll fee in almost no time (see for example, Richardson and Bae, 1998)

Unfortunately, congestion pricing not only increases efficiency; it also affects equity because it tends to change the distribution of benefits or losses, favoring some groups over others. As a matter of fact, one of the most common criticisms of congestion pricing is that it is often believed to be inequitable; for example, low-income households are thought to be disproportionately harmed. However, contrary to this belief Foster (1975) and Morrison (1986) both argue that congestion pricing will not affect low-income workers negatively. The reason is that even if they have private car it is less likely for them to drive to work. This kind of argument is inappropriate because congestion pricing will also affect public transit ridership. Some people who are used to driving car may switch to public transport because they cannot afford the fee. Therefore, public transit becomes more congested and low-income people who use public transit become worse off.

In theory, the winners could compensate the losers so that no individuals are made any worse off and some are better off from congestion tolling. The fact is that actual compensation seldom takes place, so that in practice some parties are left worse off by tolling than before. However, congestion pricing scheme can raise large amounts of revenue and therefore, the distribution of these revenues is an important consideration in its program development. That is why it is important that policy makers must develop revenue distribution formulas in order to satisfy conflicting policy goals. In this case, efficiency alone cannot be the only concern of policy makers. While mobility is considered basic needs for survival, it is equally important to take into account the issues of equity. Issues about equity include whether the benefits and burdens of congestion pricing scheme can be distributed fairly among different income groups, or a more basic issue is the effect of the scheme on people of different income status.

On one hand efficiency of congestion pricing requires meeting mobility goals with the fewest resource possible, but on the other hand, equity consideration requires meeting the mobility requirements of all people. In a more general perspective, equity in transportation is a prerequisite to reasonable, accessible, and affordable transportation services. Internalizing external costs by implementing congestion pricing improves economic efficiency but at the same time it redistributes welfare among different income groups.[3]

Issues or problems of equity in road pricing can be illustrated as the following. Suppose there is a poor commuter who has to drive to work everyday and he cannot afford the fee charged by the government for using the road because his income is just enough to feed him and his family. On the other hand a rich man who also drives on the same road will have no problem paying a few dollar because for him the fee is relatively small compared to his income and he receives the benefits due to less congested road.

The equity problem will bring us to the role of the government in allocating the revenue collected from road pricing. For example, how the government will redistribute these revenues, what are the considerations used by government to redistribute the revenue? These questions are our starting points to evaluate in more detail the equity aspect of road pricing.

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[3] The groups of travelers can also be differentiated not only in terms of economic aspect (e.g. income) but also in terms of gender, geographical area, etc., but in this study we will focus on income class.

The bottom line here is that imposing the Pigovian tax may improve economic efficiency, but at the same time it redistributes welfare among different groups of road users, which may not be desirable for the society. The goal of equity is then to determine who bears the burden, and how the burden should be distributed among various road users. As a matter of fact, from equity perspective economists are still arguing how the government should make the collection of congestion pricing as fair as possible and how revenue coming from congestion pricing should be used to increase equity.

In this regard, a survey conducted by Jones (1991) suggests that one of the keys to political viability of any road-pricing scheme will be to establish a clear link between toll revenues and expenditures on things that citizens want. He finds that public opinion in London is much more favorable toward road pricing if it is presented as part of a package including improvements to public transportation. Many authors in the United States believe that some or all of the revenues from road pricing would need to be offset by tax decreases for the concept to be acceptable. Recent survey evidence from the Los Angeles region shows that supports are rising from 40 percent to 49 percent when revenue is used to reduce other taxes (Harrington and Krupnik, 1996).

Many other studies have been done on the topic of congestion pricing. However most of these studies put too much stress on efficiency aspect. In the mean time, as we have emphasized before, equity is as important as efficiency as mobility is necessary for survival. The problem of equity can be summarized as how to set the criteria for equitable urban transport system after tax/pricing in order to: (1) meet the essential transportation needs of all residents; and (2) distribute the benefits and burdens fairly among the different income groups. To do so, we need to compare the equity impact before and after the pricing among income groups.

The purpose of this research is to study the equity impact of congestion pricing on travelers within different income classes.[4] There are three objectives covered in this study: first, to review recent literature on the equity aspect of congestion pricing both theoretically and empirically. Second, to estimate work-travel demand in the Central Business District (CBD) in Jakarta, Indonesia. Third, to develop a methodology to analyze the equity impact of congestion pricing by using the theory of welfare economics, and to use the methodology to assess the equity impact of a hypothetical congestion pricing scheme in Jakarta. For simplicity, the discussion will be focused on congestion pricing to manage traffic congestion rather than on the design of tolls to reduce air pollution, although the principles are similar for both cases.

This dissertation is organized as follows. After this introduction, Chapter 2 will review the most recent theoretical and empirical studies of the equity aspect of congestion pricing. In Chapter 3 we will discuss the theoretical framework used in this research which emphasizes the concept of random utility as the basis for travel demand modeling. In this chapter we also discuss the theory of welfare economics. Chapter 4 will explain the empirical methodology, and followed by Chapter 5 which discusses data requirement and

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[4] As a matter of fact, equity in urban transportation can be evaluated or studied in many ways and from different aspects. For example, one may study the equity of urban transportation in terms of the accessibility of urban transport facilities for every individual using the facilities (e.g. for pedestrians, handicapped, etc.)

the methodology of data collection. Travel demand estimation will be discussed in Chapter 6. Chapter 7 contains the equity analysis of the congestion tax. Finally, we draw some conclusions and recommendations in Chapter 8.

Chapter 2

LITERATURE REVIEW

2.1. Introduction

Until recently there are only few studies dealing with the equity aspect of congestion pricing. In addition, there is no real world experience on equity implication of congestion pricing because so far Singapore is the only city which has implemented a variation of congestion pricing called Area Licensing Scheme (ALS), and no evaluation has been done to see the equity impact of this scheme. In contrast, there are many examples of toll road, and some empirical studies have been carried out to evaluate the equity impact of toll road. Therefore, many literatures on this topic are kind of a mix between studies of the equity impact of toll road and that of the equity impact of congestion pricing.

Various approaches and models have been used to study the equity impact of congestion pricing. Some studies are purely theoretical by using mathematical model (Feldstein, 1972; Abe, 1975; Glazer and Niskanen, 2000), and some others use diagrammatical approach to explain the equity impact of congestion pricing (Layard, 1977; Evans, 1992; Lave, 1994). The most recent writings use survey technique to capture traveler's perception on congestion pricing (Harrington *et al*, 2001; Calfee and Winston, 1998; Giuliano, 1994; Verhoef, 1996; Jones, 1991). Finally, few authors use hypothetical or simulation approach to evaluate the equity impact of congestion pricing (Cameron, 1994; Small, 1992; Anderson and Mohring, 1995; Hau, 1986, 1987). With respect to the setting of studies, most of the surveys and simulations were conducted for some California highways; an exception is the study done by Anderson and Mohring (1995) who used Minneapolis as their case study. In addition there are two studies/surveys conducted in Europe, one in London and the other one in Ranstad (the Netherlands).

Some authors have tried to evaluate theoretically or empirically the equity impact of toll road instead of congestion pricing (Richardson and Bae, 1998; Glazer and Niskanen, 2000; Hau, 1986,1987). While their studies are very useful for understanding the equity impact of road pricing and they will be reviewed in this chapter, however, congestion pricing is different from toll road because in the former drivers do not have alternative route to drive (except by paying the congestion fee), but in the latter drivers have alternative route to drive. Therefore, in terms of equity, toll road is generally considered more equitable than congestion pricing.

The earliest studies of the equity impact of congestion pricing are those done by Feldstein (1972) and Abe (1975). Both studies are purely theoretical, in which Feldstein shows us how to introduce the distributional weights into public goods pricing to deal with problems in the absence of costless lump sum income redistribution. He demonstrates that distributional equity can be explicitly and operationally integrated into the optimal pricing rule for public enterprises or regulated industries. Even though his focus is on public enterprises that produce two commodities, his model can also be applied to the case of peak hour or peak season pricing such as traffic congestion (in which peak hour highway use and off-peak hour highway use are two distinctive goods).

Abe (1975) applies Feldstein's procedure to a more specific problem of optimal pricing of urban transport with particular attention paid to the distributional aspect of pricing. He shows that when we take into account the distributional aspect of pricing, there would be price deviation from marginal cost pricing. That is the case when marginal cost yields Pareto efficiency but distributional equity requires the price to deviate from the marginal cost. Furthermore, he also argues that price will also deviate from marginal cost when various second best constraints are introduced. There are three constraints that he considers: (1) when a budget constraint is introduced; (2) when car users pay only average costs; and (3) when capacity constraint of the highway system exists. He concludes that we need further departure from marginal cost pricing when the distributional aspect of urban transport pricing is considered. Since his study is also very theoretical, he does not discuss the empirical size of the distributional parameters of the services he uses in his model.

Other studies, with different approaches, have focused around the issues of how individuals are affected by congestion pricing; including whether congestion pricing is regressive or not, and also what conditions we need for congestion pricing scheme to be accepted by public. In the following sections we are going to review these studies based on important issues mentioned above: first, how individuals are affected and how regressive congestion pricing is; second, on what variables does equity depend; and third how revenue should be allocated which is considered an important condition for political acceptability. This chapter then will close with some conclusions.

2.2. How Individuals are affected by Congestion Pricing

According to Else (1996) and Cohen (1997) it is very difficult to predict the distributional consequences of proposed pricing scheme. If it is assumed that revenues are not distributed in any ways, congestion tolls will generally result in gains for upper-income groups and losses for lower-income groups. However, revenues can be distributed and if this is going to be done then we will have different distributional consequences. Giuliano (1992) also agrees that without revenue distribution it benefits upper income groups and hurts lower income groups. However, with distribution of revenues it is possible that all income groups in general will benefit from the congestion-pricing scheme. Unfortunately, no matter how revenues may be distributed, some individuals may still be made worse off.

Richardson (1974) provides similar conclusion. He analyzes the distributional effects of road pricing and warns that road pricing would be regressive in the sense of penalizing low-income car owners for the benefit of richer car owners and non-motorists. Foster (1974) also finds that road pricing tends to be regressive within the car owning class, but much depends on the way in which the revenue from the schemes is redistributing welfare.

Calfee and Winston (1998) come up with different point of view. They use stated preference method to estimate the value of commuters' willingness to pay (WTP) to save travel time. They find that this value is low and is not affected much by traffic conditions and by how toll revenue is spent. They conclude that high-income individuals do not value travel time savings enough to benefit substantially from tolls, even after making adjustment for congestion through their mode of travel, housing location, place of work, and time of travel. One explanation for this surprising result is that the respondents simply do not believe in the time saving they are going to experience. This means that respondents are skeptical about the effectiveness of congestion pricing in reducing traffic congestion. Another explanation is that commuters who are expected to value the timesaving due to congestion pricing scheme really have a low value of travel time. Alternatively, commuters with a high value of time are not in their sample because after making decision about housing and working location, these people do not have to drive in heavily congested roads. Finally, some commuters who deal with road congestion may not be eager to forgo much money for timesaving.

With respect to equity impacts, Small (1983) presents some of the most in depth results in his analysis of a hypothetical $ 1.00 peak expressway toll in San Francisco Bay Area. By using three alternative assumptions about redistribution of toll revenues he computes the incidence of congestion tolls for three possible levels of congestion. He concludes that without revenue distribution, the average low-income commuter would lose $ 0.28 per day and the average middle income commuter would lose $ 0.13, while the average high income commuter would gain $ 0.08.

If revenues were redistributed on an equal per capita basis, all groups would gain but the lowest income group would gain the least. However, it is possible to redistribute revenues more progressively in ways that could even make the poorest group of drivers as a whole gain more. Unfortunately, within the group it is almost certain that some individuals may still lose, for example, those with long commutes, few prospects for changing jobs, tight budgets, and no capacity to change either the time or mode of travel.

Anderson and Mohring (1995) carried out some simulations of the impact of congestion pricing on freeways and all tolled roads in the Minneapolis-St. Paul metropolitan region. They examined the impact of the pricing on four income groups with average annual household income of $25,900, $ 44,900, $ 65,000, and $ 87,520, respectively. In all cases the lowest-income group suffers most. This is because they waste their time trying to find alternative or different route to avoid the toll. In their study they came up with an interesting feature of the value of travel time. Based on their estimation, most of the value of time are typically based on modal choice decisions (transit vs. auto) of commuters. Another finding is that about three-quarters of trips are non-work related trips and that many of these trips take place during peak traveling hours.

Layard (1977) studies the impact of congestion tax on income distribution by using a discrete journey approach. He concludes that the tax will discourage travels with low time values and probably encourage travels with high time values. He models the effect of the tax on which journeys are made by using the following simple diagram.

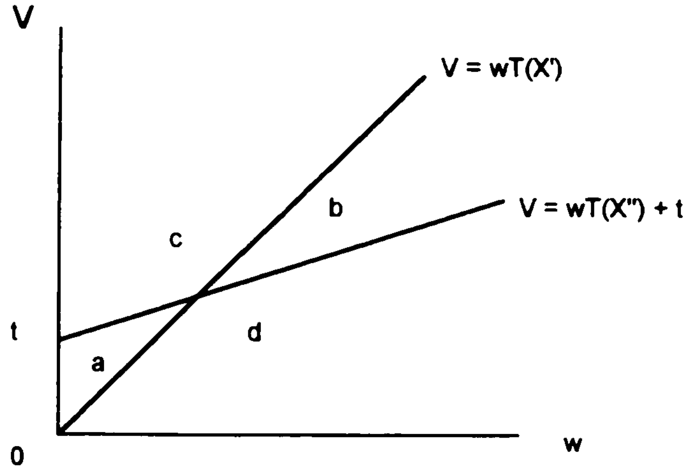

Figure 1. The Effect of Tax on Trips Making

Source: Layard (1977)

Where,

V = marginal trip (demand for trip)

w = cost per unit time of trip

T= travel time

t = optimal congestion tax/fee

X = number of trip, with $X'' < X'$

Without congestion tax, the marginal trip equal to $V = wT(X')$. Marginal trip is a function of value of travel time (w), and total travel time $[T(X')]$. $T(X')$ is also the slope of the line. All trips are made above this line. There are two extreme cases, first, when V is steep, only few trips are made implying that traffic congestion is high so that T is high. The other case is when V is flat many trips are made implying that traffic congestion is low, so that T is also low. Between these two extreme cases, there is a unique slope of the line (as shown in the diagram) where the number of trips made (above the line) create some traffic congestion.

With the existence of optimal congestion tax, marginal trip becomes $V= wT(X'') + t$. The congestion tax is assumed to reduce trips, so that $T(X'') < T(X')$. In other words, the new slope, $T(X'')$ is flatter than the old one, $T(X')$. From the diagram we can see there are four areas (a,b,c,d) representing possible effects of congestion tax on trip making: (a) trips made before tax, but not made after tax (i.e. travelers who have high $v w$, and low w); (b) trips not made before tax, but made after tax (i.e. travelers who have low $v w$, and high w); (c) trips made before and after tax (i.e. travelers who have high $v w$, or high w); and (d) trips not made before or after tax (travelers who have low $v w$, and low w). The equity impact of congestion pricing on individuals can also be explained by looking at area *a*, *b*, *c*, and *d* on the diagram. Area *a* represents travelers who lose up to *t*, area *b* represents travelers who benefit, area *c* represents travelers who get some losses (up to *t*) and some gains, and finally area *d* represents travelers who are unaffected. Based on this analysis, he concludes that congestion tax may be regressive, but for more accurate estimation we need to calculate the inequality of incomes before and after congestion tax.

Gomez-Ibanez (1992) identifies three groups of winners, three groups of losers and an indeterminate seventh group in an analysis of road with congestion tolls compared to HOV (High Occupancy Vehicle) services (for example, carpool lanes) and regular untolled roads. The winners include single drivers who benefit from time-saving more than the toll fee they have to pay; existing users of HOV lanes; and those who receive toll revenues (assuming toll revenues are distributed). The losers include single drivers who value their timesaving less than the toll; those who shift to a less convenient mode or route; and those already using these alternatives, now more congested, roads. Finally, the impact on the single drivers who shift to HOV is less clear because it depends on a comparison of the toll saving with the degree of inconvenience associated with using the HOV mode.

2.3. On what Aspects does Equity Depend

Else (1986) and Cohen (1987) suggest that the distributional impact of congestion pricing depends on both the relative propensities of various income groups to drive to work on congested facilities and on the redistribution of toll revenue. Furthermore, Giuliano (1992) argues that in addition to the relative propensity of various income groups to drive to work on congested roads and disposition of toll revenues, equity is also affected by the level of congestion itself. The level of congestion affects the equity because when we have more congested road, we need higher toll fee and consequently the difference of benefits or losses among income groups is becoming larger. According to Giuliano (1994) and Litman (1996) the distributional effects are also vitally dependent on the precise details of the road-pricing scheme. This includes how the collected revenues are redistributed to travelers and on whether there are available travel alternatives. Giuliano also suggests that we must take into account both the distributions of benefits associated with reduced congestion and the distribution of costs needed to achieve the congestion benefits. She summarizes the three main conclusions of previous studies on distributional impact of congestion pricing. First, the net impacts depend on how toll revenues are allocated. Second, in general the high-income individuals will benefit more than the low-income individuals. Finally, we could not make everybody happy by compensating all individuals involved, so some groups will be made worse off by the tolls

In her study of two hypothetical sets of alternatives for middle income and for low income commuters, Giuliano concludes that the distributional impacts of costs and benefits are less related to income than to other conditions (for instance, gender, opportunities for flexible work schedules, the availability of transit and high occupancy vehicle services). She believes that the obstacles to a widespread introduction of congestion pricing are great so that she is very pessimistic about the prospect of congestion pricing being implemented in the United States.

By employing an economic model of a congested road network in a stationary state, and adopting an exponential demand function with three different forms of congestion costs, Evans (1992) demonstrates that the shape of the supply curve is very important in determining the effect of road pricing on individuals, and unfortunately there is no conformity on the basic shape of the supply curve.

According to Cameron (1994), congestion costs increase with income. There are two reasons: first, high-income individuals spend more time traveling (and consequently are at greater risk from delays), and second, they value their time higher because they earn more. In his study he concludes that the equity of congestion pricing will depend on how the scheme is designed and implemented. For example, in what form revenues are redistributed will determine whether congestion pricing is equitable or not.

By using two spreadsheet models called Transportation Efficiency and Distribution (TREAD) and Transportation Incentives Planning System (TRIPS) models Cameron analyses the impact of a 5 cents per mile VMT (vehicle mile traveled) fee in Southern California area. He finds that based on quintile income groups, the lower the income the greater the cutback in auto travels. Furthermore, the burden is increased by the fact that the initial distributions of the net benefits of the existing transportation system are weighted against the poor. He estimates a net benefit of $650 per year for a person in the lowest quintile compared with a net benefit of $3,750 for a person in the highest quintile, although the middle quintiles gain more when net benefits are expressed in percentage of income (16-18 percent of income).

Small (1983) argues that the distributional impacts of congestion pricing are determined by two factors working in opposite directions: higher income individuals have a greater propensity to drive, but also have greater value of time. These effects combine so that the net burden exclusive of distributed revenues is smaller for higher-income groups. In the meantime, lower income drivers are worse off because they have to share the roads with people who value congestion relief highly. The latter forces the uniform toll to a higher level than would be optimal if all commuters were in low-income group.

Glazer and Niskanen (2000) develop a mathematical model that assumes a traveler who has two options: to travel on a congestible fast mode or on a congestible slow mode. By considering heterogeneous travelers, they demonstrate how a congestion toll can increase aggregate travelers' welfare. The analysis describes the pattern of tolls that is not rejected by public, where users who most value their time will use the fast mode, and a toll on the slow mode can induce some people who initially use that mode to switch to the fast mode. In the meantime a toll on a slow mode with revenue not returned to users then necessarily reduces the welfare of all users. A toll on a fast mode may increase aggregate travelers' surplus. They conclude that differential tolls are likely to face less political opposition than uniform tolls on all modes. If we make an assumption that the value of time increases with the wage rate, then the tolls that maximize traveler's welfare will be on the fast mode only, thereby raising revenue only from more affluent travelers. Unfortunately, the conclusion of this study is just showing that politically acceptable tolls may increase congestion or increase average travel time.

Hau (1986) uses discrete choice model to evaluate the distributional impact of congestion tolls. He uses an ex ante approach to cost-benefit analysis. He attempts to integrate equity into efficiency framework of discrete choice models by using simulation model on increasing lane capacity. First, he creates the method of making social welfare analysis empirically viable by using discrete choice model. Second, he segments a sample according to certain characteristics, in this case by three income groups and three types of trips to get the equity impacts of a policy. Instead of using the concept of distributional characteristics of a good - which he claims would have a problem of how to determine these characteristics, his approach is by segmenting the population in order to carry out distributional cost-benefit analysis.

By using Interstate highway 580 of San Francisco Bay Area as a study case, Hau concludes that we should perform distributional cost-benefit analysis by making explicit our assumptions and value judgments and their implications. His simulations on increasing lane capacity indicate that it is necessary to segment across different market to find the distributional impact of a policy because of wide variation in incidence of benefits/losses. He agrees to the belief that the ultimate choice of the form of the social welfare function and the distributional weights would still depend on the preferences of the planner or of the electorate that the planner represents.

2.4. Conditions for Political Acceptability.

Lave (1994) develops graphical model to see the interactions between road pricing, user demand, travel speed, and toll charges. The model then is applied to analyze the source of public resistance to road pricing. He postulates that the acceptance of toll road depends on the condition that the amount of inconvenience experienced by drivers who are tolled off being quite low compared to the gain for the drivers who remain. But it is not sufficient that the number of losers is small. Political acceptance also depends on the change of utility. He argues that three conditions must be satisfied: (1) the loss in utility to those being pushed off is small - perhaps they have alternatives and so are quite willing to move; (2) the gain in utility of the users is large - perhaps they get a substantial time savings while paying only small fee; and (3) the proportion of losers to gainers must be low. As conclusions he argues that the political response will depend on the relative numbers of losers and gainers and the amount of utility loss by those motorists who are pushed off. Using demand curve for a highway with a user fee he shows that losses and gains are strongly independent of how high the price must be set to push enough drivers off.

Harrington *et al* (2001) conducted a survey of Southern California residents designed to examine whether the details of policy design can make congestion pricing more attractive to the motoring public. Their survey was quite explicit about the use of the collected revenues. For example, they presented respondents with policies that returned a substantial portion of the revenues to the public, either in the form of cash or in the form of coupons to be used for vehicle emissions equipment repair, transit, and the like. In addition they examined the intensity and type of opposition to congestion pricing if it applied only to a part of a roadway, leaving the motorist free to choose between free lanes and toll lanes. They find that a promise to offset the imposition of congestion fees by other taxes can result in 7 percent point increase in support for congestion pricing policies, and the restriction of congestion pricing to a single lane on a freeway attracts from 9 percent to 17 percent points of additional support. In conclusions, they find that the level of support for congestion pricing among survey respondents is sensitive to specific policy features designed to deal with two prominent objections to congestion pricing: the sentiment that congestion pricing is just a tax increase by another name and that high fees unfairly penalize users who, having made their household location and occupational decisions, have little choice but to continue driving.

Verhoef (1996) explores some of the equity implications of road pricing via a survey of peak road users in the Ranstad area of the Netherlands, covering 1327 respondents. Although about one-half of the respondent were opposed to road pricing, most stated that their opinions depended upon how revenues would be allocated. The survey indicated a preference for the following uses (in descending order): investment in new roads, reduction in vehicle ownership taxes, fuel tax cuts, public transit subsidies, investment in carpool facilities, general tax reductions, general public investment, and government budget relief. As a generalization, respondents preferred allocations of the revenues in ways that directly benefit them as road users. Possibly, the most progressive use of the revenues would be to replace some of the vehicle ownership taxes used to finance roads, especially by reducing these taxes more on the smaller and cheaper vehicles predominantly owned by the lower income drivers.

Jones (1991) finds, as many others do, that road pricing was by far the least popular of several proposals for reducing congestion. Support for road pricing among people in the UK increased from 30 percent to 57 percent when respondents were told that revenues would be spent on a mix of improved transit, local traffic management and better pedestrian facilities. Based on a survey he finds that in areas with high congestion there is now sufficient public support to consider the implementation of an imaginative package of price-based traffic restraint, using the finance raised to improve alternative modes and the physical environment. He concludes that the pricing of road use provides clear market signals as to when additional road capacity is warranted, in circumstances where the full costs of overcoming social and environmental problems arising from the new road can be met by potential users.

Richardson and Bae (1998) evaluate the equity aspect of congestion toll of FASTRAK, a privately financed 10-mile toll road in Orange County, California in December 1995. They conclude that the objection of congestion tolls disappears in cases where the priced road adds to capacity. However, adding road capacity is not always possible. A privately financed road also deals directly with the revenue distribution problem according to the benefits principle.

In another study Hau (1987) analyzes general equilibrium effects of an alternative transportation policy proposal (toll fee on new road facility) using a multi-modal, benefit cost model of demand and supply within a discrete choice framework. He uses the expenditure function as an empirical construct to yield Hicksian consumer surplus measures, and then to evaluate a new specification for travel demand models by employing both econometrics estimation and simulation techniques. The model is applied to a corridor simulation model of Interstate highway 580 of San Francisco Bay Area. The corridor simulation model yields interesting implications for transportation policy analyses. The substantial benefits from relieving congestion on the San Francisco-Oakland Bay bridge mean that we should consider increasing the capacity of the bay bridge itself. This conclusion is similar to the study done by Richardson and Bae (1998).

Small (1992) employs the principle of tax offsets (to use some portion of toll revenues to reduce or offset existing tax) as part of an attempt to describe a congestion pricing package that would be Pareto improving to broad classes of people in that the average person in each identifiable income class or interest group would be made better off. Furthermore, he outlines a scheme of public transit investments and tax reductions aimed at achieving a broader distribution of net benefits. He gives guidance on using congestion pricing revenues to give compensation to road users, and at the same time can be accepted by political or interest groups. The general idea is to use the revenue to finance projects/programs with many varieties of distribution impacts, so that most people who are negatively affected will benefits, and the majority will see the overall package as an improvement. He proposes that one third of the revenue to be used for: (1) returned to travelers as a group (in the forms of rebates to drivers); (2) substitute for general tax now used to finance transportation (tax reductions); and (3) new expansion of transport services (especially public transit). By using Los Angeles as a study case he concludes that the impact of these redistribution policies are able to benefits the majority of people and interest groups.

Goodwin (1994) points out that imposition of congestion pricing will both liberate road space and generate revenues, and plans must be made for dealing with each. His recommendations for revenue disposal are similar to Small's: apportion them to improvement in transport alternatives, improvements in roads, and reductions of other taxes.

From different perspective, Kain (1994) studies the impacts of congestion pricing on transit services using data from 15 large and heavily congested metropolitan areas in the US. Surprisingly he warns us not to accept the argument that revenues from congestion pricing should be used to increase transit subsidies if there are subsidies already in place. He suggests that the revenues should be used to reduce other taxes or to reduce transit subsidies if there are ones already in place.

2.5. Conclusions and Comments

Most of the studies we have discussed before agree that congestion pricing obviously affects the distribution of income of individuals/households. They also mostly agree that congestion pricing is regressive. However, how individuals are affected by congestion pricing is a very complex thing. The impacts on individuals not only depend on the imposition of tax /pricing but also on other related policy measures. For example, whether revenues are distributed or not. Even the way revenues are distributed is very crucial to the outcome.

The next issue is related to the question of what is considered a fair distribution of burden due to congestion pricing among different income groups. Unfortunately, the literature we reviewed does not have the answer for this, even though it gives guidance on how we should allocate the revenues from congestion pricing so that the public would accept it.

It is believed that taxes (in this case pricing) could be based on the individual's ability to pay, for example, the criterion of horizontal equity requires that persons in the same or similar positions so far as pricing/tax purposes are concerned be subject to the same tax liability. Alternatively, taxes could be based on the benefits principle in which there should be some correspondence between what the individual pays and the benefits he receives.

Under the benefit principle taxes are seen as serving a purpose similar to that of prices in private transactions, that is, they help determine what activities the government undertakes as well as who pays for them. If this principle could be implemented, resource allocation would be directly responsive to the wishes of citizens as consumers of public services, not just as voters. To the extent that the demand for public services does not rise in proportion to income, benefit-related taxes would be regressive.

However, in congestion pricing we are more concerned with vertical equity, which is focused on the treatment of individuals, and classes that are not alike. By this criterion, the distribution of costs and benefits should reflect people's needs and abilities (including ability to pay). Vertical equity often requires that disadvantaged people receive more public resources than those who are advantaged do. For example, transit services for wheelchair users require greater than average financial subsidy per trip, this is considered fair because wheelchair users' needs are also greater than average. Those who emphasize vertical equity argue that the society is defined morally according to how it treats disadvantaged members, while others point out that providing extra resources to disadvantaged people reduces the incentives for individuals to overcome such disadvantages. Most people seem to recognize vertical equity as being a legitimate social goal, but we learn from the literature review that there is little agreement as to what constitutes the 'correct' allocation of resources by this criterion.

The ability to pay principle requires that the total tax burden be distributed among individuals according to their capacity to bear it, taking into account all of the relevant personal characteristics in such a way that the relative loss in economic capacity resulting from tax is equal. The implication of this principle is that people who do not have ability to pay cannot be excluded from using the road.

Our literature review has convinced us that the distribution of benefits and costs within society is very important. Based on some empirical studies, road pricing has been criticized for falling into the category of being non-equitable. However, the current method of transportation funding is worse - it is inequitable where users of the systems are not the only ones to pay for the system, and negative externalities are not internalized, i.e., road users do not pay for pollution or traffic jam they created. Furthermore, payment is not proportional to use. In addition, congestion pricing can be designed to meet equity goals and the more detail the design the more likely that congestion pricing will be accepted. Finally, we have to keep in mind that whatever the design is, there would be losers as well as gainers.

Chapter 3

THEORETICAL FRAMEWORK

3.1. Introduction

The issue of congestion pricing or congestion tax is basically similar to those of other types of taxes. The implication of this tax is to affect individuals' income or expenditure, and thus affect individuals' welfare. The equity aspect enters into the picture because tax affects individuals differently, for example, depending on income levels, preferences, etc. When we discuss the implication of congestion tax this is just a case of a more general area of taxation. Therefore, the appropriate theoretical framework is welfare theory. We will start with the discussion of welfare criteria, followed by the concept of utility and demand in urban transport, and finally we will discuss the welfare and equity measurement.

3.2. Welfare Criteria

There are at least three criteria commonly used by economists in judging whether a proposed policy change is an improvement and thus can be accepted. These three criteria are the Pareto criterion, the Hicks-Kaldor criterion, and the Scitovsky criterion. In the following we will discuss each of these criteria.

3.2.1. The Pareto Criterion

This welfare criterion states that any change is justifiable if it makes some people better off without making any other people worse-off. According to Milward (1971) the Pareto criterion is based on the following set of assumptions: first, society is better-off if we can make individuals better-off; second, an individual is the best judge of his or her welfare; third, welfare is defined only in terms of economic well being; fourth, Pareto optimality is achieved when there no further improvement can be made without making some people worse-off. Indeed, the Pareto criterion is very restrictive.[5] The implication of this criterion is that we can not accept a policy proposal that will benefit some people and harm some others. In fact, it is very rare to have policy changes, which benefit some members of the society without making others worse-off, because any policy changes will usually have different impacts on different members of the society, it may be positive or negative. If we only use this criterion most likely we will not have any policy proposal accepted. Therefore, this criterion is very difficult to implement and we need another criterion to overcome this problem.

3.2.2. The Kaldor-Hicks Criterion

Kaldor (1939) and Hicks (1940) argue that to overcome the problem we have in using the Pareto criterion, we can use the compensation test. This test relies on the assumption that as long as the benefits due to the proposed policy is greater than the

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[5] This is because Pareto criterion is dealing only with efficiency aspect, i.e., it favors the status quo in terms of initial income distribution.

losses, then we have a potential welfare improvement and the proposed policy change can be accepted. In this case, the actual compensation from the gainers to the losers does not have to take place, because it is sufficient that the amount of benefits exceed the amount of losses. The most important thing is that as long as there is potential Pareto improvement we can go on with the proposed policy. This criterion seems to be more flexible than the Pareto criterion. However, it is also criticized because it may suffer from inconsistency when there are price changes. For example, before the policy change the gainers can compensate the losers, but after the policy change it is also possible that the losers can also compensate the gainers due to changes in relative prices. This inconsistency is called the 'Scitovsky paradox' which leads us to the next criterion proposed by Scitovsky.

3.2.3. Scitovsky Criterion

Due to the weakness of the Kaldor-Hicks criterion mentioned above, Scitovsky (1941) proposes an additional and stricter compensation test to the criterion in order to avoid inconsistencies. First, we still use the Kaldor-Hicks criterion to see whether there is improvement or not as a result of policy changes. In this case, we want to know if the gainers can compensate the losers. Second, we want to make sure that the losers can not compensate the gainers after policy change. If both compensation tests pass then we can say that there is a welfare improvement due to the change of policy.

Unfortunately, both the Kaldor-Hicks and the Scitovsky criteria are still unsatisfactory because they are only concerned with potential compensations. Since there is no actual compensation, there is no income redistribution from people who benefit from the policy changes to people who are worse-off. Both criteria are in favor of status quo distribution as the measure of the relative strength of feeling of two individuals.[6]

From previous discussion we learned that we have to make interpersonal comparisons of utilities in order to pass beyond the stage of judging by potential improvement and decide which allocation is actually preferable. An acceptable cardinal form of utility representation can be chosen for an individual. Furthermore, we can add up individual utilities and use the resulting index to represent social utility, which is called a social welfare function as introduced by Bergson (1938). Later on we will explain in more detail the theoretical framework of individual utility and social welfare measurement. Before doing so, in the next section we will discuss consumer theory of urban travel demand.

3.3. Consumer Theory of Urban Travel Demand

Different from traditional, four-step approach to urban travel demand modeling, which is more long-run oriented and more appropriate for highway network design, disaggregate (behavioral) demand modeling is usually applied for the short run objective which incorporate behavior force behind travel decision. Therefore, it is the appropriate method for analyzing policy sensitivity or impact to travelers' behavior/decision. Another advantage is that it is very flexible, because it is not based on one model. Depending on

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[6] We should note that the compensation criteria preclude interpersonal utility comparison, which may be responsible for the occurrence of inconsistencies.

the circumstances or need we may develop a very complex model or the simple one. In terms of integration the conventional model is not integrated because, for example, a trip generation mode may be developed quite independently of a model of modal split. In contrast, the disaggregate model is more unified. However, the most advantage of the disaggregate model is its ability to incorporate behavior force behind travel decision, in which travel demand is generated by choice behavior which maximize utility or preference.

In this section we will briefly review the essential elements of consumer demand theory, since we will perceive of individual travelers as consumers of urban trips. In this section we will discuss the derivation of the utility function and the demand function.

3.3.1. The Random Utility and Multinomial Logit Model

The utility representation of a typical urban traveler (individual ‘consuming’ urban transport services) is characterized by dichotomous or polichotomous choices. For example, a traveler may have to decide whether to travel using private car or public transit or other modes of transport (e.g. carpool, train, etc.). As a consequence, in such situations the dependent variable takes a discrete number of mutually exclusive and collectively exhausted values. In the case of dichotomous choices we can use binary logit or probit model and this model can be generalized as multinomial logit or probit model to allow more than two alternatives modes of transport. This model is basically developed based on the random utility model (McFadden, 1973).

In the case of urban travel, the outcomes of traveler's choice of transportation to work (e.g., by bus, train, or car) is categorized as unordered.[7] As a consequence, we do not assume that car is 'better' (so it belongs to higher order) than bus as a mode of transport. Even though individual may have preference (ranking) of one mode of transport over the other, however, this ranking is purely subjective. Models where the outcomes are unordered are most easily estimated by logit method.[8] This is the reason why multinomial logit is used in many studies involving multiple outcome models such as ours.

In this model, the utility of a traveler is specified as a linear function of the characteristics of the traveler and the attributes of the alternative transport modes, plus error terms. The characteristics of the traveler are usually related to the level of income (e.g. high, medium, low), and the attributes of the mode that represents the quality of services (e.g. speed, comfort). The probability that a particular traveler will choose a particular mode of transport is given by the probability that the utility of that mode of transport is greater than the utility of other available alternative modes of transport. For example, a traveler decides to travel by bus because its utility is higher than that of other modes of transport such as train, or automobile.

As a starting point, we can define the problem faced by a typical urban traveler as the following. A typical traveler is to maximize utility from consuming two goods: urban

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[7] In contrast, a person's health status can be considered as ordered. For example, the outcome associated with 'excellent' health is better than 'good' health, and the latter is better than 'poor' health.

[8] Although in principle it is possible to estimate such models by probit, for computational reasons it is often more complicated and time consuming.

trips and 'all other goods' subject to the budget constraint. In the simplest form, the direct utility function, U_d is represented by,

$$\mathbf{U_d = U_d(X,T)}$$

$\mathbf{U_d}$ is defined as a function, which represents the preferences of a typical traveler when choosing mode of transport. These preferences are assumed to depend on **X** that represents the vector of traveler characteristics and of trip attributes. In addition, $\mathbf{U_d}$ also depends on **T**, which represents consumption of 'all other goods'. A typical traveler maximize this utility subject to the following budget constraint,

$$\mathbf{b = tc + To}$$

where, **tc** is the vector of trip costs and **To** is the amount of money spent on goods other than travel. Furthermore, the indirect utility, which corresponds to the maximum value of the direct utility above, can be written as,

$$\mathbf{U\ (X,c,b) = U^*(X,c,b)}$$

This indirect utility, however, is too general and we need more specific one. In this case we can write the indirect utility received by a typical individual from choosing mode **m** as:

$$U_m = \sum a^k X^k + \sum b^l Y^l$$

Where,

X = characteristics of travelers (e.g. income, education)

Y = mode's attributes (e.g. speed, comfort)

$\mathbf{a^k}$, $\mathbf{b^l}$, = parameters whose values must be identified from observation of the actual choices of a sample travelers. We assume that travelers always choose the travel mode which offer them maximum utility.

U_m is assumed to be the same for all individual travelers, so this is called as 'systematic' or the 'fixed' element in the utility for an average traveler. However, in addition to this systematic utility there are random terms, which represent the difference between a typical traveler's utility specification and the average traveler's. These terms represent the heterogeneity in individual utilities. We need to include these random terms into U_m to take into account some factors that are not fixed. Then, we specify the utility that a traveler receives when choosing alternative or mode **m** as:

$$V_m = U_m + \varepsilon_m$$

Where, again U_m is the average traveler's indirect utility, and ε_m represents the uncertainty about the specification. ε_m represents the unobservable or unmeasurable factors of utility such as 'force of habit' of the individual being observed, or errors in the measurement of the factors that have been included. When the mean of the random term ε_m is set equal to zero, for example, the expected value or mean of the random utility, V_m equals the 'systematic' or 'fixed' utility, U_m.

3.3.2. The Demand Function

Next, we need to know the probabilities that an individual chosen at random will select alternative mode **m**. This is basically the same as individual demand function. The key to the estimation of the probabilities of choice/mode is to make specific assumption about the probability distribution function (p.d.f.) of the random terms ε_m. A specification of a distribution for these unobserved factors then generates a distribution of choices in the population. In the general case of multiple alternatives of transport modes, the probabilities of choice may be determined by using the 'Gumbel' or 'double exponential' probability distribution function. The computational simplicity is the major benefit of this model; the probability of an individual selecting a given alternative is articulated, and a likelihood function can be formed and maximized in simple manner (Kennedy, 1992; Gujarati, 1995).

When the random utility terms ε_m are identically and independently distributed (i.i.d.) with a double exponential p.d.f., the probability that an individual will choose alternative mode **m** that gives her the maximum random utility can be formulated as:

$$P_m = e^{\beta U m} / \sum e^{\beta U k}$$

This type of function is called the 'multivariate logit' model. $\mathbf{P_m}$ is the expected demand for alternative **m** for a single traveler, which is equal to her probability of choosing the alternative. The value of parameter β is inversely related to the standard deviation of the random errors on the utility's specification. The role of parameter β may be illustrated by giving it extreme values. For example, when $\beta = 0$, the variance of the random terms (σ^2) is infinite, implying complete lack of information by the modeler about the alternative's utility. Conversely, an infinite value for β implies that the variance of the random terms is zero, which means that we have perfect information.

In order to estimate the expected received utility from choosing an alternative mode, we need to translate the previous result in terms of the observed demand $\mathbf{d_{nm}}$ of an individual traveler **n** for alternative mode **m**. This individual demand function is random, and in the case of binary model it can only take the two values **0** or **1**; either traveler **n** chooses the alternative or does not.

So we can simply state demand as,

$$d_{nm} = \delta m \; ; \; \forall \; n,m$$

where, $\boldsymbol{\delta m}$ = **1** if **m** is made, **0** if not

and the Bernoulli p.d.f. is, $\mathbf{P}\,(\boldsymbol{\delta_m} = \mathbf{1}) = \mathbf{P_m}$, $\mathbf{P}\,(\boldsymbol{\delta_m} = \mathbf{0}) = \mathbf{1} - \mathbf{P_m}$

On the average, in the long run, individual travelers with the same random utility specification would be observed to choose alternative **m**, $\mathbf{P_m}$ percent of the time. This implies that in a sample of **N** such individual travelers chosen at random, the expected value for the random, total number $\mathbf{N_m}$ of travelers choosing alternative **m** is **N** times the mean of the above Bernoulli distribution.

$$E(N_m) = NP_m; \; \forall m$$

Then, we can calculate the variance and covariance as:

$$\mathrm{Var}\,(N_m) = NP_m\,(1 - P_m); \; \forall m$$

$$\mathrm{Cov}\,(N_m, N_k) = -\,NP_m\,P_k; \; \forall m, \, k$$

The negative sign is due to the fact that the sample size is fixed and equal to **N**, when the demand for a given alternative goes up, the demand for other alternative must go down. The magnitude of the covariance shows the degree of (linear) correlation between the numbers of travelers choosing two given alternatives as they vary jointly from sample to sample.

Now, we can derive the estimation of the expected utility by individual. The utility received by individual travelers depends on which choice they make, and therefore depends on the value of the random utility terms $\boldsymbol{\varepsilon_m}$. This quantity is random, but we can simulate these random utilities. In general, the average utility received by an individual traveler is equal to:

$$EU_m = E\{Max.\ V_m\} = E\{Max\ (U_m + \varepsilon_m)\}$$

Specifically, when the random utility terms ε_m in $V_m = U_m + \varepsilon_m$ are i.i.d. with a double exponential p.d.f., the expected utility an individual chosen at random receives from utility maximizing choices is given by:

$$EU_m = 1/\beta \ln \sum e^{\beta U_m}$$

3.4. Welfare and Equity Measurements

3.4.1. Consumer or Traveler Surplus

The parameter estimates from transportation demand models can be used as inputs to measure consumer surplus that reflects welfare loss/gain due to congestion tax policy. The consumer surplus may be used as an appropriate indicator of the impacts of changes in urban transport policy such as congestion tax on individual demand. Although the basic concept of consumer surplus is simple, there are a number of ways of calculating it. We will discuss two of them, first, Marshallian consumer surplus and second, Hicksian consumer surplus.

Marshallian Consumer Surplus. The most common conception of consumer surplus is based on ordinary (Marshallian) demand. Marshall (1924) defined consumer surplus as the 'the excess of the price that he would be willing to pay rather than go without the thing, over that which he actually pays." According to Marshall, when there is price changes (for example decrease), the consumer surplus consists of two parts, the direct reduction in price on units that would have been purchased anyway, and the increase in welfare from additional units whose costs is now less than the consumer's willingness to pay. Given a specification for the demand curve, one can directly calculate Marshallian consumer surplus by integrating it between any two points. Furthermore, by assuming that consumers are alike and that their utilities can be added up, Marshall argued that we could sum the individual consumers' surpluses in a market to obtain an aggregate welfare measure.

Hicksian Consumer Surplus. As pointed out by Hicks (1956), the Marshallian consumer surplus is not an exact welfare measure. This is because a price decline in a good will increase the effective income available (purchasing power) to consumer and therefore shift the consumer to a higher utility curve. The appropriate demand curve to use for more accurate consumer surplus therefore is compensated demand curve, which is the amount that the consumer would demand if income were adjusted sufficiently to maintain the same utility level. Since for a given income the utility level at a new price is different from the utility at an old price, there are two compensated demand curves, which correspond to each end of price change. Therefore, in principal Hicksian consumer surplus can be calculated with respect to either one of them, giving rise to a distinction between 'equivalent variation' and 'compensating variation'. Equivalent variation is defined as the amount by which one would have to increase (or reduced) his/her income to make him/her just as well off after a change in prices. Compensating variation is defined as the amount of money an individual would be willing to give up after a price change to make him as well off as he was before the change.

Both Marshallian and Hicksian measures of consumer surplus are basically used for measuring the welfare of a single consumer. In evaluating the overall effect of a policy/tax change, use is often made of the aggregate value of the surplus/loss in a specified population group. This is equivalent to the use of social welfare function defined as a simple sum of the surpluses, so it implies no aversion to inequality on the part of the judge.

With respect to distributional aspect of policy change, Boadway (1974) has criticized this method. He argued that simply summing consumer surpluses and disregard the distributional effects of the policy change are only necessary but not sufficient conditions, because we do not know to whom the surpluses accumulate. The use of hypothetical compensation as welfare criteria is not a good reason to neglect the distribution of welfare. One important conclusion from his article is that we have to make strong assumption of identical marginal social utility for all. If this assumption holds then the sum of aggregate surplus changes are valid indicators of welfare.

Boadway suggests that we have to make interpersonal comparison and imposing value judgment for a given amount of surplus of each different income group before we sum up the surpluses. Therefore, an alternative approach is to specify a social welfare function that differs in two ways from the total surpluses/losses. First, the welfare function may be specified in terms of individual utilities, and secondly, the form of the welfare function may allow for some aversion to inequality.

Atkinson (1970) and Kolm (1964) open the avenue to the measurement of social welfare, which is based on explicit social welfare functions. However, the type of social welfare functions they introduced is not defined on the distribution of individual welfare. Instead they are using income as the measure of welfare. The problem is that measures based on individual welfare equal to those based on individual income if and only if preferences are identical and homothetic for all consumers (Mullbauer, 1974 and Roberts, 1980). Similar to this statement, Chipman (1973) and Moore (1980) showed that the compensation principle (as Hicks') provides a valid indicator of social welfare only if measures of individual welfare are identical and homothetic.

3.4.2. Social Welfare Function

As indicated in the beginning of this chapter, the useful idea of Pareto optimality is to a large extent too restrictive to offer an adequate groundwork for normative economics. That is why we will rely more on the concept of a social welfare function, originated by Bergson (1937) and Samuelson (1947), which provides a means of overcoming the disadvantage of the Pareto criterion. According to Sen (1977) we need cardinal instead of ordinal measures so that we can make personal comparison among individuals.

Following the tradition of Atkinson and Kolm above, the discussion of inequity always have some normative content, be it explicit or, and more likely, implicit. The normative approach to the measurement of inequity takes the view that it is best to make the exact nature of egalitarian value judgment explicit, and to derive inequity measures based on these judgments, rather than to rely on implicit persuasion based on descriptive measures.

We can use the model of a 'representative' consumer to illustrate the essential ideas of social welfare. The clearest description of this model is based on identical and homothetic preferences for all individuals. The aggregate demand function then is assumed to be of the same form as individual demand functions. Welfare of each individual is proportional to total expenditure and inversely proportional to an index of the cost of living. These measures can be combined into an indicator of normative measurement of social welfare based on Bergson's concept of a social welfare function.

A social welfare function is a function that characterizes some ethical belief, which was required to be rational in the sense of enabling complete and transitive welfare judgments over alternative social states. We will use SWF as a vehicle for deriving normative measures of inequity. In the context of our previous discussion, we postulate that social welfare **W** is a function of the vector of expected utility $(\mathbf{EU_m})$ of all travelers from choosing a mode of transport.

$$\mathbf{W = W\,(EU_{m1}, EU_{m2}, \ldots\ldots\ldots\ldots, EU_{mn})}$$

Given the size of travelers' expected utilities, $\mathbf{EU_m}$, we want to evaluate alternative distributions of this fixed total. This SWF is meant to capture all of the society's value judgments. Therefore, specific properties of W will model specific value judgments. To calculate the consumer surplus by using Marshalian approach we can compare the expected utility after and before the tax.

$$\mathbf{\Delta W = W^1(EU_{m1}, EU_{m2}, \ldots\ldots\ldots\ldots, EU_{mn}) - W^0(EU_{m1}, EU_{m2}, \ldots\ldots\ldots\ldots, EU_{mn})}$$

where W^0 is the before tax welfare and W^1 is the after tax welfare.

In order to accommodate the equity concern, we introduce the Atkinson index of inequity. Atkinson (1970) defined a particular form of social welfare function that is based on a family of additive social welfare functions (SWFs) of the form,

$$\mathbf{W = \Sigma\ 1/1\text{-}\eta\ (EU_m)^{1-\eta}}$$

The parameter η governs the concavity, and therefore the degree of inequity aversion, shown by the function. Note also that for η equal to zero the function merely aggregates all incomes, and therefore ranks the same as the mean, given a constant population. Furthermore, we can attach distributional weights, δ to the welfare function, so that it becomes:

$$W = \sum 1/1-\eta \; \delta(EU_m)^{1-\eta}$$

Chapter 4

EMPIRICAL MODEL

4.1. Introduction

In previous chapter we have exclusively concentrated on the theoretical development of the travel demand model and welfare measurement. In this chapter we will apply the theoretical model for the actual data to see the equity impact of congestion tax for the city of Jakarta. First of all, we give a short background of the transport problem in Jakarta. Then we will provide the method to estimate the values of parameters in our demand model by using actual data. We will also explain the data requirement to be used in our model. The result from these estimates then can be used as inputs to assess the equity impact of a (hypothetical) congestion tax.

4.2. Traffic Congestion in Jakarta, Indonesia

Indonesia is the fourth most populated country in the world. In the year 2000 the population of Indonesia was approximately 220 million. Even though the population is scattered in many islands, unfortunately most of them (approximately 60 percent) are concentrated in the island of Java, which only represents less than 10 percent of the area.

The city of Jakarta, which is located in the western part of Java, is the capital city of Indonesia. Jakarta is not only the location for the central government administration but also the center for trade, business, education and cultural activities.

In terms of population Jakarta and its surrounding areas have been experiencing a very rapid growth in the last two decades. This rapid growth is mainly due to urbanization. As the population increases, the city grows in terms of housing development as well as infrastructure such as transportation. However, the population growth rate is much higher than the growth rate of transportation facilities and services especially public transport. With the lack of public transport, people are forced to use private vehicles such as automobile and motorcycle. Unfortunately, the high increase in the use of private vehicles is not sufficiently accompanied by the increase in the development of road networks as well. As a result, traffic congestion and pollution can not be avoided. For the last ten years or so traffic congestion in Jakarta becomes one of the most crucial problems experienced by almost everyone living in the city and its surrounding area. In Jakarta, peak hour traffic speeds can be as low as 7 km/h on certain roads within a 10-km distance from the city, while traffic speeds during business hours average between 15 and 16 km/h. Traffic congestion problem in Jakarta if not addressed and solved promptly, could have a larger negative impact on economic as well as social activities in the very near future.

In dealing with the increasingly worsening traffic congestion in Jakarta, some measures based on Transport Demand Management (TDM) have been considered and being studied. Although other transport demand management measures should not be ignored, congestion pricing is the only one that seems to reduce peak traffic significantly while at the same time promoting the use of public transport, two extremely important goals of efficient urban traffic management. Furthermore, it has also been pointed out that improving and/or building roads alone will not solve the congestion problem and that the implementation of TDM especially congestion pricing is necessary.

Until now, to alleviate traffic congestion in Jakarta, a measure based on TDM has been in progress for a couple of years, namely the 3-in-1 scheme, i.e. only cars with 3 passengers or more are allowed to enter the Central Business District (CBD), [The map of Jakarta and the 3-in-1 streets can be seen in Attachment-1]. This scheme has been initiated and implemented since April 1992. Before the implementation, socialization of the scheme was carried out through the mass media. The basic operational framework is as follows:

- Vehicles restricted: passenger cars with less than 3 persons (taxis and public buses are exempted from this restriction)
- Days in operation: Mondays to Fridays, from 6:30-10:00 AM
- Restricted corridors: Thamrin, Sudirman, and Gatot Subroto streets (CBD area)
- Policemen do enforcement and offenders are apprehended on the spot.

An evaluation of the scheme was carried out one month after the implementation of the scheme. The evaluation shows that 3-in-1 measure is effective in reducing the number of vehicles entering the restricted zone, and a smoother traffic flow during the restricted time was observed. In addition, travel speed in the restricted corridors increased by approximately 35 percent and the number of passenger cars decreased by about 40 percent.

However, after a couple of years of its implementation, the majority of drivers thought that the 3-in-1 scheme had not reduced congestion. The reasons are: first, the streets running parallel to the restricted streets are overcrowded with the vehicles bypassing the restricted streets. Consequently traffic on the parallel streets increases during the restricted hours and decreases the travel speed significantly; second, temporary passengers called 'jockeys' waiting outside of the restricted zone to satisfy the number of passenger requirement for an average fee of Rp. 2,000. There are also some drawbacks of the scheme. First, the current minimum requirement of three passengers cannot be flexibly raised for stricter restriction nor eased for more lenient restriction. Second, there is no revenue collected from this scheme, while the traffic police for enforcement incur a cost.

With respect to congestion pricing, a survey has been carried out to estimate the willingness to pay of travelers. The following summarizes the survey's findings:

- A majority of the respondents (81 percent) would be willing to pay Rp. 2,000 or more if there is travel time reduction of 15 to 20 minutes. The rest of the respondents (19 percent) would shift to public transport or detour using parallel roads.
- If the congestion tax were increased to Rp. 4,000 only one third (35 percent) of the respondents would continue driving and pay the fee, 25 percent of the respondents would shift to public transport, and 40 percent of the respondents would make a detour.
- Finally, a congestion tax of Rp. 6,000 or higher would make most of the auto drivers to be tolled-off.

The survey shows that a congestion tax of Rp. 2,000 is acceptable for most car users. The current toll of Rp. 2,500 for cars on intra-urban roads basically supports this finding. However, from the survey we know that people who would shift from private cars to public transport or detouring are only 19 percent. This will certainly not be able to reduce the level of congestion significantly. In addition, we also have to consider other aspects, for example, the local government of Jakarta has an objective to increase the use of public transport in the CBD area by certain ratio, and a congestion charge of Rp. 2000 for passenger cars may be too low to achieve this objective.

From the survey we know that there is an indication that drivers are willing to pay when there is quite significant reduction in travel time, which means there is improvement in traffic flows. However, we cannot make policy decision based only on this survey. We learn from the literature review that the impact of congestion pricing is very complex. Many aspects, especially distributional impact, must be considered.

4.3. Estimation of the Demand Model

In this paper, we are not going to estimate demand equations for all types of trips. We will focus our study on modeling types of trips where the decision making process is relatively clear and direct (working trip decision is an example, because that decision is made repeatedly and routine everyday), and where reasonably accurate data can be collected and developed for statistical estimation. With these criteria in mind we will concentrate on estimating the work-trip demand model, and limit to the choice of mode (modal split), i.e. what mode of transport is used by individual to go to work, for example, car, bus, train, etc.

One important reason for focusing on work related trips is that they represent about 60 percent of all trips in CBD area in the year 2000 (The Study on Integrated Transport Master Plan for Jabotabek, 2000). We also only focus on the modal split and ignoring the origin-destination because choices of trip destination are highly constrained for work trips. In addition, typically there is no feedback between two of them (origin-destination and modal split) in the sense that modal split is only a function of modal attributes, regardless of what the origin-destination is. Therefore, these choices are of less interest than the choice of mode for work trip. For the mode choice we will limit the number of modes to three: private car, motorcycle, and transit rider (buses). These three modes in the year of 2000 represent more than 80 percent of the total work-trip per day in the CBD area.

4.3.1. Model Parameter Estimation

On the previous chapter all parameters appearing in the models were left unspecified, as symbols without a numerical value. Actual model application to forecast travel demand requires that these parameters be given specific values. We are going to address the issues of parameter estimation as a prerequisite to practical application.

The model of travel demand, which has been developed in the previous chapters, incorporates various inputs whose values reflect prevailing conditions under which the model is applied. These inputs may be classified into two main categories, respectively, model coefficients and model parameters. The basic difference between coefficients and parameters is that in general the value of coefficients will be estimated from direct observations or measurements, or through application of specific formulas or special techniques, but in any event exogenously to the model itself.

On the other hand, parameter values cannot be measured directly, but must be estimated endogenously to the model, specifically from the predicted values for the model's variables. In general, the parameters that must be estimated in our travel demand models get involved in the specification of the utilities facing the traveler at the various levels of choice. Additionally, they also specify the level of variability in random utility, in the form of the β values in the resulting logit models.

A given model must be supplemented with a parameter/model estimation procedure. It may be useful to articulate at the outset the general principle underlying model estimation, even though it may appear somewhat obvious. Specifically, the unknown parameters should be given values such that the travel demands predicted with the model thus 'calibrated' conform, to the greatest extent possible, to travel demands as observed in reality. In other words, a model should be so specified as to be maximally consistent with empirical observations.

Therefore, we need to translate and specify how to measure the 'conformity' between predicted and observed values for the model's variables. We assume that individual travelers' choices are independent of one another, and consequently, parameters may be calibrated on the basis of observations of individual travel behavior and personal characteristics. This obviously leads to the most detailed level of model specification, as it is consistent with the fact that the travel demand models are based on individual traveler choices, and should therefore be identified at that level. Individual choice models cannot be calibrated using simple curve fitting techniques like linear regression analysis. This is because the dependent variable of an individual choice model is a probability, which cannot be observed. What can be observed is whether individuals make the actual choices when they are faced with two or more alternatives. In this case, we will use a calibration approach called maximum likelihood. This procedure searches for coefficients which, when multiplied by appropriate values of alternative characteristics, generate probabilities which are most likely to produce the observed distribution of choices for the sample.

4.3.2. The Maximum Likelihood Method

This method basically states that parameter values should maximize the probability, or likelihood, as predicted by the model, of occurrence of an observed sample of individual travel demand. This principle is called maximum likelihood (Wonnacott and Wonnacott, 1977). In the case of binary choice we can write the probability of individual choosing one mode, let say, automobile, **c** as following,

$$P_c = 1/(1 + e^{\beta(At - Ac)})$$

where,

$$A_m = \sum a^k X_m \; ; \quad m = c(\text{automobile}),\ t\ (\text{transit/bus})$$

$\mathbf{A_m}$ can be interpreted as the attractiveness of mode **m** due to its attributes. $\mathbf{P_c}$ represents what is known as the cumulative logistic distribution function. If $\mathbf{P_c}$ is the probability of choosing automobile **c**, then $\mathbf{(1-P_c)}$ is the probability of choosing bus, **t**. Furthermore, we can write,

$$\mathbf{P_t/P_c} = e^{\beta(At - Ac)}$$

By taking the natural log of this function we get the logit model as the following,

$$\mathbf{Ln}\ (\mathbf{P_t/P_c}) = \beta(A_t - A_c)$$

In the case of more than two modes of transport, we can write the above model as,

$$\mathbf{P_m} = \mathbf{e}^{\beta Am}/(\mathbf{e}^{\beta A1} + \mathbf{e}^{\beta A2} + \ldots\ldots\ldots + \mathbf{e}^{\beta Am})$$

where P_m is the share of the ridership of mode *m*, and A_m is its attractiveness.

The maximum likelihood procedure could be applied to this logit case. We will assume that we have a set of observations for the choices of modes for a sample of **N** individuals, numbered **1,2, ...,n,.......,N**. Such data might, for instance come from 'focus groups'. The observed choice of individual as illustrated in previous chapter is denoted as,

$$\delta_{nm} = 1 \text{ if traveler n has chosen mode } \mathbf{m}$$

$$= 0 \text{ if traveler n has not chosen mode } \mathbf{m}$$

Since δ_{nm} is binomially distributed, we can write the log of probability of observing a given sample as,

$$\mathbf{L} = \sum [\delta_{mn} \log P_{mn} + (1-\delta_{mn}) \log(1-P_{mn})]$$

$$= \sum \log(1+\exp \beta(A_t - A_c)) + \sum \delta_{mn} \beta(A_t - A_c)$$

This is termed the log likelihood function. Now suppose β is unknown. The method of maximum likelihood argues that the calculated probability of observing the given sample should be highest when the unknown β is near the true value, and hence that a satisfactory estimate of the parameters is the maximand of the log likelihood function, or, in other words, a value β which maximizes **L**.

The maximum can be found in the ordinary way by differentiating the equation above with respect to β and setting the derivatives equal to zero. The solution of the resulting set of equations yields the maximum likelihood estimates for β. The first order condition for a maximum is

$$\partial L/\partial\beta = \sum (\delta_{mn} - P_{mn})(A_t - A_c) = 0$$

The second order condition for maximum is

$$\partial^2 L/\partial\beta^2 = -\sum (A_t - A_c)P_{mn}(1 - P_{mn})(A_t - A_c) < 0$$

The right hand side of the last equation is the negative of a weighted moment matrix. Hence provided that the data are not multicollinear, the matrix of second partial derivatives of **L** is negative definite, implying that **L** is strictly concave, the maximum likelihood estimate is unique, and the second order condition holds.

Chapter 5

SURVEY METHODOLOGY

5.1. Introduction

Most of travel demand analyses usually use survey data. It is difficult to overstress the importance of collecting reliable data, and there is a large body of experience on ways to do so. Many transportation demand models include one or more 'generic' variables, such as travel time or cost that have the same meaning but with different values for different alternatives. In the case of disaggregate models such as what we have here, we must know the value of generic variable taken for each individual in the sample, and each for the three modes. For example, to explain the mode choice, we need to know what time and costs members of the sample faced using auto, motorcycle or transit.

One way of meeting this requirement is to use values reported by the user. Doing so, however, has severe weakness. People are likely to have poor knowledge of the attributes of travel options they do not use. Even worse, the value they report may be biased to justify the choice they made. For example, people choosing to drive may believe that bus service is very poor and so overstate the travel times by bus, while those who use transit exaggerate the severity of traffic congestion facing solo drivers. Such systematic variable constructed this way appears very powerful in the model, the analyst may be delighted with it - not realizing that the causation runs at least partly in the opposite direction from that assumed by the model.

Almost all the empirical models in urban transport demand have been estimated with data describing travelers' preferences as revealed in actual decision making. These data are said to portray revealed preferences. Another way to study decision making is to ask respondents about hypothetical scenarios, in which case the preferences displayed are called stated preferences. This analysis is especially useful when people cannot reveal their preferences because an alternative is not available on the market. Stated preferences analysis is also useful when we want to set up specialized decision-making situations that rarely occur in practice, for example, study of commuter's willingness to pay congestion tolls to save travel time given hypothetical scenarios of how the toll revenue will be disbursed. This kind of example has been illustrated in the chapter of Literature Review.

Stated preference data have some additional advantages. From a statistical point of view, explanatory variables generated from revealed preferences may not have a great variation. If everyone faces the same bus fare, their choice cannot reveal what the effects of changing the bus fare would be. By contrast, when collecting stated preference data, the values for the explanatory variables can be varied widely and independently of each other, creating more opportunity to observe how decision-makers respond to them. Another advantage of stated preferences is that people can rank several alternatives rather than just state their first choice, and thus provide additional information that can be used to improve precision of estimates.

Nevertheless, we have to be highly cautious about believing travelers' responses concerning situations about which they have little experience. They may make implicit assumptions not intended by the researcher, or they may attempt to influence policy or demonstrate a particular set of values. Extensive experimentation has taught survey designers how to minimize such biases, but some risks remain. An ideal solution in some situations may be to combine revealed and stated preference data to reap the advantages of both. For example, each respondent first provided revealed preference data based on an actual recent trip by either car or train. The same respondent was then given descriptions of two hypothetical trips, one by car and one by bus, and asked about his or her preference. This stated preference data were designed to independently vary a few key modal characteristics: cost, number of transfers, and a comfort indicator.

In this study we will use data from a single cross-sectional sample drawn from sample survey. Use of these data assumes that respondents have had time to adjust to their current situation or, if not, that the effects of incomplete adjustment vary randomly across the population. Cross-sectional data are also appropriate for understanding long-run behavior. The problem with the cross-sectional data is heterogeneity. This is when we include heterogeneous units in a statistical analysis; the size or scale effect must be taken into account so as not to mix apples with oranges.

For the purpose of this study, travelers' survey was carried out. The number of sample is approximately 300 respondents and this number is divided into 3 separate groups of individuals. The first group is those who go to work using bus, the second group is those travel to work with cars, and the third group is those using motorcycle within or passing the CBD area. The information collected from the respondents basically will include (see attachment 2 for the questionnaire form) their characteristics: income, number of people in the households, expenditure for transport, travel distance; and also the attributes of the modes they are using: travel speed/travel time, comfort, reliability.

5.2. Survey Method

There are four survey methods generally used: mail survey, telephone interviews, face-to-face interviews, and drop-off survey, which is a combination of face-to-face interviews and mail survey. In this regard we will use both face-to-face interview and drop-off surveys. The main reason is that most likely there are two different groups of respondent we are going to have: first, those in the middle or high level status/position in their jobs with busy schedule and are more educated, and second, those in the lower level status/position in their jobs with less busy schedule and are less educated. Face-to-face interview is best suited for collecting information from people who are not likely to respond willingly or accurately - like our second group of respondents - by using other methods. Meanwhile, drop-off method is directed for respondents who have very busy schedule and are more educated - like our first group of respondents - so that they do not have time for face-to-face interviews and most likely they are also able to answer the question without help from the interviewers. In the second method the surveyor will deliver the questionnaires by hand and let respondents complete the questionnaires on their own and leave them out to be collected.

5.3. Number of Samples

Two aspects are being considered in determining the number of respondents. First, the number of respondents is expected to be large enough so that they can represent the population and also represent the users of three mode of transport (bus, auto, and motorcycle). Second, cost efficiency is also considered because of the time and budget constraint. With these two considerations in mind we decide on a sample size of at least 267 respondents. This sample size will give us ± 6% margin of error and ±95% level of confidence.

For large populations (one million or more) the relationship among the confidence interval, the level of confidence, and the standard error of sample proportion can be expressed by the following equation:

$$C_p = + Z_\alpha (\sigma_p)$$

where Cp = confidence interval in terms of proportions

Z_α = Z score for various levels of confidence (α)

σ_p = standard error for a distribution of sample proportion

The formula for the standard error of the true population mean proportion is $\sigma_p = \sqrt{p(1-p)/n}$; substituting it into the previous equation we can rewrite the equation as follows:

$$C_p = + Z_\alpha \sqrt{p(1-p)/n}$$

Solving for n yields

$$n = \left(\frac{Z_\alpha \sqrt{p(1-p)}}{C_p}\right)^2$$

As we have seen the true proportion (p) is unknown. The most conservative way of handling this uncertainty is to set the value of p at the proportion that would result in the highest sample size. This occurs when $p = 0.5$. Therefore for population of one million or more (we do not have the exact number of population of travelers working at CBD, but it is quite save to approximate them as more than one million), the number of sample is calculated by using the following formula:

$$n = \left(\frac{Z_\alpha (0.5)}{C_p} \right)^2$$

where n is the sample size, $Z\alpha$ *is* the Z score for various level of confidence (α), and C_p is the confidence interval (margin error) in terms of proportions. With 95 percent level of confidence the associated Z score is 1.96, and with C_p = 6 percent then we have:

$$n = \left(\frac{1.96 (0.5)}{0.06} \right)^2$$

$$= 267$$

This number is expected to be the number of completed, usable questionnaires we need. However, we also expect that some portion of the filled and returned questionnaires are illegible or incomplete. Assuming that 10 percent of the returned questionnaires can not be used, we will need 267/0.90 = 297 samples or respondents. In addition, we also have to anticipate that some respondents may refuse to be interviewed or to fill out the questionnaire. Assuming 25 percent of respondents will refuse to participate in the survey, we will need 297/0.80 = 396 samples. These samples will be selected randomly from the list of employees, which is also randomly selected from some employers or companies.

5.4. Sampling Method

First of all, for the purpose of this study the target population are the travelers working at the Central Business District area (their offices are located at *Thamrin-Sudirman-Subroto* streets). We use a multistage random sampling technique. In this case the sample is selected in stages, the sample units in each stage being sub-sampled from the larger units chosen at the previous stage, with appropriate methods of selection of the units being adopted at each stage. The main reason for using this method is because sampling frames (e.g. list of persons or travelers) are not available for all the ultimate observation units in the population.

In the first stage we use stratified sampling. In this case we divide the population into sub-population (groups/strata). This is used because we may expect the respondents to vary among different sub-populations. We expect that people working at these three locations/streets have different characteristics because for example, there are more banking offices on *Sudirman* Street than those on the other two streets. This has to be accounted for when we select a sample from the population in order that we obtain a sample that is representative of the population. In this case we divide the population into three groups (with same samples proportion) based on the street where their offices are located: *Thamrin* street, *Sudirman* street, and *Subroto* street. With 396 samples we will need 132 samples from each strata/street.

In the second stage we use cluster sampling where for each strata (street) we divide it into groups, or clusters, and a random sample of these clusters are selected. In this case the clusters are the buildings located in each street. Cluster technique is used and justified on practical ground. One reason is that even though we do not have a complete list of the members of the population, we can obtain a good list of buildings or 'clusters' of the population. Another reason is for cost and time efficiency because the surveyors, instead of having to go to many different buildings/offices - which may be so widely scattered - can just interview one or two respondents. In this stage we are going to make a list of the buildings in each street and a random sample of these clusters/buildings are selected. For practical reason the number of building to be selected randomly is five buildings for each street. Therefore we will have 132/5 = 27 samples from each building.

After buildings are being selected for each street, the next stage is to select one employer/company on each building (most likely one building is occupied by some tenants) by using simple random sampling technique. Finally, the last stage is to select respondents from the list of the employees working with the company/office selected in the previous stage. Again from each company we will need 27 respondents.

5.5. Implementation

By employing one survey coordinator and 6 surveyors, the survey is completed within nine weeks including time for preparation, orientation to the surveyors/interviewers, sending notice letter to companies/employers, and collecting information from respondents.

Since we use both drop-off and face-to-face techniques some survey materials are needed which will include: an interviewer name tag, a letter that explains the purpose and objective of the survey; an interview's manual explaining general information as well as specifics about the survey; and the questionnaire.

The implementation starts with the identification of the buildings in the CBD area. There are 129 buildings at the CBD area, 35 of them are located at Thamrin street, 47 at Sudirman street, and 41 at Subroto street. After randomly selecting the buildings, we randomly select offices for being surveyed. At this point we encounter some problems, some of the offices that have been selected randomly refuse to participate in the survey. After repeatedly trying to select other buildings and offices from the list, finally we are able to obtain 12 offices that participated in the survey instead of 15. Four of the offices selected are located at Thamrin Street, five at Sudirman, and three offices at Subroto Street. In order to meet the number of samples required we have to increase the number of respondents in each cluster, i.e. office, from 27 to 34. The reduction of the number of offices being surveyed from 15 to 12 will certainly reduce the heterogeneity or variability of the samples, for example, in terms of their economic characteristics or mode of transport they are using. This is of course unfavorable because it will affect the quality of the data.

From these 12 offices the total respondents who participated in the survey are 320 travelers. The rest 76 travelers refuse to participate. Unfortunately, those who refuse to participate represent individuals in high-level occupation and thus they are high-income travelers. This certainly also affects the data collected, since we are only able to capture very few representations of travelers from high-income travelers. For example, the highest monthly income of respondent in our survey is Rp. 7 million. We suspect that many workers in Jakarta have income of more than Rp. 7 million, because as a metropolitan and business center, Jakarta is the place for many high executives with monthly salary higher than Rp. 10 million. However, we are not able to capture this segment of travelers because most of them refuse to participate in the survey.

From the 320 questionnaires, 23 of them can not be used because the data supplied by respondents are incomplete. Therefore, we end up with 297 usable questionnaires that consist of 115 respondents who ride bus to work, 104 respondents drive car, and 78 respondents use motorcycle. We summarize the data from the survey in Table 5.1.

Table 5.1.
Summary Statistics of the Surveyed Data

Variables	Total	Bus	Car	Motorcycle
Number of Respondents	297	115	104	78
Age (average)	35.40	34.72	38.34	32.5
Male	226	78	74	74
Female	71	37	30	4
Monthly Income (average, in Rp)	2,053,448	1,752,304	2,701,375	1,633,538
- Standard Deviation	(1.211567)			
Monthly Travel-cost (average, in Rp)	341,421	166,634	680,153	147,470
- as percentage of income	16.62%	9.50%	25.17%	9.02%
- Standard Deviation	(0.356120)			
Distance (average, in km)	23.41	23.88	21.38	23.12
- Standard Deviation	(14.52005)			
On Vehicle Speed (average, km/hour)	-	17	21	33
Average Number of Transfer (bus only)	-	2.17	-	-

Chapter 6

WORK-TRAVEL DEMAND ESTIMATION

6.1. Introduction

The purpose of this chapter is to present the estimation of work-travel demand in the 3-in-1 area in Jakarta by using survey data collected in February and March 2002. Generally, the objectives of estimating work-travel demand empirically are twofold. First, to test and explain the application of the theory to the real data. In the meantime, a successful forecasting model also must assess correctly the impact of costs or level of service changes on demand of transport. In calibration process we need to sort out the effect of the level of service changes from the effects of non-transportation variables. Therefore, our second objective is to produce numerical estimates of model parameters. In the following chapter we will use these numerical estimates to calculate the expected utility and travelers' surplus. In the meantime, the next section will explain samples data and variables.

6.2. Samples Data and Variables

6.2.1. The Nature of the Data

As explained in Chapter 5 the data on the characteristics of travelers and attributes of the modes were collected by using multistage survey method. Three modes of transport are chosen as dependent variables: bus, car, and motorcycle. Mode bus consists of various buses, which only have slight differences in terms of size (capacity), speed, and level of service (AC and non-AC). However, in this study we treat all these buses the same and include all types of bus into one category. The main reasons for not separating or distinguishing different types of buses are that there are not much differences among them and that most of travelers who travel by bus cannot freely select particular bus they want. They are constrained by the fact that not every route is served by all types of buses. Therefore most travelers have to ride only one of particular buses or combination of some particular buses (if they have to make transfer). Based on the summary statistics presented on Chapter 5, on average a traveler who rides bus to work has to make transfers as many as 2.17 times. In short, if a traveler rides a particular bus or buses that is simply because he/she does not have choices. Therefore, there is no point for making bus classification. Dependent variable car represents travelers who travel to work by driving alone. We do not include carpooling since the numbers of travelers using carpooling are not significant and data for this type of mode are difficult to obtain because more than one person is involved in the same trip. Finally, a dependent variable motorcycle consists of those who travel to work by using motorcycle alone.

Since there are various buses, the fares are also varying. Depending on the type of bus the fare ranges from Rp. 750 to Rp. 3,000 per trip/person, and there is no monthly bus pass available. For this reason we cannot use the fare as the generic data to represent travel cost borne by bus users. Instead, we use the actual travel expenditure as revealed by respondents. In fact, all of the data are individual- and choice- specific. Even for example, data on the speed of the mode is also considered as individual specific because it depends very much on the perception of individual as well as other aspects such as road and traffic condition, housing location, etc.

Most data on independent variables need no explanation since they are quite straightforward. One exception may be the data on income. Data on income is limited to wage/salary income, which include bonuses, allowances, etc. The reason for limiting income data only from wage/salary is because of the difficulties to obtain income data coming from other sources (such as interest, rent, etc). Also, we can safely use wage/salary as the proxy of individual income considering the fact that wage/salary is still the largest part of individual income, and also it is considered as the only source of income for most people. We also do not have data on household income, because most of the respondents do not know how much money the other members of the household make (if any). If the respondent is the only person who works and makes money, then the individual income is equal to household income (about 50% of respondents reported that households' income equal to respondent's income). However, if there are other members of the household who also work and make money, then the household income is greater than individual income.

6.2.2. Variables

We define the dependent variable Yi for each of the i = 1, ..., 297 travelers in the sample such that:

- Yi = 1 if individual travels to work by BUS
- Yi = 2 if individual travels to work by CAR
- Yi = 3 if individual travels to work by MOTOR

The explanatory or independent variables used in multinomial logit specification can be classified into two groups: first, variables that represent the characteristics of travelers; second, variables that represent the attributes of the mode.

Travelers' characteristics are the following:

- SEX =1, if the traveler is female; SEX = 0, otherwise (male)
- AGE = 1, if the traveler is 40 years old or older; AGE = 0, if younger than 40
- HISCHOOL =1, if the traveler has high school education or lower; HISCHOOL = 0, otherwise (undergraduate or higher)
- GRADUATE = 1, if the traveler has a Master or PhD degree; GRADUATE = 0, otherwise (undergraduate or lower)
- WAGE is per hour wage in Rupiah, it is calculated as, WAGE = [Monthly Income/(4.33 weeks x 40 hours)]
- VEHICLEOWN = 1, if the traveler own motor or car; VEHICLEOWN = 0, otherwise
- HOMEOWN = 1, if the traveler own a house; HOMEOWN = 0, otherwise
- DISTANCE is in kilometer (km) which represents the distance from home to office

Mode's attributes are the following:

- TRANSFER1 = 1, if the person has to transfer (bus) once; TRANSFER1 = 0, otherwise (no transfer)
- TRANSFERM = 1, if the person has to transfer (bus) more than once; TRANSFERM = 0, otherwise
- TRAVELTIME, this is in-vehicle time, two-ways, and in minute
- TRAVELTIMEB, this is waiting time and walking time to and from bus stop, in minute (bus specific)

- TRAVELCOST is the cost of travel per trip. It is obtained as TRAVELCOST = [Monthly Travel Expense/22 working days]/2 trips per day.
- SLOW = 1, if the speed of the mode is slow; SLOW = 0, otherwise (neutral)
- FAST = 1, if the speed of the mode is fast; FAST = 0, otherwise (neutral)
- COMFORT = 1, if the mode is comfortable; COMFORT = 0, otherwise (neutral)
- UNCOMFORT = 1, if the mode is not comfortable; UNCOMFORT = 0, otherwise (neutral)
- SAFE = 1, if the mode is safe; SAFE = 0, otherwise (neutral)
- UNSAFE = 1, if the mode is not safe; UNSAFE = 0, otherwise (neutral)

The last six variables are qualitative ones, therefore they are very subjective and depend on the perception of each traveler.

6.3. Model Specification and Estimation

Theoretically, some characteristics of travelers and modal's attributes are expected to be the important determinants for individual in selecting certain mode of transport. Therefore, in selecting variables for the specification we try to follow the theoretical or the important role of the variables in the decision making process of work-travel. In addition, statistically, variables entered into the specification are being evaluated and selected based on z-statistics and the log-likelihood ratio test.

Choice of mode of transport depends on alternative's attributes and individual's characteristics. Among others the most important attributes are cost of travel and level of service (i.e. travel time/speed, reliability, comfort, and safety). In the meantime, income and vehicle ownership also plays an important role from the perspective of individual characteristics, which directly affect the choice of mode decision. Other variables may not directly affect individual's modal choice decision, but they may be able to explain the choice. For example, the family size variable may have important role in modal choice because - ceteris paribus -with the same income a smaller family may be able to afford to buy a vehicle, while a larger family may not, because most of its income is consumed for other purposes. Another example is variable education, even though the level of education does not directly affect work-travel decision making, we expect that the higher the level of education of the respondent the more likely he/she earns more money, and consequently may have ability to afford a car.

Even though many variables other than income, travel costs, and level of service may have roles in the choice of mode, but according to McFadden (1997) many empirical tests show that the introduction of variables other than those mentioned in a disaggregate mode choice model may improve only marginally the ability to 'explain' observed choices in a calibration data base, but it may significantly improve forecasting accuracy.

6.4. The Empirical Results and their Interpretation

Specification 1:

$$Y_{CAR} = C + X1*WAGE + X2*TRAVELTIME + X3*TRAVELCOST$$

$$Y_{MOTOR} = C + X1*WAGE + X2*TRAVELTIME + X3*TRAVELCOST$$

In this first specification we try to include only few variables that we think as the most important variables for work-travel decision making such as WAGE, TRAVELCOST and TRAVELTIME. As we can see in Table 6-1 for dependent variable

Y_{CAR}, WAGE, TRAVELCOST, and TRAVELTIME variables all have positive (+) signs, this implies that when these three independent variables increase the relative probability of traveling with mode car increases. Statistically, all independent variables are significant except for variable WAGE.

In this specification variable WAGE has the expected sign, as income increases, the relative probability of traveling to work by car increases. However, we need to explain the positive signs of the other two dependent variables. When variable TRAVELTIME increases the relative probability of traveling with car also increases. The same thing also happens for variable TRAVELCOST. These may seem contrary to the theory that if travel-time or travel cost increases the probability of using particular mode should decrease. However, recalling that the change in the relative probability is in comparison to the base mode, i.e. bus, we can think this estimation is a possibility. One possible explanation is that car drivers still consider that traveling by car give them higher utility (especially compared to bus), even after increases in the value of both variables. As for TRAVELTIME the explanation is that increase in travel-time does not affect much on the overall time and monetary cost spent for the trip, especially considering that most of travelers live quite far from their workplace (on average car driver drives 21.38 km from home to workplace).

For dependent variable Y_{MOTOR}, WAGE, TRAVELTIME, and TRAVELCOST have negative impact on the relative probability of riding motor for going to work. As the values of these variables increase, the relative probability of riding motor for going to work decreases. An increase in WAGE will reduce the relative probability of riding motor. This implies that bus is preferred than motor when wage increases. For the variable

TRAVELCOST as we expect it has negative impact on the relative probability of riding motor to work because travelers will shift to other modes which are cheaper. The signs of these two variables - WAGE and TRAVELCOST - seem to be inconsistent. In one hand bus is preferred because it is cheaper, on the other hand when wage increases (ability to pay increases) bus is still preferred than motor. For variable TRAVELTIME, as travel-time increases the utility received by travelers from using motor for working decreases, so they tend to shift to another mode.

Specification 2.

$$Y_{CAR} = C + X1*TRAVELCOST/WAGE + X2*TRAVELTIME + X3*WAGE*TRAVELTIME$$

$$Y_{MOTOR} = C + X1*TRAVELCOST/WAGE + X2*TRAVELTIME + X3*WAGE*TRAVELTIME$$

On the first specification we put WAGE (as it represents travelers' characteristic) into the model, but since this variable is not statistically significance (where $|\text{z-stat}| < 1$), on this second specification we replace it with TRAVELCOST/WAGE which represents the share of wage spent for transport. In this case, it's $|\text{z-stat}| > 1$ for both Y_{CAR} and Y_{MOTOR}. Unfortunately, the sign of this new variable is both positive for dependent variable Y_{CAR} as well as Y_{MOTOR}. This means that as the income share for transportation costs increase, the relative probability of using the existing modes increases.

Theoretically, this does not seem right because we expect that travelers will eventually shift to other mode of transport if the existing mode they are using is increasingly costly. However, for Y_{CAR} this result is consistent with the previous specification, and the similar explanation can be used.

As for TRAVELTIME, it is statistically significant for both Y_{MOTOR} and Y_{CAR}. Different from the first specification, the sign for this variable is now negative for both Y_{CAR} and Y_{MOTOR}. This means that as travel-time increases the relative probability of driving car and the relative probability of riding motor to work decrease. In this case variable travel-time does affect the utility of auto and motor travelers very much to make them switch to bus.

In specification two we introduce new variable, WAGE*TRAVELTIME. By using this variable we want to see the impact (increase or decrease) of wage or travel-time or both on the relative probability of using particular mode of transport. Theoretically, an increase in each or both of these variables will increase the opportunity cost of traveling. We expect that if wage or travel-time or both increases the relative probability of choosing particular mode will decrease, because it is considered more expensive. The model tells us that an increase in one of these variables or both will increase the probability of using existing modes. Therefore, in terms of these variables, motor and car are still preferred than bus even after an increase in the opportunity cost of using car and motor. In terms of the log-likelihood value, second specification is no better than the first one. The pseudo R2 and $\chi 2$ values are lower as well. In general the first specification is better than the second specification.

Final/Full Specification

$$\begin{aligned} Y_{CAR} = {} & C + TRAVELCOST/WAGE + X2*WAGE*TRAVELTIME \\ & +X3*COMFORT + X4*SAFE + X5*DISTANCE + X6*HISCHOOL \\ & +X7*SEX \end{aligned}$$

$$\begin{aligned} Y_{MOTOR} = {} & C + X1*WAGE + X2*TRAVELCOST + \\ & X3*WAGE*TRAVELTIME + X4*COMFORT + X5*FAST + \\ & X6*UNSAFE + X7*SEX \end{aligned}$$

After trying and evaluating different sets of specifications we come to this final/full specification. Statistically, except for WAGE*TRAVELTIME in dependent variable Y_{MOTOR}, all variables in this final specification are significant. In Y_{MOTOR} WAGE enters the specification not in the form of TRAVELCOST/WAGE but it enters independently. In this full specification there are some other new variables which enter into the specification. We start with variable COMFORT. This variable is a dummy variable that represents traveler's perception of the quality of the mode. The positive sign of its coefficient indicates that the existence of this variable will increase the relative probability of individual to choose car or motor over bus. In other words, with respect to COMFORT car and motor are preferred than bus.

For dependent variable Y_{CAR}, the coefficient estimates also show that variable SAFE has positive signs which means that in terms of this attribute car is preferred than bus, so that the existence of this variables (dummy=1) will increase the relative probability of travelers to choose car over bus. On the contrary, the existence of UNSAFE in dependent variable Y_{MOTOR} will reduce the relative probability of travelers from using motorcycle because the sign of its coefficient is negative. Dummy variable SEX=1 tells us that if individual is a female the relative probability of driving car or motor to work is small. This means that females prefer bus over car and motor. In Y_{CAR} variable HISCHOOL has a negative sign, which means that if individual's highest education is high school, the relative probability of this individual to drive car is small. Variable FAST in Y_{MOTOR} has positive sign which indicates that in term of this variable motorcycle is preferred than bus. Finally, variable DISTANCE enter into dependent variable Y_{CAR} with negative sign, this means that as the distance increases the relative probability of driving alone decreases.

For dependent variable Y_{MOTOR}, variable WAGE and TRAVELCOST enter the specification individually not as a ratio like the one in dependent variable Y_{CAR}. This is because they are statistically better than when they enter individually. The signs of coefficients for the two variables are negative. This means that when the cost of travel increases the relative probability of using motor decreases and travelers will shift to other mode that is cheaper, e.g. bus. Similarly, when wage increases the relative probability of riding motor also decreases. Again there is inconsistency of the decision made by travelers regarding these two variables.

In Table 6.1, we summarize the three specifications and report the goodness of fit of the model. The first measure of goodness of fit is the log-likelihood. In this case our final specification posses better log-likelihood value than the previous ones. We also present the log-likelihood values both with full model (parameters included) and model with intercept only. We compares the model estimated with all variables suspected of influencing the choice decision process to the model that has no parameters whatsoever. L(0) is the log-likelihood computed when all coefficients are constrained to be zero, and

Table 6.1

Work-Travel Demand Estimation

Independent Variables	Parameter Estimates (z-statistics are in parenthesis)		
	Specification 1	Specification 2	Final Specification
Yi = CAR			
Constant	-4.9677 (-4.9547)	-3.7987 (-5.2297)	-3.8165(-4.0263)
Wage	0.0546 (0.2597)		
Travelcost	0.1398 (5.9566)		
Traveltime	0.1398 (1.1427)	-0.0542 (-4.7001)	
Travelcost/Wage		0.0235 (6.9622)	19.2077 (4.5911)
Wage*Traveltime		2.1053 (5.7901)	1.2092 (4.0334)
Comfort			1.7345 (2.5534)
Safe			1.1413 (1.9494)
Distance			-0.0901 (-2.8018)
Hischool			-1.5438 (-2.5446)
Sex			-1.6332 (-2.3812)
Yi = MOTOR			
Constant	0.6591 (1.5590)	-0.2306 (-0.6361)	0.7293 (1.5041)
Wage	-0.0978 (-0.6617)		-0.4901 (-1.8374)
Travelcost	-0.0019 (-1.2139)		-4.1159 (-2.0299)
Traveltime	-0.2156 (-2.3574)	-0.0132 (-1.5146)	
Travelcost/Wage		0.0033 (1.2645)	
Wage*Traveltime		0.1261 (0.4754)	0.3339 (0.9381)
Comfort			1.4109 (2.9422)
Fast			0.8355 (1.9828)
Unsafe			-1.0854 (-2.4407)
Sex			-2.5952 (-3.8160)
- Log-likelihood (0)	-322.53	-322.53	-322.53
- Log-likelihood (β)	-192.69	-216.26	-161.43
- $\chi^2 = -2[L(0)-L(\beta)]$	259.68	212.54	322.20
- McFadden R^2 = $1-L(\beta)/L(0)$	0.40	0.32	0.50

Note: Bus is used as a base mode

L(β) is the log-likelihood computed with no constraints on the model. Clearly, the model with some parameters has larger log-likelihood. This means that the explanatory variables have significant role in explaining the dependent variables. For large differences in log-likelihood there is evidence to support preferring the more complex model to the simpler one. In our final specification the differences in log-likelihood are higher than those of the other two specification.

The second measure of goodness of fit is McFadden R^2 or pseudo-R^2 and its formula are also reported. A zero value corresponds to the entire slope coefficient being zero, and a value of 1 corresponds to a perfect prediction. Unfortunately, as Greene (2000) notes, the values between 0 and 1 have no natural interpretation, though it has been suggested that McFadden R^2 increases as the fit of the model improves. This is exactly what we have in our last specification, the McFadden R^2 is higher than those in previous specifications. We also calculate the prediction success of the probability presented in Table 6.2. The model is considered to predict the modal split choice quite well especially for bus (79 percent correct) and car (87.5 percent correct). In the meantime, the overall percent of correct prediction is 76 percent.

Table 6.2
Prediction Success Table

Actual Choice	Predicted Choice	Percentage Correct
Bus, n = 115	91	79%
Car, n =104	91	87.5%
Motor, n =78	46	59%

Overall percent correct = 76%

6.5. Value of Time

The estimated utility function (V_m) can be used as a dependent variable to estimate the value of time for travelers using car and motor. In order to do this we run an ordinary least square with the estimated utility function depends on variable WAGE, TRAVELCOST, and TRAVELTIME. The results are the following (with t-statistic in parenthesis):

$$V_{CAR} = -7.275498 + 5.405407*TRAVELCOST*WAGE +$$
$$(-13.26499) \qquad (12.29862)$$

$$1.159033*TRAVELTIME$$
$$(10.65149)$$

$$V_{MOTOR} = 0.682941 - 1.727291*TRAVELCOST*WAGE -$$
$$(2.077275) \qquad (-6.556313)$$

$$0.240884*TRAVELTIME$$
$$(-3.693071)$$

These models are specified so that the ratio of each of the travel-time coefficient to the travel-cost coefficient is proportional to the per-hour wage rate. The value of time (VOT) can be calculated as,

$$VOT_{CAR} = 1.159033/(5.405407/WAGE) = 0.21WAGE$$

$$VOT_{MOTOR} = -0.240884/(-1.727291/WAGE) = 0.14WAGE$$

The estimated parameters indicate that car travelers value their time approximately at 21 percent of per-hour wage rate, and for motor travelers, they value their time approximately at 14 percent of per-hour wage rate. As expected, the value of time for individuals travel by car is higher than that of individual travel by motor because on average the former have higher income than those who travel by motor.

In general, these values are low compared to other studies which estimate work-trip's value of time. For example, in the United States studies by Lisco (1967) and Lave (1969) show that the value of time for work trip is approximately 41 percent of the wage rate. Furthermore, McFadden and Domencich (1975) conclude that the value of time is approximately one third of wage rate. However, in another study McFadden, Talvitie and Associates (1977) come up with a higher value of time which is 49 percent of the wage rate.

In the United Kingdom the value of time is somewhat lower than that in the United States. For example, Quarnby (1967) finds out that the value of time is between 21 to 25 percent of wage rate. Similarly, a study by Bruzelius (1979) shows that the value of time for work trip is between 20 to 30 percent of wage rate. Finally, In Australia Hensher (1989) concludes that the value of time for work trip is approximately 28 percent of the wage rate.

Our finding and all of the above studies on the estimation of value of time are basically in line with the conclusion given by Calfee and Winston (1988) and also Small (1997) that travel time values are modest fractions of income (wage) and that this fraction diminish as income increases. Furthermore, Small (1997) also argues that the value of travel time may vary from 20 to 100 percent of gross wage rate from one country to another, or from various groups of income.

Chapter 7

EQUITY ANALYSIS OF CONGESTION TAX

7.1. Expected Utility

By using our work-travel demand estimated in the previous chapter, we are now ready to calculate the expected utility received by travelers. As mentioned in Chapter 3 the expected utility an individual chosen at random receives from utility maximizing choices can be calculated by using the following formula:

$$EU_m = 1/\beta \ln \Sigma e^{\beta U_m}$$

This formula tells us that expected utility of individual choosing mode of transport *m*, depends on the utility received and parameter β. The value of parameter β in the formula above is related to the variances of random components, ε. This can be explained as the following. By assuming that the error distribution is the Gumbel or double exponential distribution, which is the member of the family of extreme value distributions, the mean and variance of the distribution are (For derivations see Anderson et al., 1992, page 57):

$$\mu = 0$$

$\sigma^2 = \pi^2/6\beta^2$; so that we have the following:

$$\beta = \pi/\sqrt{6}\sigma\varepsilon$$

This formula tells us that the value of parameter β is inversely related to the standard deviation of the random error on the utility's specification.

The role of parameter β may be illustrated by giving it extreme values. For example, when $\beta = 0$, the variance of the random terms is infinite, implying complete lack of information by the modeler about the alternative's utilities. Consequently, one might expect that the respective probabilities of observing the individual traveler choosing any given alternative should be equal, or independent of any traveler or alternative characteristics. On the other hand, an infinite values of β implies that the variance of the random terms is zero, that our information about alternative's utilities is deterministic, or perfect. In this case we might expect that the probability of observing the individual traveler select the alternative with the highest utility would be equal to 1 (one), and the probabilities of observing him or her select any other alternative equal to zero. The expected demands would then be nonzero for only one alternative. In the case where, say *m* alternatives have the same, maximum utility, the respective probabilities of observing the individual traveler select them should be equal to *1 m*. Thus, the role of parameter β is to set the dispersion of the distribution of expected demands at some intermediate level between these two extremes.

Based on the final specification of work-travel demand, the value of standard deviation (σ) of the residual or error terms is, $\sigma\varepsilon = 0.352178$ and the corresponding value of β is 3.641765897. We use this value to calculate the expected utility by using formula stated in the beginning of this chapter. The table of expected utility for every traveler could be seen in Appendix-1. The table shows that each traveler has positive expected utility but its value varied greatly from one individual to another. For example the highest expected utility received by a traveler is Rp. 86,683 and the lowest is Rp. 128 per trip. The average expected utility received by all travelers is Rp. 12,568 per trip. This average expected utility represent 113 percent of the average per-hour wage, which is Rp. 11,081. Furthermore, if we compare the average expected utility to the average travel-cost per trip, which is Rp. 7,759, it represents 162 percent.

7.2 Congestion Tax Scenario

To calculate the welfare and equity implication of the congestion tax, we need to establish a hypothetical congestion tax scenario/policy. And before setting the congestion tax scenario we have to consider what the objective of the tax is. If the objective is to collect as much revenue then there will be an optimal congestion tax that will maximize the revenue. On the other hand if the objective of congestion tax is to reduce traffic congestion by inducing travelers to use other modes, then we need to charge congestion tax high enough so that the acceptable or the optimal level of traffic congestion can be achieved. To set the congestion tax with each of these objectives a further study is absolutely required.

Since the objective of this study is to see the welfare implication of a certain congestion tax, and not to determine the optimal tax, we can set the tax rate in a much simpler way on arbitrarily basis. In doing so we use three different tax scenarios, Tax Scenario 1 for low tax, Scenario 2 for medium tax, and Scenario 3 for high tax. Furthermore, we can evaluate each of congestion tax schemes in terms of its welfare effect. For automobile we will use the following amount of congestion tax: Rp 6,000 (low), Rp. 7,000 (medium), Rp 8,000 (high). This amount of congestion tax represents respectively 19%, 22%, and 25% of the average travel expenses of respondents who use auto to work. Compared to the willingness to pay (WTP) reported by other study conducted in 1995 in Chapter 3 these taxes are little bit higher, but if we take into account the effect of inflation and the severity of congestion these taxes are very reasonable. The congestion taxes for motor differ from those of car, they are much lower because the average travel expense spent by those using motor is much lower. For motorcycle we will use the following scenario for congestion tax: Rp. 1,000 (low), Rp. 1,500 (medium), and Rp. 2,000 (high). This scenario of congestion tax represents respectively 16%, 24%, and 32% of the average travel expenses of respondents who use motorcycle to work. The congestion tax for car at every level is higher than that of motorcycle because cars contribute higher negative externalities, in congestion, pollution, etc. In addition, motor travelers are usually associated with low-income group, therefore for equity reason the charges are lower (according to our survey, the average income of individuals using motorcycle to work is 60 percent lower than the average income of individuals using car to work)

Furthermore we group travelers into three income classes: low, medium, and high income. To determine the grouping we adopt the World Bank criterion, which divides the population into three classes, i.e. 40 percent of those having low income, 40 percent having medium income, and 20 percent with high income. Based on this criterion, monthly income of Rp. 1.575 million or lower is classified as low income, monthly income between Rp. 1.575 million and Rp. 3.054 million is classified as medium income, and monthly income above Rp. 3.054 million is grouped as high income. Based on this income grouping we have 119 respondents belonging to low income group, 119 respondents in medium income class, and 59 respondents in high-income group.

7.3. Welfare Changes (Travelers' Surplus) and Equity Implication

Based on the scenarios of congestion tax we have established in the previous section, we are now ready to evaluate the impact of congestion tax on the welfare of travelers. The congestion tax affects travelers by increasing their travel cost. We are particularly interested in both the efficiency and the equity impacts of the tax on the welfare of the travelers as a whole, and also travelers from different income groups. Traveler's surplus can be calculated by subtracting the expected utility received by each travelers before congestion tax from the expected utility received by each traveler after the tax. If the resulting number is positive, this means that this particular traveler has surplus as a result of the tax policy. On the other hand, if the resulting number is negative, this means that this person experiences loss from the tax policy. For this purpose we have calculated the expected utility before and after tax both by income class and by modal split; the travelers surplus are also calculated both by income class and by modal split; and finally we calculate the total welfare changes by decomposing them into changes in efficiency and changes in equity. First, we measure efficiency that is independent of the degree of aversion to inequality, and after that we take into consideration the equity aspect. For this purpose we use only two equity criteria, the utilitarian and the cost-benefit criteria.

Basically, there are four important findings from this empirical study. First, in every level of tax scenario (low, medium, and high) there is always welfare gain for all income groups. Second, the higher the tax level, the higher is the welfare improvement. Third, the median income group receives the largest welfare improvement at any level of tax, while the low-income group receives the least except at medium tax level. Finally, we find out that welfare improvement is only associated with group of travelers who use car to work. In other word, even though the total welfare changes are positives, travelers who use motor and bus experience loss in welfare.

In efficiency analysis we want to know the impact of imposing congestion tax on the welfare of the travelers. By observation we find out that every traveler has positive expected utility before and after tax. This means that everybody experiences net benefit from traveling to work. By looking at Table 7.1 we can see that in general the imposition of a congestion tax would increase the expected utility of travelers as a group (some travelers have lower expected utility after tax). In each tax scenario all three income groups also have higher expected utility compare to the expected utility before the tax.

Table 7.1.
Expected Utility by Income Class
(per trip, in Rupiah)

	Income Class			
Tax Scenario	Low n=119	Medium n=119	High n=59	Total n=297
1. Before Tax	1,135,671 (9,543)	1,644,560 (13,819)	952,626 (16,146)	3,732,858 (12,568)
2. Low Tax	1,378,556 (11,584)	2,076,655 (17,450)	1,080,327 (18,310)	4,535,540 (15,271)
3. Medium Tax	1,399,956 (11,746)	2,102,497 (17,668)	1,085,440 (18,397)	4,587,893 (15,447)
4. High Tax	1,428,937*) (12,007)	2,138,735*) (17,972)	1,106,815*) (18,759)	4,674,488*) (15,739)

( ) = Average Expected Utility
*) = Highest Expected Utility

Before the tax, the high-income group travelers on average receive the highest expected utility followed by medium and low-income groups. After all three tax scenarios are imposed, the high-income group still receives the largest expected utility in absolute terms in scenarios 1 and 3. However, the percentage increase of expected utility received by high income group travelers is the smallest compare to that received by the other two income groups. From the same table we can also look at the relationship between the tax level and the expected utility received by travelers. The result shows that the higher the tax level, the higher the corresponding expected utility for every income group.

We also calculate travelers' surpluses by comparing the expected utility before and after tax. All three income groups experience positive travelers' surplus, which indicates that congestion tax increases the welfare of the travelers. Since the high-income group's expected utility after tax increases by the smallest percentage, the travelers' surplus received by this group is also the smallest as a consequence. The medium income group receives the largest percentage of traveler's surplus followed by the highest income group. These results suggest that a congestion tax might be regressive, at least for the low income group. However, if we compare middle and high income groups, the tax is progressive.

In addition to comparing the expected utility and travelers' surplus based on different income groups, we also compare them based on modal split. In this case we want to know the expected utility and the surplus received by travelers by classifying these travelers based on the mode of transport they are using. In Table 7.2 , we can see that even though all income groups experience an increase in welfare but this welfare improvement is attributed mostly to those who travel by car. For those who travel by bus and motor, they actually experience relatively small losses (negative surplus) after the imposition of tax as indicated by smaller expected utility after the tax in each scenario. However, in total all travelers together still receive net benefits/surplus. Even though the respondents who use car to work constitute only 35% of all travelers in the sample, since they gain much higher expected utility after tax, they can hypothetically compensate the loss experience by those who travel with bus and motor, thus, a net welfare gain for all travelers as a whole.

Table 7.2
Expected Utility by Modal Split
(per trip, in Rupiah)

Tax Scenario	Modal Split Bus n=115	 Car n=104	 Motor n=78	 Total n=297
1. Before Tax	374,190 (3,253)	2,641,369 (25,397)	717,298 (9,196)	3,732,858 (12,568)
2. Low Tax	346,893*) (3,016)	3,497,714 (33,631)	690,932 (8,858)	4,535,540 (15,271)
3. Medium Tax	346,306 (3,011)	3,548,098 (34,116)	693,489 (8,890)	4,587,893 (15,447)
4. High Tax	346,421 (3,012)	3,630,372*) (34,907)	697,694*) (8,944)	4,674,488*) (15,739)

( ) = Average Expected Utility
*) = Highest Expected Utility

With respect to distributional or equity analysis we attach distributional weight to the welfare function. We have the following form of social welfare function developed by Atkinson (1970):

$$W = \Sigma\ 1/1\text{-}\eta\ \delta(EU_m)^{1-\eta}$$

The parameter η governs the concavity, and therefore the degree of inequity aversion. We also include distributional weights, δ in this function. Usually we use the social marginal utility of income to calculate δ, i.e. $\delta = Y^{-\eta}$. To measure the welfare, first, we use the concept of utilitarianism, which puts emphasis on efficiency. In this case we set the value of society's aversion to inequality, $\eta=0$. The distributional weight, associated with the value of this η is $\delta=Y^0=1$. This is basically the case that we have discussed before. The results are presented in Table 7.3 for travelers' surplus by income class and table 7.4 for travelers' surplus by modal split.

Table 7.3

Travelers' Surplus by Income Class

(per trip, in Rupiah)

[Utilitarian Criterion]

	Income Class			
Tax Scenario	Low	Medium	High	Total
	n=119	n=119	n=59	n=297
	$\delta=1$	$\delta=1$	$\delta=1$	
1. Low Tax	242,390	432,590	127,700	802,681
	(2,036)	(3,635)	(2,164)	(2,702)
2. Medium Tax	264,284	457,937	132,813	855,035
	(2,293)	(3,990)	(2,249)	(2,964)
3. High Tax	293,265*)	494,175*)	154,188*)	941,629*)
	(2,464)	(4,152)	(2,613)	(3,170)

( ) = Average Travelers' Surplus

*) = Highest Travelers' Surplus

Table 7.4
Travelers' Surplus by Modal Split
(per trip, in Rupiah)
[Utilitarian Criterion]

Tax Scenario	Modal Split Bus n = 115 $\delta = 1$	 Car n = 104 $\delta = 1$	 Motor n = 78 $\delta = 1$	 Total n = 297
1. Low Tax	-27,296 (-237)	856,344*) (8,234)	-26,366 (-338)	802,681 (2,702)
2. Medium Tax	-27,884 (-242)	906,728*) (8,718)	-23,809 (-305)	855,035 (2,878)
3. High Tax	-27,768 (-241)	989,002*) (9,509)	-19,604 (-251)	941,629 (3,170)

( ) = Average Travelers' Surplus
*) = Highest Travelers' Surplus

Second, we also perform a distributional cost-benefit analysis. In this case, we calculated the distributional weight associated with society's aversion to inequality of $\eta=1$. However, instead of using directly the inverse of income as distributional weight, we first calculate the average income share for each income group, and then the distributional weights is basically the inverse of the share of average income. The corresponding values of distributional weights are 1.85, 0.99, and 0.52 for low, medium, and high income group respectively. As a result of putting distributional weights into the welfare function, the low and medium income travelers receives even higher surpluses as compared to the utilitarian case. In contrast, the high-income group experiences positive but smaller surpluses (See Table 7.5 for the summary of travelers' surplus by income class, using cost-benefit criterion). Another important difference is that the total welfare received by travelers as a whole increase greatly. This big increase is due to efficiency and equity improvements.

Table 7.5
Travelers' Surplus by Income Class
(per trip, in Rupiah)
[Cost-Benefit Criterion]

Tax Scenario	Income Class Low n=119 $\delta=1.85$	 Medium n=119 $\delta=0.99$	 High n=59 $\delta=0.52$	 Total n=297
1. Low Tax	448,421	428,261	66,404	943,086
	(3,768)	(3,598)	(1,125)	(3,175)
2. Medium Tax	488,925	453,357	69,062	1,011,344
	(4,108)	(3,809)	(1,170)	(3,405)
3. High Tax	542,540$^{*)}$	489,233$^{*)}$	80,177$^{*)}$	1,111,950$^{*)}$
	(4,559)	(4,111)	(1,358)	(3,744)

( ) = Average Travelers' Surplus
*) = Highest Travelers' Surplus

It is one of our interests to distinguish welfare changes due to efficiency and that due to equity. For this purpose we can break down the welfare changes into the aspects of efficiency and equity, as presented in Table 7.6. The decomposition of the changes in travelers' welfare into changes in efficiency and equity is important because we want to know how much welfare changes are attributed to efficiency and how much are to equity. In terms of efficiency, our measure is independent of the degree of aversion to inequality. Congestion tax (scenario 3) increases efficiency by as much as Rp. 0.941

million and the equity gain from the tax is as much as Rp. 0.170 million, this is equivalent to Rp. 3,170 efficiency gain per person/trip, and Rp.573 equity gain per person/trip respectively. In term of percentage, 84 percent of welfare gain is attributed to efficiency, and 16 percent is due to equity.

Table 7.6
Changes in Welfare
(per trip, in rupiah)

Tax Scenario	Total Welfare	Change in Travelers' Welfare Efficiency	 Equity
1. Low Tax	943,086 (3,175)	802,681 (2,702)	140,405 (472)
2. Medium Tax	1,011,344 (3,405)	855,035 (2,878)	156,309 (526)
3. High Tax	1,111,950 (3,743)	941,629 (3,170)	170,321 (573)

( ) = Average Welfare Change

By using sensitivity test we can analyze to show how much change in the weights (δ) is required to change from 'non-progressive' to 'progressive'. In order to achieve progressiveness of the after tax travelers surplus we only need to put a higher weight for the low income group without changing the weights of the other two income groups (in other words the weights for the other income groups are equal to one or the same as in utilitarian criterion). The weight for low income travelers can even be lower than the one we have in Table 7.4. We only need δ = 1.8 in order for the tax to be progressive. The result of this sensitivity test is demonstrated in Table 7.7 and the changes in welfare is presented in Table 7.8. From these two table we can see that the surplus experienced by medium and high income groups of travelers are the same as we have in the utilitarian criterion. In this case we do not have to sacrifice the surplus of medium and high income by reducing the surplus they receive. As a result, the total travelers' surpluses are higher. The increase in the travelers' surplus is fully attributed to the equity changes as we can see in Table 7.8.

Table 7.7
Travelers' Surplus by Income Class
(per trip, in Rupiah)
[Cost-Benefit Criterion with Sensitivity Test]

Tax Scenario	Income Class Low n=119 δ=1.80	 Medium n=119 δ=1	 High n=59 δ=1	 Total n=297
1. Low Tax	436,302 (3,666)	432,590 (3,635)	127,700 (2,164)	996,592 (3,355)
2. Medium Tax	475,711 (3,997)	457,937 (3,990)	132,813 (2,249)	1,066,461 (3,590)
3. High Tax	527,877*) (4,435)	494,175*) (4,152)	154,188*) (2,613)	1,176,240*) (3,960)

( ) = Average Travelers' Surplus
*) = Highest Travelers' Surplus

Table 7.8
Changes in Welfare with Sensitivity Test
(per trip, in rupiah)

Tax Scenario	Total Welfare	Change in Travelers' Welfare Efficiency	Equity
1. Low Tax	996,592 (3,355)	802,681 (2,702)	193,911 (652)
2. Medium Tax	1,066,461 (3,590)	855,035 (2,878)	211,366 (711)
3. High Tax	1,176,240 (3,960)	941,629 (3,170)	234,611 (789)

( ) = Average Welfare Change

7.4. Conclusion

From previous discussion we may conclude that congestion tax in Jakarta is a welfare improvement instead of a welfare loss. This means that congestion tax would increase efficiency. In addition to the efficiency improvements, by performing cost-benefit analyses there are additional gains from equity. We also observe that congestion tax in Jakarta is neither progressive nor regressive. Even though all income groups experience welfare improvement from the imposition of tax, the middle-income group receives the largest benefit, followed by high income group, and the low-income group benefits the least. In this case we may suspect that congestion tax in Jakarta could be regressive, but because of the drawbacks of the survey (as we explain in Chapter 6) we are not able to include enough number of high-income travelers who value their time much higher. We notice that before the tax is imposed they have already received higher expected utility from work-trip compared to the low and medium income groups. On the average the high income group receives 14 percent higher expected utility than those received by the average medium income class, and 61 percent higher expected utility than those received by the average low-income class. The timesaving by the rich in terms of monetary value may be far too small relative to their income. On the contrary, for median and low-income groups the timesaving in terms of monetary value are much greater relative to their income. For medium and low-income group, even though they also have to spend relatively larger portion of income to pay the toll, the net effect is much greater.

The fact that higher tax rates are accompanied by higher expected utility may have something to do with the level of congestion. The possibility is that the level of congestion is very severe so that we may need a relatively higher tax to reduce congestion significantly in order to achieve a traffic flow closer to the optimal flow. Otherwise, if the tax is relatively too small/low there will be only small timesaving and as a result the gain is also smaller. That is why higher tax is associated with higher expected utility. This result is basically in line with that of other study, which concludes that people are willing to pay if there is significant reduction in travel time. To have significant reduction in travel time we need high tax rate.

Another important point is that even though in a whole there is welfare improvement, bus and motor travelers experience relatively small welfare losses. This may be due to the very low value of time (VOT) of motor riders, and some of them are pushed to shift to bus, and consequently mode bus will be more congested and uncomfortable. As a result, the users of these two modes experience reduction in their expected utility (negative travelers' surplus). This fact motivates us not only to concentrate on the impact of tax policy from the perspective of various income classes, but also from other perspective such as evaluating from different modes of transport that travelers use. This finding may lead us to a completely different policy recommendation. For example, instead of distributing welfare from one income group to another, we may have to redistribute welfare from a group of a particular mode's users to another regardless of their income level. This also suggests that equity should be defined not only in terms of income but also in a broader way, which may include other non-economic aspects such as gender, age, etc.

Finally, by introducing sensitivity test we are able to change the effect of the tax from 'non-progressive' to 'progressive'. By doing this we are not only able to show how much change in distributional weights is needed to make the tax 'progressive' but we also show that the total surpluses will be higher if we do not put too much weights. In other words if we are willing to balance between efficiency consideration and the cost-benefit criterion the outcome is more desirable (i.e. increases both efficiency and equity).

Chapter 8

CONCLUSIONS AND RECOMMENDATIONS

8.1. Conclusions

This paper tries to evaluate the impact of the imposition of hypothetical congestion tax in CBD area in Jakarta. First, we estimate the demand for work-trip, and then we calculate the expected utility and analyze the effect of the tax. The demand estimation shows that some characteristics of travelers and attributes of the modes of transport have important contribution to the model. In terms of the characteristics, variables wage, sex, education, and travel cost are proven to be very important in the modal split decision. Additionally, some attributes of the modes such as comfort, safety, and speed also play important role in the process of work-travel decision making.

The implementation of hypothetical congestion tax scenario for the Central Business District in Jakarta, Indonesia shows that the tax has desirable effect on efficiency. By looking at individual traveler in the sample we find out that even though there are some travelers' experience losses due to the tax, many other travelers benefit from it. This is in accord with the result of other study stating that some will benefit and some other will lose. For all travelers in the whole sample there are net surpluses, which means that the gainers will be able to hypothetically compensate the losers.

The benefits of congestion tax are not the same for each income group. The initial (before tax) distribution of benefit (in terms of expected utility) from work-travel is in favor of high-income group. Furthermore, this study shows that without the redistribution of the net surplus, the middle income class receives the highest surplus, followed by the high-income class, and low-income group receives the least. At the highest tax scenario, on the average low income travelers benefit Rp. 2,464 per trip/person, middle income travelers receives Rp. 4,152 per trip/person, and high-income travelers receives Rp. 3,613. As opposed to commonly agreed that congestion tax is regressive, this result suggests that congestion tax in Jakarta may not exactly be overall regressive but at least it is regressive for the low-income group of travelers. The data may be responsible for this result. The survey might not be able to include enough samples of high-income travelers who value their time high, and thus most likely get higher benefit from the tax. Alternatively, high-income travelers do not value travel timesaving enough to benefit substantially from the tax. This conclusion is in line with the study carried out by Calfee and Winston (1998).

Comparison of the expected utility among different users of mode of transport suggests that congestion tax only benefit travelers who drive car to work. Bus riders and motorcycle users experience losses even though relatively small. This result may be caused by the fact that travelers with motorcycle only have very low value of time. After tax is imposed many of them may be forced to switch to bus. In the meantime, mode bus is becoming more crowded and uncomfortable. That is why travelers of the two modes together experience negative surplus.

If we are only concerned with efficiency and there is no redistribution of the surplus, the middle income group will benefit the most, and the low-income group benefits the least from the tax. In contrast, if we are in favor of the status quo we have to redistribute the surplus from the middle income group to the high-income group so that the relative welfare status of all three income groups is the same before and after tax. However, if we are willing to use cost-benefit criterion the low-income group will receive the largest benefit. This is due to the effect of distributional weights we put on the welfare function. Furthermore, there will be additional benefit coming from equity improvement. The decomposition of welfare changes into efficiency and equity aspects shows that at high tax scenario there will be efficiency gain of Rp. 3,170 per person/trip, and equity gain of Rp. 573 per trip/person. Finally, redistribution of welfare is a normative argument, but at least theoretically and empirically we can give concrete magnitudes and solidify the consequences of some alternative redistribution schemes. Finally, the sensitivity test shows that if we only assign the distributional weights just to make the distribution to be progressive the total surpluses will be higher, this is due to increases in equity (the distribution is more equitable).

There are many important aspects that are not included and discussed in this study. For example, this study does not take into account the supply side, and thus it does not analyze the implication of tax in Equilibrium State. Incorporating supply side of urban travel will certainly involve many decisions made by the operator of public transport and the authority of the urban road network. There are many such decisions, and examining them will require a lot of information. For example, we will need to address traffic control and management, land use planning, and also network layout. Incorporating supply side is certainly very important, but at least this study can be used as the starting point for more in-depth and larger scale studies in the future. We also suggest that for further study larger samples would be absolutely required. A better information is also very important; for example, in terms of income data in the future we may be able to obtain non-salary income, and income of household rather than that of individual. In the future, we may also need to estimate not only the work-trip demand but also other types of trips (i.e., business-trip, shopping-trip, etc), because congestion tax also affects other types of trips.

8.2. Recommendations

This study has shown that congestion tax if implemented in Jakarta may have some favorable outcomes but also some undesirable implication. Since the tax is likely to increase efficiency of urban transport for all different groups of travelers, the most important aspect to think about is the redistribution of the surplus. Even though this redistribution is purely normative, there are some recommendations that may be able to improve the urban transport system in Jakarta as a whole.

Assuming that there will be quite big revenues collected from the tax (after subtracting the cost of running the scheme), we recommend that the revenue from the tax is used for: (1) improvement of public transit, not only in terms of capacity increase but also better quality of services, and also to create a more integrated transport system which ensure a better connection among various mode of transport. There are many areas of quality of service that can be improved but it is too technical to be discussed in this paper;

(2) subsidize the use of high occupancy vehicle by employers. This is important to encourage workers to use carpool and reduce the number of workers who drive alone or ride motorcycle to work.

To help improving the public transit, in addition to the use of revenue from the tax we also suggests a cross subsidy from car users to bus riders. We may imposed higher tax on various tax related to the use of private car such as gasoline tax, registration fee, import tariff and allocate part of the tax revenue to improve public transit. This not only helps to improve public transport but also to discourage the use of private car in areas outside the CBD. This will improve public transit as a whole not only in at the CBD area. Therefore, travelers in other part of the city also enjoy the impact of the whole scheme and the overall timesaving experienced by travelers will be significant.

With respect to the tax rate this study suggests that higher tax rate is associated with higher expected utility. This finding may be useful to determine the approximate tax rate for the congestion tax scheme. The low tax scenario (Rp. 6,000 for auto) somehow reflects the willingness to pay of auto drivers to pay the tax, because currently many drivers pay the 'jockeys' still for in average Rp. 2,000 per person which means that for three passengers the amount would be approximately the same as Rp. 6,000. However, if we set the tax rate according to willingness to pay there will be not much reduction in the congestion level. That is why we need to set the tax rate higher than Rp. 6,000 in order to reduce the traffic congestion significantly.

In term of the scheme, to be more effective in discouraging people to drive and also reduce traffic congestion on the street corridors nearby CBD area, we suggest to implement an area licensing scheme so that more streets in the surrounding area is also under the congestion tax scheme. This scheme certainly incurs higher costs to operate because more entry booths are required and more people have to be employed but it is more effective in reducing congestion.

Finally, even though this study is specifically using Jakarta as the case study we believe that this study can serve as a blue print for similar studies to be carried out in other big cities in South East Asian Countries such as Bangkok, Manila, and Kuala Lumpur. These cities basically have very similar characteristics with Jakarta especially in terms of the urban transport problems such as traffic congestion and insufficiency of reliable public transit. With the increasingly difficulties in financing the development of a better mass transit system in these cities, congestion tax scheme offers an alternative solution to urban transport problem.

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Appendix 1

Expected Utility Before Tax

(in Rupiah, per trip)

1	4173.11	50	3978.33	99	2813.13	148	6051.12
2	1202.13	51	394.77	100	2176.67	149	3620.61
3	1647.24	52	9493.52	101	4183.15	150	35216.65
4	622.30	53	1914.42	102	2850.14	151	6056.23
5	156.48	54	244.46	103	233.27	152	759.81
6	316.09	55	2810.85	104	1976.35	153	22450.84
7	6352.97	56	3071.58	105	4851.81	154	1947.80
8	1236.69	57	5317.89	106	1852.28	155	11175.52
9	6028.29	58	128.12	107	1876.67	156	8054.09
10	8805.55	59	14880.94	108	2173.35	157	23363.49
11	8337.45	60	3486.64	109	1117.84	158	23383.71
12	3066.62	61	1408.30	110	1854.40	159	6949.17
13	1884.27	62	1777.68	111	381.65	160	23140.28
14	3485.71	63	2039.83	112	1867.39	161	11290.21
15	244.75	64	6318.88	113	3825.59	162	79095.86
16	3632.10	65	3419.65	114	1082.13	163	11750.74
17	1691.85	66	3265.33	115	3560.62	164	8616.06
18	389.03	67	3609.41	116	14578.12	165	6954.45
19	822.39	68	2373.97	117	15621.34	166	20616.44
20	1963.76	69	369.65	118	26327.86	167	10862.77
21	7374.74	70	3456.03	119	15013.01	168	17352.63
22	15428.11	71	2576.81	120	59526.86	169	51772.71
23	535.28	72	7400.43	121	46323.66	170	37416.27
24	3548.05	73	4773.99	122	86683.92	171	17213.22
25	13320.76	74	2102.51	123	20697.95	172	6794.69
26	1506.88	75	1746.48	124	11116.22	173	11732.03
27	14410.62	76	5033.32	125	71919.02	174	15424.79
28	158.77	77	5756.70	126	18490.64	175	73178.52
29	7175.37	78	1137.36	127	10261.75	176	21408.30
30	16579.28	79	2293.55	128	24284.94	177	67859.77
31	3591.79	80	4353.02	129	46826.35	178	21948.96
32	3572.47	81	370.41	130	20925.28	179	18414.71
33	4593.39	82	2375.33	131	59082.37	180	34600.00
34	477.35	83	4576.08	132	12453.56	181	45729.39
35	1997.91	84	248.45	133	10505.43	182	5923.82
36	1497.26	85	727.42	134	70032.25	183	18274.96
37	4044.83	86	968.48	135	22093.86	184	2749.80
38	4147.18	87	1219.02	136	53957.49	185	42505.51
39	1623.24	88	12679.46	137	48540.94	186	5253.14
40	938.05	89	2428.00	138	42411.66	187	37960.91
41	253.41	90	345.86	139	65731.89	188	14778.01
42	822.73	91	1102.18	140	34381.74	189	8202.86
43	1251.37	92	11047.18	141	30581.68	190	46876.05
44	845.48	93	190.25	142	31164.37	191	13552.74
45	1089.95	94	1802.27	143	28387.74	192	18906.85
46	1731.80	95	1124.18	144	14517.06	193	9251.64
47	190.43	96	8302.68	145	8899.03	194	18087.15
48	2181.32	97	867.91	146	607.61	195	14782.50
49	2009.11	98	1248.61	147	6187.34	196	41870.29

Appendix 1(continued)

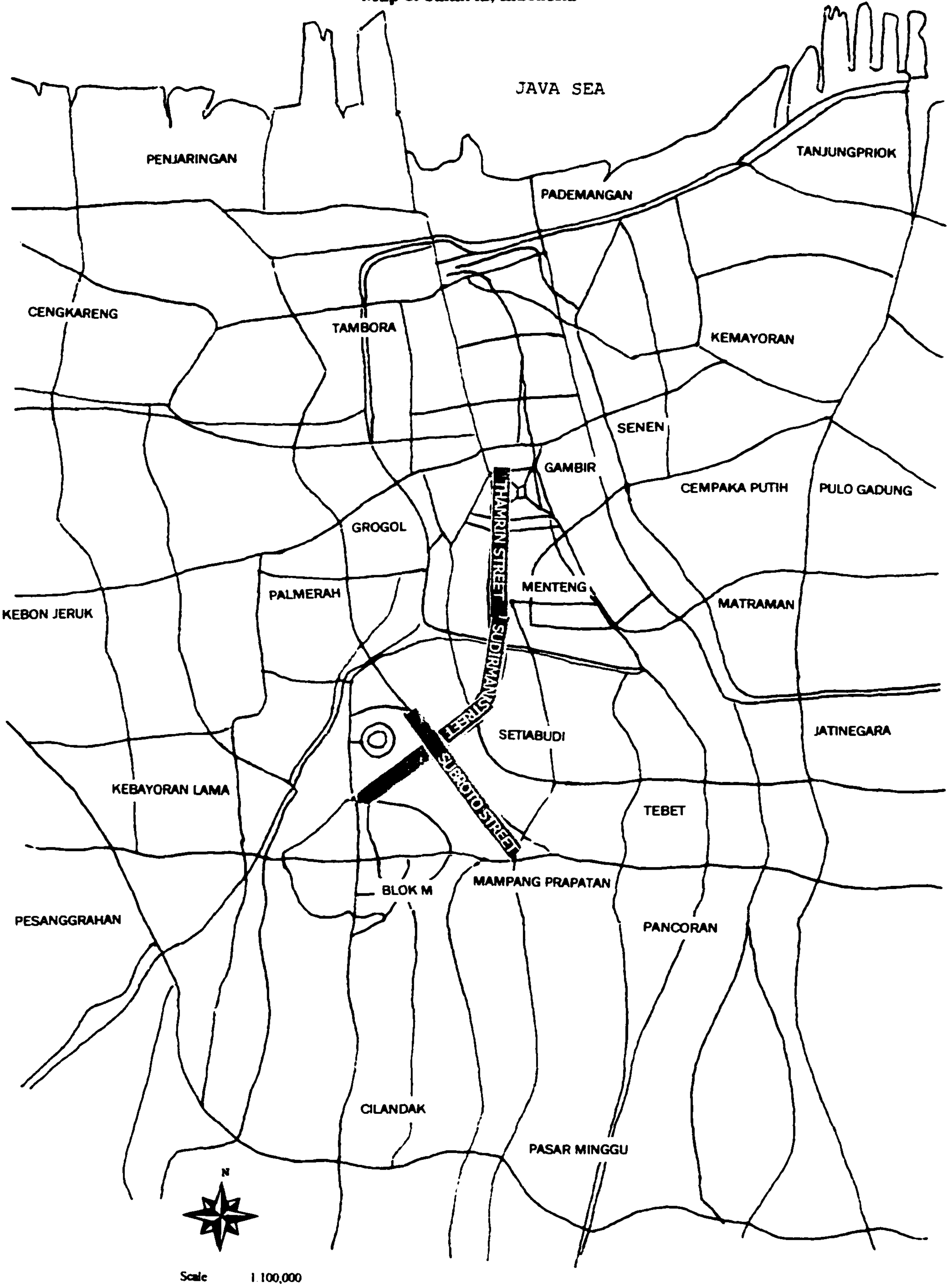
Expected Utility Before Tax

(in Rupiah. per trip)

197	17754.34	248	2347.94
198	15676.64	249	9940.88
199	16689.73	250	3955.26
200	27665.28	251	11113.34
201	8374.56	252	550.32
202	27447.43	253	17810.11
203	11192.53	254	12516.60
204	5383.40	255	8609.14
205	46348.99	256	14107.65
206	26668.16	257	6840.12
207	7297.78	258	7604.14
208	25409.90	259	7432.53
209	4258.93	260	14551.84
210	70120.38	261	13696.65
211	53439.15	262	14265.60
212	16215.14	263	2303.90
213	35614.65	264	9905.24
214	22183.14	265	13720.93
215	7668.67	266	4804.91
216	28463.37	267	13980.86
217	36609.12	268	2225.90
218	17365.82	269	4844.62
219	24211.47	270	4182.56
220	4323.97	271	11424.26
221	4196.09	272	11293.86
222	22614.85	273	2304.65
223	4700.10	274	16129.97
224	16004.78	275	2125.35
225	3751.57	276	3299.76
226	3754.86	277	1935.73
227	15059.63	278	13043.81
228	16192.77	279	14789.46
229	15595.83	280	10244.54
230	7773.01	281	21382.82
231	16021.67	282	13931.25
232	8562.28	283	24128.95
233	1564.91	284	11410.53
234	7972.82	285	11349.08
235	4205.37	286	7016.51
236	1611.44	287	7044.99
237	11696.39	288	2041.30
238	4803.97	289	8201.79
239	4233.52	290	14638.50
240	4709.75	291	5613.79
241	2576.43	292	15518.73
242	2820.25	293	2239.58
243	5034.55	294	14454.77
244	11689.85	295	15926.01
245	9242.53	296	19778.39
246	2515.31	297	14746.12
247	6744.77		

Attachment 1

Map of Jakarta, Indonesia



Attachment-2

WORK TRAVEL SURVEY

PART I. ECONOMIC AND DEMOGRAPHIC INFORMATION

A. Individual Characteristics

1. Name of Respondent (optional): ____
2. Sex: M/F   Age: _____
3. Highest Education: _____ Senior High School
   _____ Non-Degree College
   _____ Bachelor
   _____ Master/Doctor
4. Home Address: ____
5. Status in Household: Head/Member
6. Occupation and Job Title: ____
7. Name of Business Employer and Address:

   ____

8. Gross Income per Year:

	(a) Wages and Salary	Rp.____________________
	(b) Bonus	Rp.____________________
	(c) Benefit	Rp.____________________
	(d) Income from other sources	Rp.____________________

B. Household Characteristics

1. Number of Residents in Household: ____
2. Status of Home Ownership: owned/rented/provided by employer
3. Number of Years Living in this House: ____
4. The Value of the House (if rented, what is the monthly or annual rent): Rp. ____________________
5. Do you have Car(s) and/or motorcycle(s)? _____ Yes. Go to question # 6

   _____ No. Go to question # 7

6. What kind of Car(s) and/or motorcycle(s) do You Have in Your Household?

No.	Make and Model	Year	Estimated Current Value	Status of Ownership
1.	____________	____	Rp.____________	owned/rented/provided by employer
2.	____________	____	Rp.____________	owned/rented/provided by employer
3.	____________	____	Rp.____________	owned/rented/provided by employer
4.	____________	____	Rp.____________	owned/rented/provided by employer

7. How many People in your Household are Working? ______________________________

8. What is the Total Household Gross Income (if more than one person working)?

(a) Wages and Salaries	Rp.________________
(b) Bonuses	Rp.________________
(c) Benefits	Rp.________________
(d) Income from other sources	Rp.________________

PART II. WORK TRAVEL RELATED INFORMATION

How do you normally travel to work everyday (check the one most frequently used)?

____ by Auto. Go to section A
____ by Bus. Go to section B
____ by Motorcycle. Go to section C

Section A. Auto Travel

1. Do you drive alone? ____ Yes.
____ No. ____ I have a driver.
____ I am ridesharing/carpooling. Do you have to pay?
____ No
____ Yes. How much? Rp. ______

2. If you are not carpooling, how much is your average travel expense per month?

- Operating Cost (gasoline, oil, etc)	Rp. __________
- Maintenance Cost	Rp. __________
- Parking Fees (if applied)	Rp. __________
- Toll Fees (if applied)	Rp. __________
Total Expenses	Rp. __________

3. What is the distance between your home and workplace or parking area (in km.)? ____________

4. How long usually does it take you to drive from home to your office or parking area? __________

5. **How do you evaluate the attributes of the mode you are using in terms of the <u>speed</u>, <u>comfort</u>, and <u>safety</u> (circle the one most appropriate)?**

<u>Speed</u>	<u>Comfort</u>	<u>Safety</u>
a. Completely Satisfied	a. Completely Satisfied	a. Completely Satisfied
b. Mostly Satisfied	b. Mostly Satisfied	b. Mostly Satisfied
c. Neither Satisfied nor dissatisfied	c. Neither Satisfied nor dissatisfied	c. Neither Satisfied nor dissatisfied
d. Mostly Dissatisfied	d. Mostly Dissatisfied	d. Mostly Dissatisfied
e. Completely Dissatisfied	e. Completely Dissatisfied	e. Completely Dissatisfied

<u>Section B. Bus Travel</u>

1. What type of bus (es) do you ride?

________ regular bus
________ air conditioned bus
________ both

2. What is the distance between your home and your office (in km)?________________________

3. How many bus transfers you have to make? ________________________________

4. How long does it take you?

* to walk to the bus from home? ________________________________
* to wait for the bus? ________________________________
* to ride the bus(es) to the stop nearest your office (including transfer and waiting time? ________________________________
* to walk from bus stop to the office? ________________________________

5. How much is your monthly expense for using the bus to work? ________________________

6. How do you evaluate the attributes of the mode you are using in terms of the <u>speed</u>, <u>comfort</u>, and <u>safety</u> (circle the one most appropriate)?

<u>Speed</u>	<u>Comfort</u>	<u>Safety</u>
a. Completely Satisfied	a. Completely Satisfied	a. Completely Satisfied
b. Mostly Satisfied	b. Mostly Satisfied	b. Mostly Satisfied
c. Neither Satisfied nor dissatisfied	c. Neither Satisfied nor dissatisfied	c. Neither Satisfied nor dissatisfied
d. Mostly Dissatisfied	d. Mostly Dissatisfied	d. Mostly Dissatisfied
e. Completely Dissatisfied	e. Completely Dissatisfied	e. Completely Dissatisfied

Attachment-2

Section C. Motorcycle Travel

1. What is the distance between your home and your office (in km)? ____________________
2. How long does it take you from home to your office? ____________________
3. How much is your work travel expense per month?

- Operating cost (gasoline, oil) Rp. __________
- Maintenance cost Rp. __________
- Parking fees (if applied) Rp. __________

Total Expenses Rp. __________

4. How do you evaluate the attributes of the mode you are using in terms of the speed, comfort, and safety (circle the one most appropriate)?

Speed	Comfort	Safety
a. Completely Satisfied	a. Completely Satisfied	a. Completely Satisfied
b. Mostly Satisfied	b. Mostly Satisfied	b. Mostly Satisfied
c. Neither Satisfied nor dissatisfied	c. Neither Satisfied nor dissatisfied	c. Neither Satisfied nor dissatisfied
d. Mostly Dissatisfied	d. Mostly Dissatisfied	d. Mostly Dissatisfied
e. Completely Dissatisfied	e. Completely Dissatisfied	e. Completely Dissatisfied

Interviewer's Notes:

"I certify that the information listed on this interview form is accurately and completely recorded as reported to me by the respondent"

Interviewer's Signature

Date